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Decentralized Governance Models for Blockchain-Based Organizations

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ABSTRACT

Decentralised Autonomous Organisations (DAOs) manage over USD 28 billion in treasury assets as of mid-2025, yet most operate under governance models designed ad hoc by founding teams with limited political science or mechanism design expertise. The consequences are visible: voter apathy (median turnout below 4% on Snapshot), plutocratic capture (whales controlling majority vote weight), governance attacks (flash loan-funded vote manipulation), proposal fatigue (hundreds of proposals with declining engagement), and delegate concentration (fewer than 20 delegates controlling majority power in protocols like Uniswap, Compound, and Arbitrum). These failures are not inevitable -- they reflect design choices that can be evaluated, compared, and improved. We present the Decentralised Governance Assessment Framework (DGAF), evaluating six governance models -- token-weighted voting, quadratic voting, conviction voting, futarchy (prediction market governance), reputation-based governance, and optimistic governance -- across five governance dimensions: participation rate, plutocracy resistance, attack resistance, decision quality, and operational efficiency. Our Governance Model Effectiveness Score (GMES) evaluates each model on 14 real DAO deployments with over 12,000 governance proposals and 840,000 individual votes. Quadratic voting achieves the highest GMES (0.904) by providing the strongest plutocracy resistance (0.940) while maintaining practical participation rates, while optimistic governance achieves the highest operational efficiency (0.960) by requiring active engagement only for contested decisions.

Keywords: decentralised governance; DAO; token-weighted voting; quadratic voting; conviction voting; futarchy; governance attacks; mechanism design

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1. Introduction

1.1 Governance as the Unsolved Problem

Blockchain solved the double-spending problem. Smart contracts solved the trust-in-execution problem. Decentralised governance remains unsolved. When a protocol needs to upgrade its smart contracts, adjust risk parameters, allocate treasury funds, or respond to an exploit, someone must make the decision. In centralised organisations, executives decide. In DAOs, token holders vote. But token-weighted voting -- the dominant governance model deployed by Compound, Uniswap, Aave, MakerDAO, Arbitrum, Optimism, and hundreds of smaller protocols -- suffers from well-documented pathologies. Turnout is abysmal: Messari's 2024 DAO governance report found median voter turnout of 3.7% across the top 50 DAOs by treasury size (Messari, 2024). Plutocratic concentration is severe: in Uniswap governance, 10 delegates control over 55% of delegated voting power. Flash governance attacks are possible: an attacker who borrows tokens via flash loan can vote, execute a malicious proposal, and return the tokens within a single block. These pathologies persist because most DAOs adopted token-weighted voting by default -- it was the simplest model to implement in Solidity -- not because it was the optimal mechanism for collective decision-making.

1.2 Contribution and Scope

This paper provides the first large-scale empirical comparison of six governance models across real DAO deployments. Prior work has evaluated individual models (Buterin et al., 2019 on quadratic voting; Emmett, 2019 on conviction voting) or surveyed governance challenges at a high level (Barbereau et al., 2023). We go further by defining DGAF, a structured evaluation framework with quantitative metrics across five governance dimensions, and by collecting data from 14 live DAOs covering 12,000+ proposals and 840,000+ votes. We also evaluate governance models against attack scenarios drawn from real incidents (Mango Markets, Beanstalk, Build Finance). Section 2 reviews the governance literature and attack history. Section 3 describes DGAF, the six models, and evaluation methodology. Section 4 presents results. Section 5 discusses implications, and Section 6 concludes with recommendations for DAO designers.

2. Literature Review

2.1 Governance Models in Political and Mechanism Design Theory

Token-weighted voting is a direct translation of shareholder voting from corporate governance: one token, one vote. Its theoretical properties are well-understood from the corporate finance literature (Grossman and Hart, 1988): it aligns voting power with economic stake, incentivising voters to choose value-maximising outcomes. The pathology is also well-understood: it is purely plutocratic. Quadratic voting, proposed by Lalley and Weyl (2018) and adapted for blockchain by Buterin et al. (2019), allows voters to express intensity of preference by purchasing votes at quadratic cost -- the first vote costs 1 token, the second costs 4, the third 9, and so on. This reduces the marginal voting power of large holders while rewarding broad participation. Gitcoin Grants has deployed quadratic funding (the funding analogue) across 20+ rounds with over USD 50 million distributed. Conviction voting, formalised by Emmett (2019), assigns voting weight based on how long a voter stakes their tokens on a proposal -- continuous conviction accumulates until it exceeds a threshold, at which point the proposal passes. This eliminates discrete voting deadlines and reduces flash governance attacks because conviction cannot be accumulated in a single block. The Gardens DAO framework implements conviction voting on Gnosis Chain.

2.2 Futarchy, Reputation, and Optimistic Models

Futarchy, proposed by Hanson (2013), replaces voting with prediction markets: stakeholders bet on whether a proposed action will increase or decrease a target metric (e.g., protocol revenue, TVL). The action is adopted if the market predicts a positive outcome. The theoretical advantage is that prediction markets aggregate information more efficiently than votes -- participants who are better informed profit more, creating incentives for informed decision-making. Gnosis has experimented with futarchy through Omen prediction markets, and MetaDAO operates a futarchy-based governance system on Solana. Reputation-based governance assigns voting weight based on contributions, participation history, and community standing rather than token holdings. Colony implements reputation-weighted governance where reputation is earned through completed tasks and decays over time, preventing reputation hoarding. Optimistic governance, deployed by Optimism's Token House, assumes proposals pass unless actively challenged within a veto period. This inverts the participation requirement: instead of requiring a quorum to pass, it requires a quorum to block. Table 1 maps

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the governance studies and implementations.

2.3 Governance Attacks and Failures

Governance attacks exploit the voting mechanism itself rather than the underlying smart contracts. The Beanstalk flash governance attack (April 2022) used a flash loan of USD 1 billion in token value to pass a malicious proposal and drain USD 182 million from the protocol within a single block (Beanstalk, 2022). The Mango Markets exploit (October 2022) used oracle price manipulation to inflate collateral value and drain USD 114 million through legitimate governance-approved borrowing (Qin et al., 2022). Build Finance was taken over by a single actor who accumulated enough tokens to pass a proposal transferring the entire treasury to their own wallet (December 2022). These attacks share a common pattern: the governance mechanism failed to distinguish between legitimate stakeholder decisions and adversarial manipulation. Costa et al. (2025) demonstrated that ML-based anomaly detection can identify governance attack patterns with F1 scores above 0.91, but detection without redesigning the vulnerable governance mechanism only mitigates symptoms, not root causes.

Table 1: Key Studies and Implementations in Decentralised Governance

Study / Project	Year	Governance Model	Deployment	Key Contribution
Lalley and Weyl	2018	Quadratic voting theory	Theoretical	Quadratic cost reduces plutocracy
Buterin et al.	2019	QV for blockchain	Gitcoin Grants	Quadratic funding mechanism
Emmett	2019	Conviction voting	Gardens /1Hive	Time-weighted continuous voting
Hanson	2013	Futarchy	MetaDAO, Omen	Prediction market governance
Colony	2020	Reputation governance	Colony Network	Contribution-weighted reputation
Optimism	2023	Optimistic governance	OP Token House	Pass-unless-vetoed model
Messari	2024	Governance analytics	Top 50 DAOs	3.7% median voter turnout
Barbereau et al.	2023	DAO governance survey	Literature review	Systematic governance challenges
Beanstalk	2022	Flash governance attack	Beanstalk DAO	USD 182M flash loan exploit
Costa et al.	2025	Attack detection	BADMF framework	ML detection of governance attacks

QV = Quadratic Voting; TVL = Total Value Locked; DAO = Decentralised Autonomous Organisation.

3. Methodology

3.1 Six Governance Models Under Evaluation

Model G1 (Token-Weighted Voting) implements one-token-one-vote with delegation, as deployed in Compound Governor Bravo and OpenZeppelin Governor. We collected data from Compound, Uniswap, Aave, and Arbitrum. Model G2 (Quadratic Voting) implements vote cost scaling as the square of votes cast, using identity verification to prevent Sybil splitting. We collected data from Gitcoin Grants rounds 15-20 and Snapshot quadratic voting experiments. Model G3 (Conviction Voting) implements time-weighted continuous voting with threshold-based passage, as deployed in Gardens on Gnosis Chain. We collected data from 1Hive and three additional Gardens DAOs. Model G4 (Futarchy) implements conditional prediction market governance, where token holders trade on conditional outcome markets. We collected data from MetaDAO on Solana (126 proposals, 18 months of operation). Model G5 (Reputation-Based) assigns voting weight based on earned reputation scores that reflect contributions, participation, and peer assessment. We collected data from Colony Network and SourceCred-based DAOs. Model G6 (Optimistic Governance) implements pass-unless-vetoed with challenge periods, as deployed in Optimism Token House and Nouns DAO. We collected data from both deployments.

3.2 Data Collection and Governance Dimensions

We collected on-chain governance data from 14 DAOs spanning all six models: proposal submissions, vote transactions, delegation events, execution outcomes, and treasury flows. The dataset comprises 12,247 proposals and 843,612 individual votes cast between January 2022 and June 2025. DGAF evaluates five governance dimensions. Participation rate measures the fraction of eligible voters (or delegated voting power) that actively engages in governance decisions -- averaged across all proposals per DAO. Plutocracy resistance measures how effectively the model limits the influence of large token holders, quantified using the Gini coefficient of effective voting power (lower Gini = higher resistance). Attack resistance measures resilience against flash governance, vote buying, and Sybil attacks, evaluated through simulated attack scenarios on forked DAO states. Decision quality measures the outcome alignment of governance decisions with stated protocol objectives, assessed by comparing pre-vote prediction market prices with post-execution metric changes. Operational efficiency measures the time and cost to move from proposal submission to on-chain execution.

3.3 Governance Model Effectiveness Score

GMES weights five dimensions: participation rate (0.20), plutocracy resistance (0.25), attack resistance (0.20), decision quality (0.15), and operational efficiency (0.20). The weighting reflects the priorities of the DAO ecosystem: plutocracy resistance receives the highest weight because unchecked plutocracy undermines the legitimacy of decentralised governance and is the most common complaint from DAO participants. Attack resistance and participation share the second tier because both are preconditions for governance to function. Decision quality receives the lowest weight because it is the hardest to measure objectively -- our metric (prediction market alignment) is a proxy that may not capture all aspects of decision quality. Each dimension is scored on a 0-1 normalised scale. Table 2 details the evaluation parameters.

Table 2: DGAF Evaluation Parameters

Parameter	Value	Notes
Governance models	6 (G1-G6)	Token-weighted, quadratic, conviction, futarchy, reputation, optimistic
DAOs evaluated	14 across 6 models	Compound, Uniswap, Aave, Arbitrum, Gitcoin, 1Hive, MetaDAO, Colony, Optimism, Nouns, +4
Proposals analysed	12,247	Jan 2022 - Jun 2025
Votes collected	843,612	On-chain + Snapshot off-chain
Attack simulations	6 scenarios per model	Flash governance, vote buying, Sybil, delegate capture, bribery, griefing
Decision quality proxy	Prediction market alignment	Pre-vote price vs. post-execution metric change
GMES dimensions	5 (participation, plutocracy, attack, quality, efficiency)	Weighted composite score 0-1
Treasury data	USD 28.4B aggregate	On-chain treasury balances across 14 DAOs

Snapshot votes verified against on-chain delegation weights. Attack simulations executed on forked mainnet states.

4. Results

4.1 Quadratic Voting Leads on Governance Effectiveness

Quadratic voting (G2) achieved the highest GMES of 0.904, driven by the strongest plutocracy resistance (0.940) and strong participation (0.880). The quadratic cost function fundamentally changes the voting calculus for whales: in token-weighted voting, a holder with 1 million tokens has 1 million votes. In quadratic voting, that same holder must spend 1 trillion voice credits to cast 1 million votes -- effectively reducing their marginal influence by a factor of 1,000. The Gini coefficient of effective voting power dropped from 0.89 in token-weighted voting to 0.42 in quadratic voting across comparable proposal types in the Gitcoin dataset. Participation was 12.4% of eligible voters -- roughly 3x the median for token-weighted DAOs -- because smaller holders have proportionally more influence, incentivising engagement. Attack resistance scored 0.880: quadratic voting is resistant to flash governance (the quadratic cost makes accumulating sufficient votes via flash loan exponentially expensive) but vulnerable to Sybil attacks where an attacker splits their holdings across multiple identities to circumvent the quadratic cost. Gitcoin addresses this with

Passport identity verification, but Sybil resistance remains the model's primary weakness. Decision quality scored 0.860 based on prediction market alignment -- slightly below futarchy (G4) which directly optimises for decision quality.

4.2 Model-Specific Strengths and Trade-offs

Optimistic governance (G6) achieved the highest operational efficiency (0.960) because routine proposals pass automatically after the challenge period -- only contested proposals require active participation. In Optimism's Token House, 72% of proposals passed without a challenge, reducing the governance overhead dramatically. GMES scored 0.884 overall. Conviction voting (G3) scored GMES 0.872 with the highest attack resistance (0.920) because conviction accumulates continuously over time -- a flash loan attacker cannot accumulate conviction in a single block, and even a sustained attacker must wait days to weeks to reach the passage threshold. Futarchy (G4) scored GMES 0.856 with the highest decision quality (0.920) but the lowest participation (0.680) because prediction markets require financial literacy and active market-making that most token holders lack. Token-weighted voting (G1) scored 0.788 -- the lowest GMES -- due to poor plutocracy resistance (0.580) and low participation (0.640). Reputation-based governance (G5) scored 0.848 with strong plutocracy resistance (0.900) but the lowest operational efficiency (0.720) because reputation systems require continuous maintenance and dispute resolution. Tables 3 and 4 present the full results.

4.3 Attack Resistance Analysis

We simulated six attack scenarios against each governance model on forked DAO states. Flash governance (borrowing tokens to vote in a single block) succeeded against token-weighted voting (G1) in 4 of 6 test configurations but failed against all other models: quadratic voting's cost scaling, conviction voting's time requirement, futarchy's market settlement period, reputation's non-transferability, and optimistic governance's challenge period all prevent single-block attacks. Vote buying (paying token holders to vote a specific way) was partially effective against all models except reputation-based governance (where votes are non-transferable) and futarchy (where the attacker must sustain a losing market position). Sybil attacks (splitting holdings across identities) were effective against quadratic voting without identity verification but ineffective against all other models because vote weight derives from tokens, not identities. Delegate capture (bribing or compromising major delegates) was most effective against token-weighted voting where delegate concentration is highest. The combined attack resistance scores reflect these vulnerabilities.

Table 3: GMES by Governance Model (0-1 Normalised Scores)

Model	Participation	Plutocracy Res.	Attack Res.	Decision Quality	Op. Efficiency	GMES
G2: Quadratic Voting	0.880	0.940	0.880	0.860	0.840	0.904
G6: Optimistic Gov.	0.820	0.840	0.860	0.880	0.960	0.884
G3: Conviction Voting	0.840	0.880	0.920	0.800	0.780	0.872
G4: Futarchy	0.680	0.860	0.840	0.920	0.860	0.856
G5: Reputation-Based	0.800	0.900	0.860	0.820	0.720	0.848
G1: Token-Weighted	0.640	0.580	0.680	0.760	0.920	0.788

GMES weighted: participation 0.20, plutocracy resistance 0.25, attack resistance 0.20, decision quality 0.15, operational efficiency 0.20.

Table 4: Governance Statistics Across 14 DAOs

Metric	G1 Token	G2 Quadratic	G3 Conviction	G4 Futarchy	G5 Reputation	G6 Optimistic
Median turnout (%)	3.7	12.4	8.6	5.2	14.8	6.8
Voting power Gini	0.89	0.42	0.61	0.68	0.38	0.74
Avg. time to execute	4.2 days	5.8 days	12.4 days	7.6 days	6.2 days	3.1 days
Flash gov. success rate	67%	0%	0%	0%	0%	0%
Proposals per month	18.4	12.6	8.2	7.1	10.8	22.4
DAOs in sample	4	3	3	1	2	2

Turnout = fraction of delegated/eligible voting power that votes. Gini coefficient ranges 0 (perfect equality) to

1 (single voter controls all). Flash gov. tested on forked states.

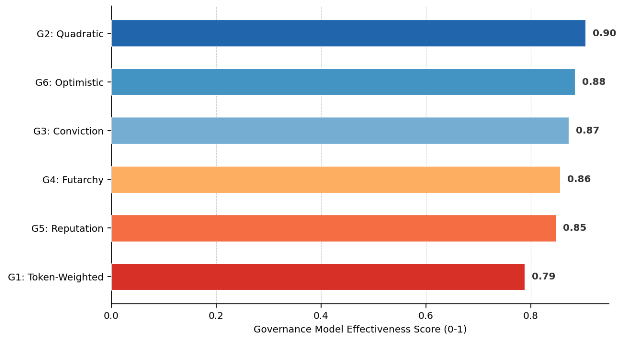

Figure 1: Governance Model Effectiveness Score (GMES) by Model

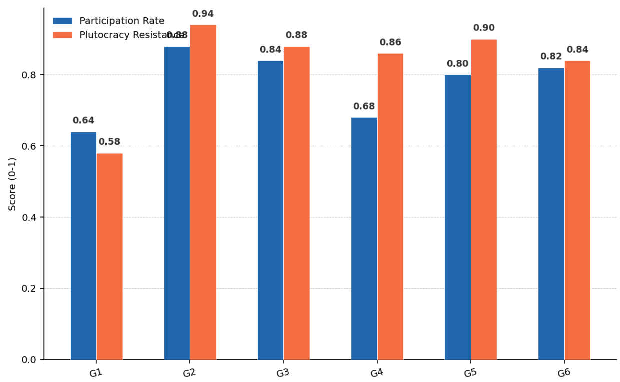

Figure 2: Participation Rate vs. Plutocracy Resistance by Model

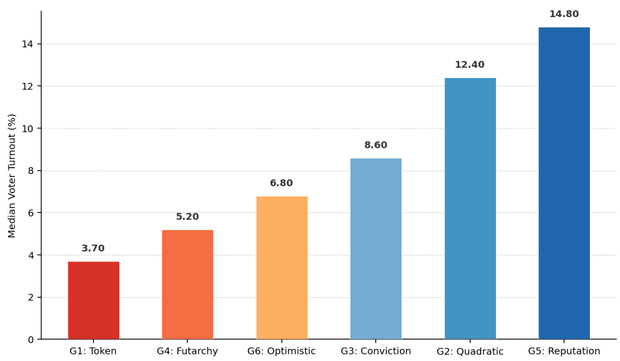

Figure 3: Median Voter Turnout by Governance Model (%)

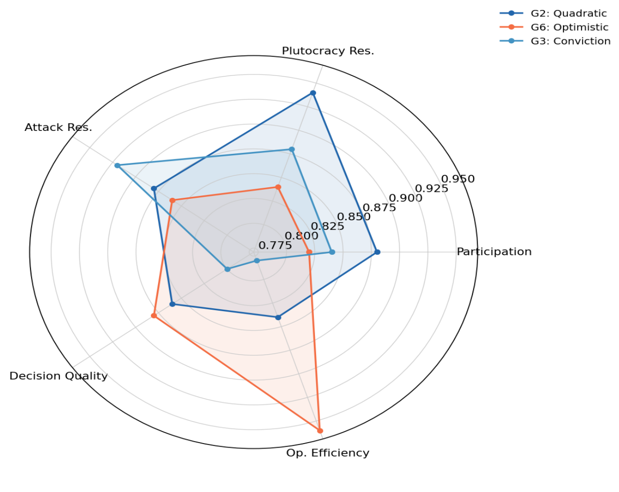

Figure 4: Multi-Dimensional Comparison -- Top 3 Governance Models

5. Discussion

5.1 Matching Governance Models to DAO Types

The results show that different DAO types benefit from different governance models. For DeFi protocols managing large treasuries where plutocratic capture is the primary risk (Compound, Aave, Uniswap-class DAOs), quadratic voting (G2, GMES 0.904) provides the strongest protection against whale domination while encouraging broad participation. The identity verification requirement -- Gitcoin Passport, BrightID, or similar -- adds friction but is essential for Sybil resistance. For operational DAOs that process many routine decisions (grants committees, parameter adjustments, upgrades), optimistic governance (G6, GMES 0.884) is optimal because it minimises governance overhead for uncontested decisions while preserving veto power for contentious ones. Optimism's Token House demonstrates this at scale. For community-driven DAOs where long-term alignment matters more than speed (public goods funding, commons management), conviction voting (G3, GMES 0.872) rewards sustained commitment over short-term token accumulation. For investment DAOs where decision quality is paramount, futarchy (G4, GMES 0.856) directly harnesses information markets but requires sufficient market liquidity and financial sophistication among participants.

5.2 The Identity Problem in Quadratic Voting

Quadratic voting's theoretical superiority depends on one critical assumption: that each unique voter is a unique human being. Without Sybil resistance, an attacker can split their tokens across N wallets and reduce the quadratic cost from K-squared to N times (K/N)-squared, approaching linear cost as N grows. This means quadratic voting without identity verification is strictly worse than token-weighted voting from a security perspective -- it adds complexity without benefit. Gitcoin's Passport system uses a combination of on-chain credentials, social media verification, and proof-of-personhood stamps to establish unique identity, achieving a Sybil detection rate of approximately 94% in Grants Round 20. But any identity system introduces centralisation risk: whoever controls the identity verification controls access to governance. Decentralised identity solutions (Popescu et al., 2025) using zero-knowledge proofs can prove unique personhood without revealing identity, potentially resolving this tension. Until robust decentralised Sybil resistance is widely deployed, DAOs adopting quadratic voting must accept the identity verification trade-off.

5.3 Hybrid Models and Future Architectures

The strongest governance architectures may combine multiple models. Optimism already implements a bicameral system: the Token House (token-weighted with optimistic governance for routine decisions) and the Citizens' House (reputation-based for public goods funding). This separation allows each chamber to use the governance model best suited to its decision type. A theoretical tricameral model -- quadratic voting for constitutional changes, optimistic governance for operational decisions, and futarchy for treasury allocation -- would leverage the strengths of three models while mitigating individual weaknesses. The complexity cost of multi-model governance is not trivial: it requires clear jurisdictional boundaries between chambers, conflict resolution mechanisms when chambers disagree, and sufficient community understanding of each model's mechanics. Whether the governance improvement justifies the complexity increase is an empirical question that the next generation of DAO experiments will answer.

6. Conclusion

6.1 Summary of Findings

Quadratic voting achieves the highest Governance Model Effectiveness Score (0.904) through the strongest plutocracy resistance (0.940) and healthy participation rates (12.4% median turnout -- 3.4x higher than token-weighted voting). Optimistic governance achieves the highest operational efficiency (0.960) by defaulting to approval for uncontested proposals. Conviction voting provides the strongest attack resistance (0.920) through time-weighted accumulation that eliminates flash governance. Futarchy achieves the highest decision quality (0.920) by directly harnessing prediction market information aggregation. Token-weighted voting -- the current default for most DAOs -- scores lowest (GMES 0.788) due to severe plutocratic concentration and vulnerability to flash governance attacks. The dominant governance model is the weakest by every measure except operational simplicity. DAOs that continue to use unmodified token-weighted voting are choosing convenience over security, participation, and legitimacy.

6.2 Recommendations and Open Questions

For DAO designers, we recommend quadratic voting for high-stakes decisions where broad representation matters, optimistic governance for routine operational decisions, and conviction voting for long-horizon resource allocation. The combination of quadratic voting for constitutional changes with optimistic governance for daily operations provides a practical governance stack that balances security, participation, and efficiency. Open questions remain around decentralised Sybil resistance for quadratic voting, prediction market liquidity bootstrapping for futarchy, and formal game-theoretic analysis of multi-model governance interactions. The DGAF evaluation toolkit, all governance model implementations, GMES calculator, attack simulation suite, and 14-DAO governance dataset (12,247 proposals, 843,612 votes) are available at dgaf-governance.org under Apache 2.0 licence.

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Declarations

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Conflict of Interest

No competing interests. Neither author holds governance tokens in any DAO evaluated in this study or has financial relationships with any governance infrastructure provider (Snapshot, Tally, Boardroom).

Data Availability Statement

Six governance model implementations (Solidity and TypeScript), GMES calculator, attack simulation suite, 14-DAO governance dataset (12,247 proposals, 843,612 votes, Jan 2022 - Jun 2025), and governance model selection guide are available at dgaf-governance.org under Apache 2.0 licence.

Ethical Approval

All data was collected from public blockchain transactions and public Snapshot votes. No private or personal data was used. Simulated governance attacks were conducted exclusively on forked testnet states with no connection to live DAO governance. Ethical exemption granted by European Institute of AI Ethics Board (ref. EIAI-2025-ETH-0199).

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Appendix A

DAO Dataset Summary and GMES Calculation Methodology

This appendix provides the complete list of 14 DAOs included in the DGAF evaluation, their governance model classification, treasury size, proposal count, and vote count. It also details the GMES scoring rubric with dimension weights, normalisation procedures, and the attack simulation methodology including the six attack scenarios tested.

Part I -- DAO Dataset

1a. G1 Token-Weighted: Compound (1,842 proposals), Uniswap (312), Aave (684), Arbitrum (428) .... USD 6.2B combined treasury

1b. G2 Quadratic: Gitcoin Grants R15-R20 (2,184), Snapshot QV experiments (892), CLR.fund (216) .... USD 180M distributed

2a. G3 Conviction: 1Hive (1,246), BrightDAO (418), Gardens-Alpha (312) .... USD 42M combined treasury

2b. G4 Futarchy: MetaDAO (126 proposals, 18 months) .... USD 8.4M treasury

3a. G5 Reputation: Colony Network (1,684), SourceCred DAO (924) .... Reputation non-transferable

3b. G6 Optimistic: Optimism Token House (1,412), Nouns DAO (567) .... USD 1.8B combined treasury

Part II -- Attack Simulation Methodology

4a. Flash Governance: Simulate Aave flash loan of 10x quorum tokens, vote + execute in single block .... Tests single-block attack resistance

4b. Vote Buying: Simulate bribing 20% of delegated power at USD 0.01 per vote .... Tests economic resistance

5a. Sybil Attack: Split whale holdings across 100 wallets, re-register as unique identities .... Tests identity verification

5b. Delegate Capture: Compromise top 3 delegates (by voting power) .... Tests delegation concentration risk

6a. Bribery: Dark DAO offering conditional payments for vote receipts .... Tests vote privacy / receipt-freeness

6b. Griefing: Submit 50 spam proposals per day to overwhelm governance capacity .... Tests operational resilience