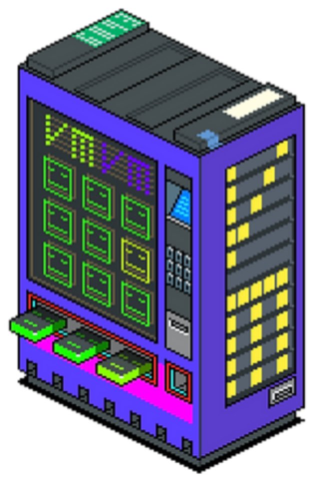
Network
Simulation Report



VENDING MACHINE

Contents

Abstract This report presents the findings of extensive simulations conducted by Vending Machine to evaluate the economic performance of the proposed $***$ token system for $***$. The study aims to assess the system's ability to incentivize network participants, including stakers and verifiers, while maintaining long-term sustainability. Through 2,000 simulation runs per scenario, the report analyzes various conditions such as transaction volumes and staking activities. Key aspects covered include model assumptions, environmental variables, simulation configurations, and established metrics with corresponding benchmarks. The report provides recommendations for optimal parameter settings, including emission rates and decay factors, to ensure an attractive and financially sustainable network. Additionally, it offers insights into the system's performance under different scenarios and includes sensitivity analyses and stress testing results.

1 Introduction

The present report outlines the simulations findings that Vending Machine performed for the proposed token design. This study aims to evaluate the economic performance of the proposed $***$ token system, which is designed to incentivize network participants, including stakers and verifiers.

The simulation leverages a comprehensive model that replicates the economic assumptions of $***$ blockchain network, enabling a thorough analysis of the system's evolution over time. By simulating 2,000 runs per scenario across various conditions, including different transaction volumes and staking activities, this report offers a detailed overview of the token system's potential performance.

Preliminary technical research was conducted to gather reliable estimates for key model assumptions, using historical data from similar blockchain systems where applicable. This approach allows us to provide actionable insights into the system's ability to meet key benchmarks and deliver sustainable rewards to stakeholders.

The findings presented in this report will guide the determination of optimal parameter settings, including emission rates, decay factors, and reward structures. Our goal is to ensure that the $***$ network is both attractive to users and financially sustainable in the long term, balancing the needs of various stakeholders within the ecosystem.

The present reports starts by highlighting the main recommendations and key findings derived from the simulation process.

A section that summarizes the technical aspects about the model, namely model assumptions, environmental variables, simulation configuration as well as the metrics established and corresponding benchmarks is presented.

Results from the main simulations performed regarding annual emission rate and annual decay rate are presented, followed by sensitivity analysis on diverse parameters and a stress testing case.

Finally, other insightful results are presented that contribute for the value-added of the present report.

2 Recommendations and Key Findings

- For key metrics, strict and weak benchmarks were quantified based on historical data of comparable dPoS networks.
- A starting annual emission rate of *** is recommended, based on simulation results which indicated that this level of annual emission rate results in the staking APR and net inflation metrics to meet the strict and weak benchmarks established.
- An annual emission decay rate of *** is recommended, as this level of decay allows for a smooth transition of yearly APRs while simultaneously allowing the benchmarks to be met.
- Based on desired terminal staking ratio of *** and target terminal staking APR of ***, a terminal emission inflation of *** is recommended for *** for the aim of attracting sufficient economic security in the long term.
- With initial emission inflation of *** and decay rate of *** per year, it is expected to take approximately *** for the network to reach the terminal emission inflation rate.
- Inflation-adjusted global staking APR under the recommended parameters significantly outperformed the benchmarks, indicating there is a smaller degree of dilution via inflationary impact from emissions on stakers and non-stakers on *** compared to the PoS networks studied to form the benchmarks.
- Decision to allow locked supply to be staking (excl. treasury and foundation allocation) has a dilution impact on staking APR and it is recommended that the staking rewards in *** for locked staked supply be subject to same vesting schedule as the underlying locked tokens.
- *** burn via the gas paid by user has a near negligible effect as a deflationary force in *** supply and thus will not be able to reduce *** net inflation in a meaningful manner.

3 Model Configuration

3.1 Model Assumptions

3.1.1 System Assumptions

Table 1: Epoch Length Parameter and Rationale

Parameter	Value	Rationale
Timestep length (in days)	1	The use of a daily reference for timesteps in the simulation avoids the loss of information if a higher period was used while, at the same time, after some empirical experimentations, did not lead to significantly higher run time of simulations. Further reasoning for choosing daily timestep was to align the model architecture as much as possible to shape of relevant historical data required (i.e. historical staking rates) for the simulations.

3.1.2 $***$ Assumptions

Table 2: $***$ Token Parameters

Parameter	Value	Rationale
$***$ total supply	$***$	Retrieved from $***$.
$***$ initial locked supply	$***$	Based on unlock schedule determined in collaboration with $***$ team
$***$ supply schedule	Time-series	Based on unlock schedule determined in collaboration with $***$.
Gas paid per transaction (in $***$)	$***$	Feedback given by $***$ team.
Treasury gas share	0%	All transaction fees are burned in order to have deflationary pressure on the token supply
Buyback gas share	100%	All transaction fees are burned in order to have deflationary pressure on the token supply

3.1.3 Stochastic Modelling of Daily Change in Staking Amount (As a Percentage of Circulating Supply)

Technical research was done into historical data of dPoS/PoS blockchains to obtain data regarding the staking rate evolution namely Stacks, Sui, Near, Tron and Solana.

The reference historical data was obtained through the average values of the blockchain's mentioned above.

An Ornstein-Uhlenbeck stochastic model was implemented to allow a higher flexibility and variability in the scenario tested. The Ornstein-Uhlenbeck process is a stochastic model that describes mean-reverting behaviour, often used to model systems that exhibit a tendency to drift towards a long-term mean.

However, using the standard Ornstein-Uhlenbeck process to model a single unique set of statistical properties for the entire period would inevitably lead to loss of accuracy, specifically capturing different means and different volatilities that usually are present in different periods of a protocol's lifetime.

Therefore, a moving average and standard deviation Ornstein-Uhlenbeck process was adopted, which gives a higher degree of accuracy in capturing different periods.

The following are parameters of the stochastic process:

Table 3: $***$ staking rate stochastic modelling parameters

Parameter	**Value**	**Rationale**
θ	1	Theta governs the rate at which the stochastic process reverts to the mean. By experimenting values below 1, it is possible to generating patterns for the staking rate evolution that deviate from the historical evolution.
Mean multiplier	0.5, 1 and 2	The mean multiplier governs the magnitude of daily change in staking amounts relative to the circulating supply. A value of 1 means that the magnitude is the same as the original data. The use of multiplier below and above 1 allows the generation of scenarios with higher and lower staking activity relative to the original case.
Window size (in days)	7	Allows to capture period-specific statistical properties. Additionally, it is standard to measure metrics on a weekly basis.

3.1.4 Staking Assumptions

The following staking assumptions were adopted.

Table 4: Staking Assumptions

Parameter	Value	Rationale
Number of verifiers	20	Obtain through *** team feedback.
Verifier commission percentage	10%	Average of historical data gathered from available sources, namely from blockchains such as Tron, Solana, Near and Sui.
Verifier MEV per transaction (in ***)	0.0003809319101	Average of historical gathered from the two sources (Ethereum and Solana) which have the most available and robust data on MEV yield.
Verifier own capital percentage	Time-series	Original data was derived from the average of historical data from Near, Cardano and Sui. Stochastic generation of a time series based on a probability density function after outlier treatment was used to simulate changes in this quantity over time.
Initial *** unlocked supply	***	Percentage of total supply. Retrieved from Supply Schedule sheet.
Initial *** unlocked staked supply	***	Percentage of unlocked supply that is staked in the beginning. Based on historical data.
Initial *** locked non-stakeable supply	***	Percentage of total supply. Retrieved from Supply Schedule sheet. Treasury and foundation allocation is considered locked and non-stakeable.
*** monthly unlocks	Time-series	Monthly total unlocks expressed as percentage of total supply. Derived from ***.
*** stakeable locked monthly unlocks	Time-series	Monthly unlocks of stakeable locked tokens expressed as percentage of total supply. Derived from ***.

3.2 Parameters to Set

3.2.1 *** Emission Rate Per Year

Annual emission of *** tokens will be distributed uniformly across the year, computed on a daily basis, to be directed to stakers and verifiers.

3.2.2 Annual *** Emission Decay Rate

This will be applied on a yearly basis to reduce the *** emission rate for the next year.

A decay rate for the annual emission rate is proposed to reduce the pressure on the protocol to emit incentives to its stakeholders over time, after it achieves sufficient scale and growth in the initial phase. It also allows the reduction of the inflationary pressure on *** token total supply.

3.2.3 $***$ Terminal Emission Rate Per Year

The terminal emission rate per year represents the projected issuance of rewards at a future point when the network reaches a steady state or long-term, mature equilibrium.

Due to the nature of the terminal rate and given the uncertainties in the accuracy of simulation results as the time scope becomes increasingly higher, the recommendation for this parameter shall be done based on theoretical computations.

3.3 Environmental Variables

3.4 Transaction Count

Historical data regarding daily number of transactions was extracted from multiple sources namely Near, Merlin, Bob, Bitlayer, Sui, Sei, Aptos and Satoshi.

The following scenarios were considered for this variable.

Table 5: Simulation Parameters

Transaction count multiplier	**Scenario description**
0.25	Allows to simulate a scenario with little protocol adoption, therefore less overall fees being generated. Given the nature of $***$ as a state-only execution layer, a low transaction volume scenario is most likely.
1	Historical data.
4	Allows to simulate a scenario with very high protocol adoption, therefore higher overall fees being generated.

3.5 Verifiers' Own Capital Staked Percentage Relative to Total Staked Under Control

Historical data was extracted from available sources, namely for blockchain's such as Near, Cardano and Sui.

The data presents itself with a very skewed distribution tending towards the lower values of own capital percentage (0-10

Therefore, after an outlier cleaning process a new Gaussian probability density distribution was produced.

This allowed an estimation of a stochastic evolution of the verifiers own staked capital percentage throughout the simulation based on the probability density distribution obtained.

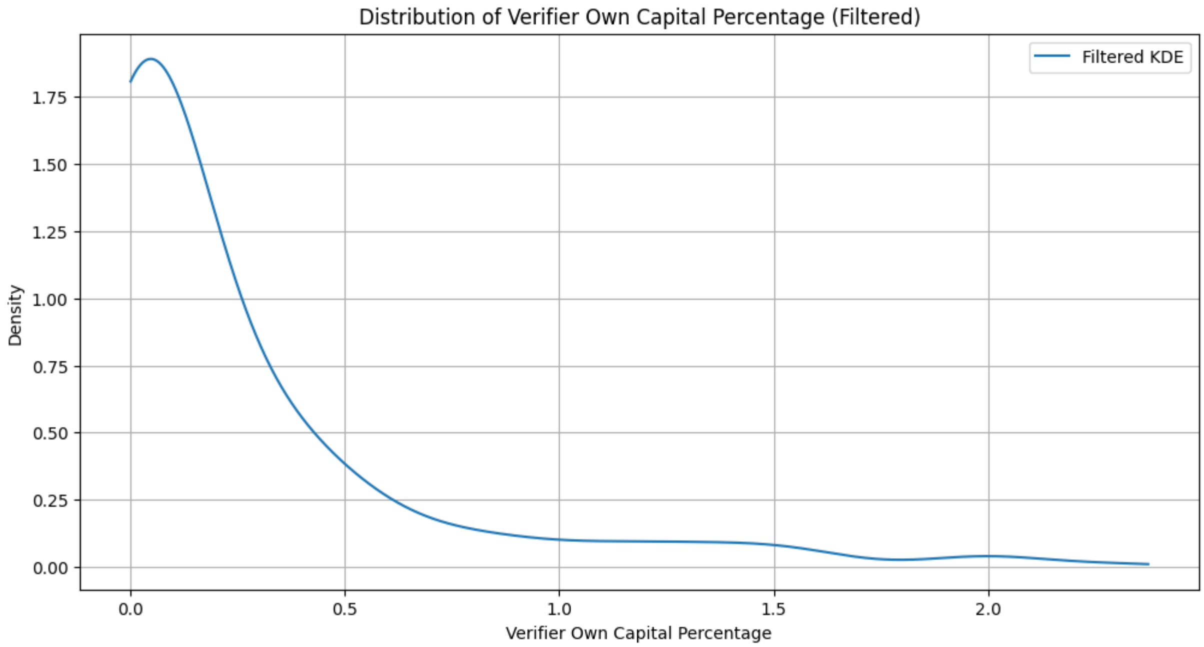


Figure 1: Verifiers' own capital probability density distribution.

3.6 Daily Percentage Change of Staking Amounts Relative to Circulating Supply

The following table presents the variations for mean multiplier of the Ornstein-Uhlenbeck process and the description of the scenario that they represent.

Table 6: Ornstein–Uhlenbeck Mean

Multiplier	Scenario description
0.5	A bearish scenario in which overall staking activity (either in the positive or negative trend) is decreased relative to historical data.
1	Historical data scenario.
2	A bullish scenario in which overall staking activity (either in the positive or negative trend) is increased relative to historical data.

3.7 Simulation Scenarios

The following combinations for the environmental variables were used in the scenarios:

Table 7: Transaction and Staking Activity Scenarios

Description	Transaction count multiplier	Daily percentage change of staking rate mean multiplier	Verifiers' own capital percentage

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Table 7: Transaction and Staking Activity Scenarios (Continued)

Low TX activity and Low staking activity	0.25	0.5	Time-series based on the probability density distribution presented
Low TX activity and Moderate staking activity	0.25	1	Time-series based on the probability density distribution presented
Low TX activity and High staking activity	0.25	2	Time-series based on the probability density distribution presented
Moderate TX activity and Low staking activity	1	0.5	Time-series based on the probability density distribution presented
Moderate TX activity and Moderate staking activity	1	1	Time-series based on the probability density distribution presented
Moderate TX activity and High staking activity	1	2	Time-series based on the probability density distribution presented
High TX activity and Low staking activity	4	0.5	Time-series based on the probability density distribution presented
High TX activity and Moderate staking activity	4	1	Time-series based on the probability density distribution presented
High TX activity and High staking activity	4	2	Time-series based on the probability density distribution presented

3.8 Simulation Configuration

This simulation study uses Monte Carlo simulations to simulate potential future scenarios given a configuration with a stochastic nature, therefore each simulation run result is different from the next.

The results from each simulation are then aggregated together and metrics are computed on the aggregate results, to be compared to the benchmarks.

Table 8: Simulation Parameters

Parameter	**Value**

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Table 8: Simulation Parameters (Continued)

Number of simulation runs per scenario	2,000
Number of timesteps	1,200 (3 years and 3 months)

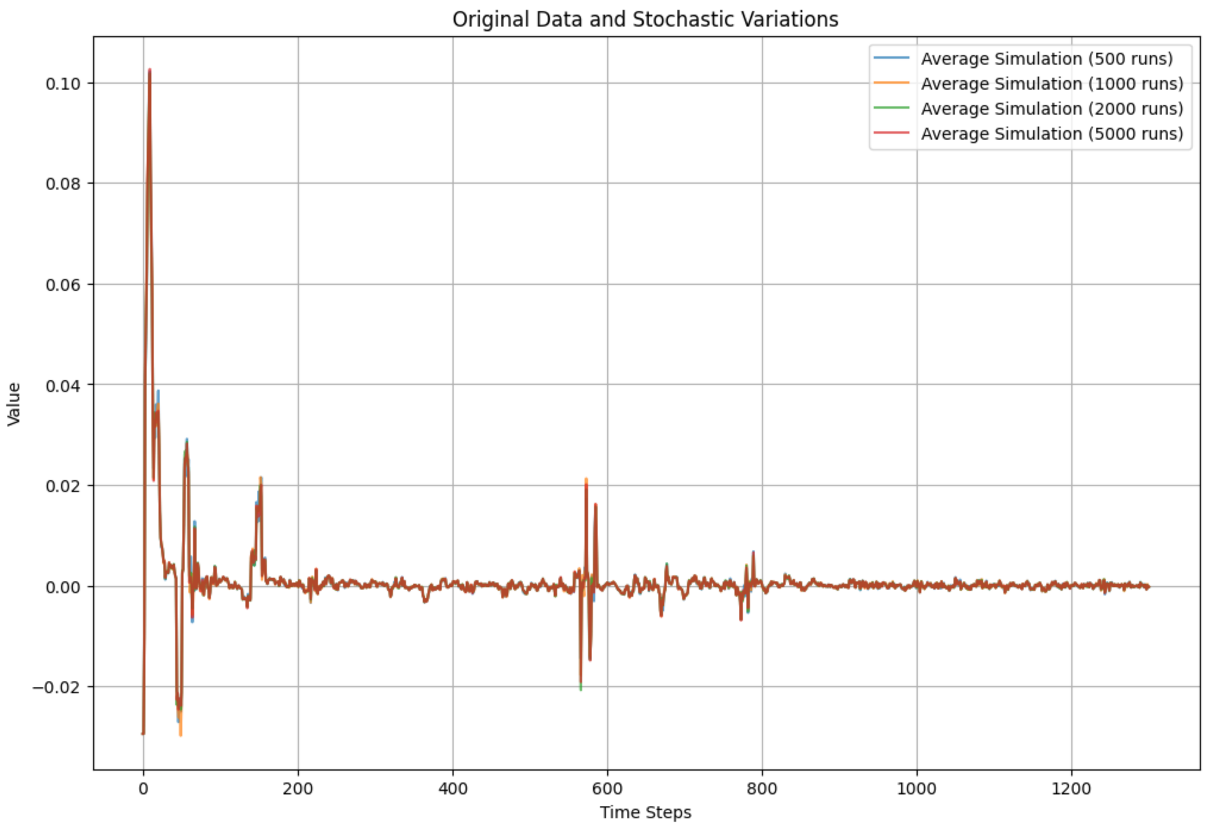

Figure 2: Convergence study.

To achieve a trade-off between sufficient accuracy and computational time, a number of 2000 runs per scenario was chosen. The 2000-run simulation grants a MSE error of around 1e-7 relative to that of a 5000-run simulation.

Each run has 1200 timesteps, each equivalent to 1 day, based on the pre-defined vesting schedule and historical data length.

3.9 Metrics

The following definitions are used:

Emissions to Unlocked * Staked**

$$R_{unlocked} = \text{Total Emissions} \times (1 - \text{Verifier Commission}) \times \frac{\text{Unlocked *** staked}}{\text{Total *** staked}}$$

Emissions to Locked * Staked**

$$R_{locked} = \text{Total Emissions} \times \frac{\text{Locked *** staked}}{\text{Total *** staked}}$$

Emissions to Verifiers

$$R_{verifiers} = \text{Total Emissions} - R_{unlocked} - R_{locked}$$

The primary metrics that are compared to established benchmarks are the following:

3.9.1 Net Inflation Rate

Net inflation rate of the *** token is calculated as the increase in total *** supply due to emissions less *** burns, as a percentage of total supply.

$$\pi_t = \frac{\text{*** emission} - \text{*** burned}}{\text{*** total supply}}$$

3.9.2 Global Staking APR

Global Staking APR represents the average staking APR for both the unlocked and locked *** tokens.

$$APR_{global} = \frac{R_{unlocked} + R_{locked}}{\text{Unlocked *** staked} + \text{Locked *** staked}}$$

3.9.3 Inflation-adjusted APR

Inflation-adjusted APR indicates the APR for staking after accounting for the dilution impact from inflation.

$$APR_{real} = \frac{1 + APR_{global}}{1 + \pi_t} - 1$$

Other metrics are also calculated to examine the state of the network:

3.9.4 Staking APR (Unlocked Tokens)

Unlocked Staking APR represents the staking APR for unlocked (liquid) $***$ tokens.

$$APR_{unlocked} = \frac{R_{unlocked}}{\text{Liquid *** staked}}$$

3.9.5 Staking APR (Locked Tokens)

Locked Staking APR represents the staking APR for locked $***$ tokens.

$$APR_{locked} = \frac{R_{locked}}{\text{Locked *** staked}}$$

3.9.6 Verifier Rewards APR

Verifier Staking APR represents the staking APR for verifiers in the $***$, based on rewards as well as commission earned on delegated stake.

This metric is not specific to any one verifier, but represents an average for the entire verifier network.

$$APR_{verifiers} = \frac{R_{verifiers}}{\text{Verifiers own *** staked}}$$

3.9.7 Verifier MEV APR

Verifier MEV APR represents the MEV APR for verifiers in the $***$, based on MEV earned per transaction.

$$MEV \equiv \text{Verifier MEV revenue} = \text{N}^{\text{o}} \text{ transaction per day} \times \text{MEV per transaction}$$

$$APR_{MEV} = \frac{MEV}{\text{Verifiers own *** staked}}$$

3.9.8 Verifier Total APR

Verifier Total APR represents the holistic APR earned by verifiers on the $***$.

$$V_{total} = V_{rewards} + V_{MEV}$$

3.9.9 Unlocked Staking Ratio

Unlocked staking ratio measures the proportion of unlocked supply that is staked, relative to the total supply.

$$USR = \frac{\text{Unlocked *** staked} + \text{Verifiers own *** staked}}{\text{*** total supply}}$$

3.9.10 Locked Staking Ratio

Locked staking ratio measures the proportion of locked supply that is staked, relative to the total supply.

$$LSR = \frac{\text{Locked *** staked}}{\text{*** total supply}}$$

3.9.11 Global Staking Ratio

Global staking ratio is the sum of Unlocked Staking Ratio and Locked Staking Ratio, representing total staked supply as a percentage of total supply.

$$GSR = USR + LSR$$

3.10 Benchmarks

Benchmarks for metrics were used to evaluate the viability of a given parameter set that resulted in metric values, to guide the overall optimisation process of the simulations.

These benchmarks were based on data extraction and analysis of relevant blockchains, including Solana, Celestia, Sui and Near.

The choice of more established and mature blockchains instead of recently-launched dPoS systems relies on the fact that for the former, a more robust data set is available, allowing for a more precise benchmark to $***$ simulations results.

- Net Inflation Rate: maximum of mean and median was chosen as the strict benchmark requirement and minimum as weak benchmark requirement
- Global staking APR: minimum of mean and median was chosen as the strict benchmark requirement and maximum as weak benchmark requirement.

Satisfaction of strict benchmarks for metrics given a parameter set was prioritized as much as possible during the simulation process, with satisfaction of weak benchmarks as optional.

3.10.1 1-year Benchmarks

Table 9: Strict and Weak Benchmark Requirements for Metrics, 1-year horizon

Metric	Strict benchmark requirement	Weak benchmark requirement
Net Inflation rate	6.60%	6.58%
Global staking APR	8.85%	8.99%

3.10.2 2-year Benchmarks

Table 10: Strict and Weak Benchmark Requirements for Metrics, 2-year horizon.

Metric	Strict benchmark requirement	Weak benchmark requirement
Net Inflation rate	6.03%	5.97%
Global staking APR	7.77%	7.96%

4 Simulation Results

4.1 Summary by Parameter to be Optimised

The process of reaching a recommendation for the initial *** emission rate had, as a first step, the quantification of metrics under the most pessimistic scenarios.

From the set of simulations scenarios, the high staking rate mean multiplier combined with a low transaction count was identified as being the scenario where the lowest staking APR and highest inflation rate would be expected.

Similarly, the low staking rate mean multiplier combined with a high transaction count gives rise to a scenario where it is expected the highest staking APR and the lowest inflation rate.

Thus, the process starts with the testing of these scenarios on different levels of initial emission rate to quickly rule out inflation rate possibilities.

If, for example, in a given level of emission rate, the benchmarks for staking APR are not met and the inflation benchmark is met with a good margin under the low staking rate mean multiplier with a high transaction count, this indicates that, in order to satisfy simultaneously all benchmarks, the next emission rate to be tested should be higher than the current one.

Based on *** staking ratio threshold for security based on stakeable supply, below are the minimum *** tokens required to meet the security requirement for 1-year and 2-year time periods

Table 11: Stakeable Supply of *** Tokens and Security Threshold (51%) over Time

Timeframe	Stakeable Supply of *** Tokens	Security Threshold ***
1-year	***	***
2-year	***	***

Table 12: Analysis of Initial Emission Rate, Inflation, and Staking APR against Benchmarks

Initial emission rate	Inflation	Staking APR
2.5%	Strict and weak benchmarks satisfied in both extreme cases for both 1-year and 2-year metrics.	No benchmark was met under extreme scenario for neither 1-year nor 2-year metrics.
6.25%	Strict and weak benchmarks satisfied in both extreme cases for both 1-year and 2-year metrics.	Strict and weak benchmarks satisfied in both extreme scenarios for 2-year metric. Strict benchmark not satisfied for 1-year metric.
6.5%	Strict and weak benchmarks satisfied in all scenarios for 1-year and 2-year metrics.	Strict and weak benchmarks satisfied in all scenarios for 1-year and 2-year metrics.
10%	No benchmark was met under extreme scenario for neither 1-year nor 2-year metrics.	Strict benchmark satisfied under all analyzed scenarios for both 1-year and 2-year metrics.

4.2 Results

4.2.1 2.5% Emission Rate

Analysis of 1-year metrics

Table 13: Analysis of Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios

Scenario	Inflation (median)	Inflation strict benchmark	Inflation weak benchmark	Global staking APR (median)	Staking APR strict benchmark	Staking APR weak benchmark
Low TX activity and High staking activity	2.49994	Yes	Yes	3.48967	No	No
High TX activity and Low staking activity	2.49905	Yes	Yes	3.961855	No	No

Analysis of 2-year metrics

Table 14: Analysis of Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios

Scenario	**Inflation (median)**	**Inflation strict bench-mark**	**Inflation weak bench-mark**	**Global staking APR (median)**	**Staking APR strict bench-mark**	**Staking APR weak bench-mark**
Low TX activity and High staking activity	2.24998	Yes	Yes	3.601235	No	No
High TX activity and Low staking activity	2.24967	Yes	Yes	4.172	No	No

4.2.2 6.25% Emission Rate

Analysis of 1-year metrics

Table 15: Analysis of Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios

Scenario	**Inflation (median)**	**Inflation strict bench-mark**	**Inflation weak bench-mark**	**Global staking APR (median)**	**Staking APR strict bench-mark**	**Staking APR weak bench-mark**
Low TX activity and High staking activity	6.24887	Yes	Yes	8.839485	No	No
High TX activity and Low staking activity	6.24802	Yes	Yes	10.06844	Yes	Yes

Analysis of 2-year metrics

Table 16: Analysis of Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios

Scenario	**Inflation (median)**	**Inflation strict bench-mark**	**Inflation weak bench-mark**	**Global staking APR (median)**	**Staking APR strict bench-mark**	**Staking APR weak bench-mark**

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Table 16: Analysis of Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios (Continued)

Low TX activity and High staking activity	5.62411	Yes	Yes	9.154505	Yes	Yes
High TX activity and Low staking activity	5.62384	Yes	Yes	10.67008	Yes	Yes

4.2.3 6.5% Emission Rate

Analysis of 1-year metrics

Table 17: Analysis of Net Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios

Scenario	Net Inflation (median)	Net Inflation strict benchmark	Net Inflation weak benchmark	Global staking APR (median)	Staking APR strict benchmark	Staking APR weak benchmark
Low TX activity and Low staking activity	6.49879	Yes	Yes	10.51206	Yes	Yes
Low TX activity and Moderate staking activity	6.49879	Yes	Yes	9.88594	Yes	Yes
Low TX activity and High staking activity	6.49879	Yes	Yes	9.23119	Yes	Yes
Moderate TX activity and Low staking activity	6.49862	Yes	Yes	10.52912	Yes	Yes
Moderate TX activity and Moderate staking activity	6.49862	Yes	Yes	9.98963	Yes	Yes
Moderate TX activity and High staking activity	6.49862	Yes	Yes	9.26536	Yes	Yes

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Table 17: Analysis of Net Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios (Continued)

High TX activity and Low staking activity	6.49793	Yes	Yes	10.51997	Yes	Yes
High TX activity and Moderate staking activity	6.49793	Yes	Yes	9.89011	Yes	Yes
High TX activity and High staking activity	6.49793	Yes	Yes	9.25329	Yes	Yes

Analysis of 2-year metrics

Table 18: Analysis of Net Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios

Scenario	**Net Inflation (median)**	**Net Inflation strict benchmark**	**Net Inflation weak benchmark**	**Global staking APR (median)**	**Staking APR strict benchmark**	**Staking APR weak benchmark**
Low TX activity and Low staking activity	5.84904	Yes	Yes	11.70904	Yes	Yes
Low TX activity and Moderate staking activity	5.84904	Yes	Yes	10.84031	Yes	Yes
Low TX activity and High staking activity	5.84904	Yes	Yes	9.91035	Yes	Yes
Moderate TX activity and Low staking activity	5.84899	Yes	Yes	11.73308	Yes	Yes
Moderate TX activity and Moderate staking activity	5.84899	Yes	Yes	10.87151	Yes	Yes
Moderate TX activity and High staking activity	5.84899	Yes	Yes	9.99930	Yes	Yes

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Table 18: Analysis of Net Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios (Continued)

High TX activity and Low staking activity	5.84877	Yes	Yes	11.77674	Yes	Yes
High TX activity and Moderate staking activity	5.84877	Yes	Yes	10.80762	Yes	Yes
High TX activity and High staking activity	5.84877	Yes	Yes	9.95986	Yes	Yes

4.2.4 10% Emission Rate

Analysis of 1-year metrics

Table 19: Analysis of Net Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios

Scenario	Net Inflation (median)	Net Inflation strict benchmark	Net Inflation weak benchmark	Global staking APR (median)	Staking APR strict benchmark	Staking APR weak benchmark
Low TX activity and High staking activity	9.99721	No	No	14.126495	Yes	Yes
High TX activity and Low staking activity	9.99637	No	No	16.0872	Yes	Yes

Analysis of 2-year metrics

Table 20: Analysis of Net Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios

Scenario	Net Inflation (median)	Net Inflation strict benchmark	Net Inflation weak benchmark	Global staking APR (median)	Staking APR strict benchmark	Staking APR weak benchmark

Continued on next page

Table 20: Analysis of Net Inflation and Staking APR with Strict and Weak Benchmarks under Different Scenarios (Continued)

Low TX activity and High staking activity	8.99776	No	No	14.649715	Yes	Yes
High TX activity and Low staking activity	8.99751	No	No	16.955975	Yes	Yes

4.3 Recommended Parameter Set Complete Results

The table below highlights the ranges of the metric values across all the scenarios that were tested using the recommended parameter values of 6.5% initial emission rate with 10% annual decay rate.

For 1-year results:

Table 21: Median Global Staking, Verifier APR, and Inflation Metrics with Corresponding Ranges

Metric	**Metric Range**
Median global staking ratio	53.58 - 63.58
Median global staking APR	9.23 - 10.52
Median verifier total APR	163.26 - 191.22
Median verifier MEV APR	1.08 - 18.33
Median net inflation	6.5 - 6.5
Median inflation-adjusted global staking APR	2.53 - 4.15

For 2-year results:

Table 22: Median Global Staking, Verifier APR, and Inflation Metrics with Updated Ranges

Metric	**Metric Range**
Median global staking ratio	48.37 - 58.91
Median global staking APR	9.91 - 11.77
Median verifier total APR	160.39 - 191.66
Median verifier MEV APR	1.21 - 20.77
Median net inflation	6.17 - 6.17
Median inflation-adjusted global staking APR	3.07 - 5.03

5 Sensitivity Analysis

- The base scenario for the sensitivity analysis assumes normal conditions for key variables.
- Specifically, it uses a normal staking rate mean multiplier of 1 and a normal transaction count, also set at 1. These parameters provide a baseline for comparing how changes in various factors affect the system's performance.

5.1 Verifier Commission

- Scenario with a 20% commission
  - 91% increase in verifiers' APR in relation to the base case of 10% after 1 year, and 90% increase after 2 years.
  - No impact on inflation.
  - 11.7% decrease in global staking APR after 1 year and a 14.6% decrease after 2 years.
- Scenario with a 5% commission
  - 45.5% decrease in verifiers' APR in relation to the base case of 10% after 1 year, and 44.9% decrease after 2 years.
  - No impact on inflation.
  - 4.4% increase in global staking APR after 1 year and a 5.1% increase after 2 years.
- As verifier commission rates increase, there's a disproportionate effect on APRs:
  - Verifiers' APR increases at a faster rate than the commission increase (91% APR increase for a 100% commission increase from 10% to 20%).
  - Staking APR decreases, but at a slower rate than the commission increase (11.7% APR decrease for a 100% commission increase from 10% to 20%).

Table 23: Impact of Verifier Commission on APR and Inflation

Metric	**5% Commission**	**10% Commission**	**20% Commission**
Verifiers APR - 1 year	93.30	171.36	327.07
Verifiers APR - 2 year	93.26	169.19	321.46
Inflation - 1 year	6.50	6.50	6.50
Inflation - 2 year	6.17	6.17	6.17
Global Staking APR - 1 year	10.43	9.99	8.82
Global Staking APR - 2 year	11.42	10.87	9.28

5.2 Number of Verifiers and Ratio of Delegated Stake to Verifiers' Own Capital

- Increasing the number of verifiers from 20 to 50:
  - Leads to a substantial decrease in verifiers' APR, approximately 55% after both 1 and 2 years.
  - Results in a marginal increase in global staking APR (about 0.5% increase after 1 year, 1.1% after 2 years).

- Doubling verifiers' own capital mean (new time series):
  - Causes a significant reduction in verifiers' APR, roughly 47% for both 20 and 50 verifier scenarios.
  - Shows negligible impact on global staking APR (less than 0.3% change).
- Analysis of combined effects:
  - Increasing both the number of verifiers and their own capital leads to a dramatic reduction in individual verifiers' APR (up to 75% decrease).
  - Despite these substantial changes, the overall staking APR remains relatively stable.
  - This indicates that the system design promotes a more decentralised validation network while maintaining consistent overall staking incentives.

Table 24: Impact of Verifier Number and Own Capital on APR and Staking

No. Verifiers	**Verifiers' Own Capital %**	**Verifiers APR - 1 Year**	**Verifiers APR - 2 Year**	**Staking APR - 1 Year**	**Staking APR - 2 Year**
20	Original time-series	171.36	169.19	9.99	10.87
20	New time-series	90.76	90.57	9.97	10.38
50	Original time-series	76.37	76.45	10.04	10.99
50	New time-series	43.12	43.70	10.01	10.44

5.3 Liquid vs Locked Split for Genesis Airdrop

- Decreasing locked percentage from 100% (base case) to 50% leads to:
  - 5% decrease in global staking APR after 1 year.
  - 9.6% decrease in global staking APR after 2 years.
- Further decreasing locked percentage to 25% results in:
  - 6.4% decrease in global staking APR after 1 year compared to the base case.
  - 11.2% decrease in global staking APR after 2 years compared to the base case.
- A higher locked percentage in the Genesis Airdrop correlates with higher staking APRs, incentivising longer-term commitment from token holders.

Table 25: Impact of Locked Percentage in Genesis Airdrop on Global Staking APR

Locked Percentage (Genesis Airdrop)	**Global Staking APR - 1 Year**	**Global Staking APR - 2 Year**
25%	9.35	9.65
50%	9.49	9.83
100%	9.99	10.87

5.4 MEV and Gas Paid per Transaction

- Doubling MEV per transaction (from 0.00038 to 0.00076):
  - 2.5% increase in verifiers' APR after 1 year.
  - 3% increase in verifiers' APR after 2 years.
  - No impact on inflation rates.
- Increasing gas paid per transaction (from 0.000005 to 0.00005):
  - Negligible impact on verifiers' APR (less than 0.1% change).
  - Slight decrease in inflation rates (0.03% after 1 year, 0.03% after 2 years).
- High transaction count scenario:
  - Amplifies the impact of MEV and gas fees on verifiers' APR.
  - 15% increase in verifiers' APR compared to normal transaction count when combined with doubled MEV.

Table 26: Impact of MEV, Gas Fees, and Transaction Count on APR and Inflation

MEV per Tx	Gas Paid per Tx	Transaction Count Scenario	Verifiers APR - 1 Year	Verifiers APR - 2 Year	Inflation - 1 Year	Inflation - 2 Year
0.00038	0.000005	Normal	171.36	169.19	6.50	5.85
0.00038	0.00001	Normal	170.83	168.77	6.50	5.85
0.00038	0.00005	Normal	171.18	169.32	6.50	5.85
0.00076	0.000005	Normal	175.58	174.31	6.50	5.85
0.00076	0.00005	Normal	175.53	174.16	6.50	5.85
0.00076	0.00005	High	202.00	204.15	6.49	5.85

5.5 Percentage of Initial Unlocked Supply that is Staked

- Scenario with 25% of initial unlocked supply staked:
  - 1.2% increase in global staking APR after 1 year compared to the base case of 50%.
  - 2.3% increase in global staking APR after 2 years compared to the base case.
  - No impact on net inflation rates for both 1- and 2-year periods.
- Scenario with 75% of initial unlocked supply staked:
  - 2.3% decrease in global staking APR after 1 year compared to the base case of 50%.
  - 6.2% decrease in global staking APR after 2 years compared to the base case.
  - No impact on net inflation rates for both 1- and 2-year periods.
- As the percentage of initial unlocked supply that is staked increases:
  - Global staking APR decreases due to rewards being distributed among a larger pool of staked tokens.
  - The effect is more pronounced in the second year compared to the first year.
  - Net inflation rates remain constant.

Table 27: Impact of Initial Unlocked Supply Staked on Global Staking APR and Inflation

Initial Unlocked Supply Staked	Global Staking APR - 1 Year	Global Staking APR - 2 Year	Net Inflation - 1 Year	Net Inflation - 2 Year
25%	10.11	11.12	6.50	5.85
50%	9.99	10.87	6.50	5.85
75%	9.76	10.20	6.50	5.85

5.6 Mean-Reversion Rate of Staking Rate

- No impact on inflation:
  - Inflation rates remain constant across different mean-reversion rates.
- Staking APR in the first year:
  - Shows slight variation between scenarios, with higher mean-reversion rates yielding lower APRs.
- Staking APR in the second year:
  - A clear pattern emerges where staking APR increases with higher mean-reversion rates.
  - 0.86% increase in staking APR from low mean-reversion rate (0.1) to base case (1.0).
- As mean-reversion rates increase:
  - Small impact on short-term (1-year) staking APR, with lower rates yielding slightly higher APRs.
  - Noticeable increase in longer-term (2-year) staking APR.

Table 28: Impact of Mean-Reversion Rate on Staking APR and Inflation

Theta	Inflation - 1 Year	Inflation - 2 Year	Staking APR - 1 Year	Staking APR - 2 Year
0.1	6.50	5.85	10.13	9.53
0.5	6.50	5.85	10.03	10.27
1.0	6.50	5.85	9.99	10.87

6 Stress Testing

6.1 Scenario Set Up

- The intention of stress testing is to observe the system performance under a scenario where not just a single, but multiple environmental variables enter an adverse state.
- A scenario where a high staking ratio is observed leads to an adversarial state for staking APR, leading to lower values for this metric.
- Similarly, a higher percentage of verifiers' own stake capital, a higher number of verifiers, and a higher commission rate lead to a higher issuance of rewards towards verifiers and lower rewards for normal stakers.
- A higher initial unlocked supply that is staked also translates into lower staking APR.
- Regarding the inflation rate, the daily number of transactions and the average gas paid per transaction heavily influence this metric. A lower number of transactions combined with a low gas paid per transaction results in a higher net inflation.
- The recommended 6.25% initial emission rate with a 10% annual decay rate was used in this test.

Table 29: Stress Test Setup Parameters and Their Adjustments

Variable	**Adjustment**
Daily changes in staking rate	Magnitude amplified 2x compared to historical
Transaction count	1/4 historical
Verifiers' own stake capital	Magnitude amplified 2x compared to historical data leading to a mean value around 2x higher
Verifiers' commission rate	2x original value
Number of verifiers	2.5x original value
Gas paid per transaction	25% reduction from original value
Initial unlocked supply staked	50% increase from original value

6.2 Results

Key Takeaways

- **Net Inflation**
  - Even in such a pessimistic environment, the strict benchmarks for this metric are met in both time horizons (1st year and 2nd year).
  - This is expected behaviour because, as concluded previously, the average gas paid per transaction is, in its original value, already very low, thus leading to a very small deflationary impact on net inflation.
- **Global Staking APR**
  - Benchmarks are not met in either 1 or 2-year time horizons.
  - However, for the year 2 results, the global staking APR is close to the strict benchmarks, with an absolute difference of approximately 0.38%.

- This represents a relative difference to the benchmark of 4.3%.

- **Inflation-Adjusted Global Staking APR**
  - Benchmarks are met for both 1-year and 2-year time horizons.

Table 30: Stress Test Results Across Key Metrics

Metric	Net Inflation	Global Staking APR	Inflation-Adjusted Global Staking APR	Median Global Staking Ratio
1 year	6.4988	8.152565	1.554872418	63.765655
2 year	5.84905	8.47356	2.105555135	58.7591

7 Other Insights

7.1 Terminal Emission Rate

To ensure the security of the ∗∗∗, the APR available for staking and validating the network needs to be sufficient for ∗∗∗ token holders to stake and maintain the integrity of the network. The more assets are locked in the network as a stake, the more secure it becomes.

$$I_t = \max(I_0 \times (1 - r)^{(t-1)}, I_T) \text{ for } t \geq 1,\ t \in Z$$

where:

- I_t: emission rate at year t
- I_0: starting emission rate at year t
- I_T: terminal emission rate at year t
- r: annual emission decay rate

Generally, the staking APR at time t, APR_t, (years) is given by:

$$APR_t = \frac{\text{Staking emissions}}{\text{Staking amount}} = \frac{I_t \times S_t}{d_t \times S_t}$$

where:

- I_t: emission rate at time t
- S_t: total supply at time t

Then, terminal emission rate can be calculated according to the formula:

$$I_T = d_T \times APR_T$$

where:

- APR_T: target terminal staking APR
- d_T: target terminal staking ratio

7.1.1 Terminal Staking Ratio

To obtain an estimate for the terminal staking ratio, research into both theoretical and empirical approaches was conducted.

The FROST + ROAST protocols ensure that the lead node can submit only one transaction per block height. If a lead node attempts to submit multiple blocks at the same height, the consensus mechanism and multisig requirement will detect and penalise the action.

The multisig threshold is set at 51%, meaning a block is only added to the chain if 51% of participants sign it. As a result, only one chain can reach the required signature threshold.

The implications of this on stake security mean that a malicious actor would need to control or influence 51% of the active verifiers in order to produce a corrupted block. When all of the tokens are liquid, this means that a malicious actor would need to purchase an amount of $***$ tokens that would enable them to bribe or create enough verifiers to pass that malicious block.

With less than half of the total supply remaining on the market, this becomes increasingly difficult.

Therefore, 51% of total supply has been chosen as the terminal staking ratio target.

7.1.2 Terminal Staking APR

For long-term staking APR, we consider the year-to-date ETH staking APR of 3.64% as an estimate.

In order to satisfy the long-term staking APR of 3.64% for a staking ratio of 51%, the **terminal inflation rate of 1.86%** is viable.

To create some buffer around this, the terminal inflation rate could be **rounded up to 1.9%**.

Based on an initial inflation rate of 6.5%, an annual decay rate of 10%, and a terminal inflation rate of 1.9%, it would take **approximately 13 years** for the system to reach terminal inflation.

The long-term staking ratio of the system may vary around 51% depending on whether the market deems 3.64% as an attractive long-term staking APR. Thus, the equilibrium staking ratio may be lower than 51% if stakers require a higher APR than 3.64% for long-term staking, and vice versa.

7.1.3 Minimum Viable Issuance

For this process, research into Minimum Viable Issuance was conducted to uncover the nuances of the empirical approach to setting terminal inflation rates for a PoS network.

It was established that a good reference for a desirable staking ratio is 25%. To account for uncertainties in the theoretical model, a conservative approach was taken, leading to the choice of a higher terminal issuance rate.

For example, in the case of the most mature smart contract blockchain, Ethereum, the approach to calculate a possible optimised staking ratio was through empirical observations of the maximum amount that a single centralised actor could hold.

- Estimates were around 5 to 10 million ETH.

Given the previous estimate, consensus around a 25% staking ratio was reached as sufficient to reasonably mitigate the risk of a centralised actor compromising the network.

However, given the absence of empirical data for $***$ and the difference in the size of the total staking pool between Ethereum and $***$, it was deemed that adopting the empirical approach to determine the terminal staking ratio and terminal inflation rate was not adequate.

7.2 Inflation-Adjusted Global Staking APR

Given the funding of staking rewards via inflating the total token supply, the simulation process also looked at the global staking APR adjusted for inflation of the total token supply.

The formula for the real staking reward rate at time t, APR_t^*, is as follows:

$$APR_t^* = \frac{1 + APR_t}{1 + \pi_t} - 1$$

where:

- APR_t: nominal global staking APR at time t

Given the benchmarks for staking APR and inflation rate used in the simulation, the implied benchmark for inflation-adjusted global staking APR is as follows:

Table 31: Inflation-Adjusted Global Staking APR Benchmarks Over Time

Period	**Strict Benchmark Requirement**	**Weak Benchmark Requirement**
1-Year	2.11%	2.26%
2-Year	1.70%	1.82%

Based on the recommended initial emission inflation of 6.5% and an annual decay rate of 10%, we can see from the summary table that the implicit benchmarks for inflation-adjusted global staking APR are met under the recommended parameters, even in the worst-case scenarios.

Table 32: Inflation-Adjusted Global Staking APR Over 1 and 2 Years

	Min	**Mean**	**Max**
Inflation-Adjusted Global Staking APR - 1 Year	2.53%	3.26%	4.15%
Inflation-Adjusted Global Staking APR - 2 Year	3.07%	3.95%	5.03%

7.3 Efficacy of Burn Mechanism in Reducing Net Inflation

Simulation results conclude that the burning mechanism has a near-negligible effect as a deflationary force in *** supply and, thus, cannot reduce net inflation in a meaningful manner.

This is primarily explained by the extremely low average gas paid (in ***), which ultimately affects the quantity burned, being orders of magnitude lower than the amount of *** being issued.

Sensitivity analysis results demonstrated that even increasing the average gas paid per transaction by a factor of 10 and using a transaction count factor of 4 relative to historical data does not provide any meaningful impact on inflation metrics (variation of 0.01% compared to the base case).

7.4 Ability to Stake Locked Tokens

The simulations performed recommended allowing locked tokens to be stakeable, with the exception of $***$ allocations to the treasury and foundation.

This has a dilution impact on the staking APR for unlocked tokens in circulation, as the same amount of rewards are now shared across both staked $***$ tokens from unlocked and locked supply.

The rationale for this recommendation is that allowing locked tokens to be stakeable increases the economic security of the network. Due to the opportunity cost, it is expected that the majority of the allowable stakeable locked tokens will be effectively staked.

Furthermore, it is recommended that rewards derived from locked stakes should have the same vesting schedule as their underlying principal, to align the actors with the best interests of the network rather than chasing quick profits.

8 Conclusion

In this simulation report, we have analysed various aspects of the proposed token economics for the $***$.

Our findings suggest that a starting annual emission rate of $***$ is recommended, balancing network security with sustainable inflation. Additionally, we propose an annual emission decay rate of $***$. This more gradual decay rate allows for a smoother transition and better long-term stability of the network's economic model.

Key metrics such as net inflation, global staking APR, and inflation-adjusted global staking APR have been evaluated against strict and weak benchmarks, with generally positive results even under stress-test conditions.

We've recommended allowing locked tokens to be stakeable to enhance network security, while noting that the current burn mechanism has minimal impact on reducing net inflation due to low gas fees. A terminal issuance rate of $***$ has been proposed, aiming for a desirable staking ratio of $***$ to ensure sufficient economic security without excessive dilution.

While these recommendations are based on thorough simulations and analysis, it's important to acknowledge the limitations of our model and the evolving nature of the crypto ecosystem. Continuous monitoring and potential adjustments may be necessary as the network develops and market conditions change.

8.1 Potential Next Steps

- After the launch of $***$, real data gathered from stakers' and verifiers' behaviour can be ingested by the simulation model to project future outcomes based on historical experience for ongoing economic monitoring.
- Given that MEV earned by verifiers is a function of network activity as well as the $***$ token price, introducing more complexity into modelling the MEV component and accounting for fluctuations in data gathered from Ethereum and Solana may provide better estimates for the MEV component in verifiers' APR.
- Should $***$ introduce priority fees, which will flow to verifiers, additional complexity may highlight more nuanced projections of future states, as not only gas costs will become more variable and impact $***$ net inflation, but also alter the level of APR that verifiers receive.

9 Limitations

This section highlights the limitations of the model used for simulations and by extension the recommendations made.

- **MEV Computation**
  - The model uses a simplified approach for the MEV computation, wherein it solely depends on an average MEV per transaction and the number of transactions on the network.
  - This simplification may not capture the full complexity and variability of MEV opportunities in real-world scenarios.
- **Staking Dynamics**
  - The simulation assumes simplified staking behaviors and does not fully capture the complexities of real-world staking decisions.
  - Factors such as market sentiment, competitive staking opportunities in other networks, and varying risk appetites of stakers are not comprehensively modeled, which may lead to discrepancies between simulated and actual staking ratios.
- **Smart Contract Risk**
  - The model does not assume any smart contract risk or any events that occur due to the presence of it, therefore the actual economic metrics from the model may deviate from the simulated results should such cases arise.

10 Disclaimer

This token design documentation is provided by Vending Machine, a token design firm, for informational purposes only. The information contained herein is based on a modeling based systems engineering process and is intended solely for the use of $***$. Vending Machine makes no representation or warranty, express or implied, for the information contained in this documentation.

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Appendices

A Differential Specification for the Underlying ∗∗∗ Network Model

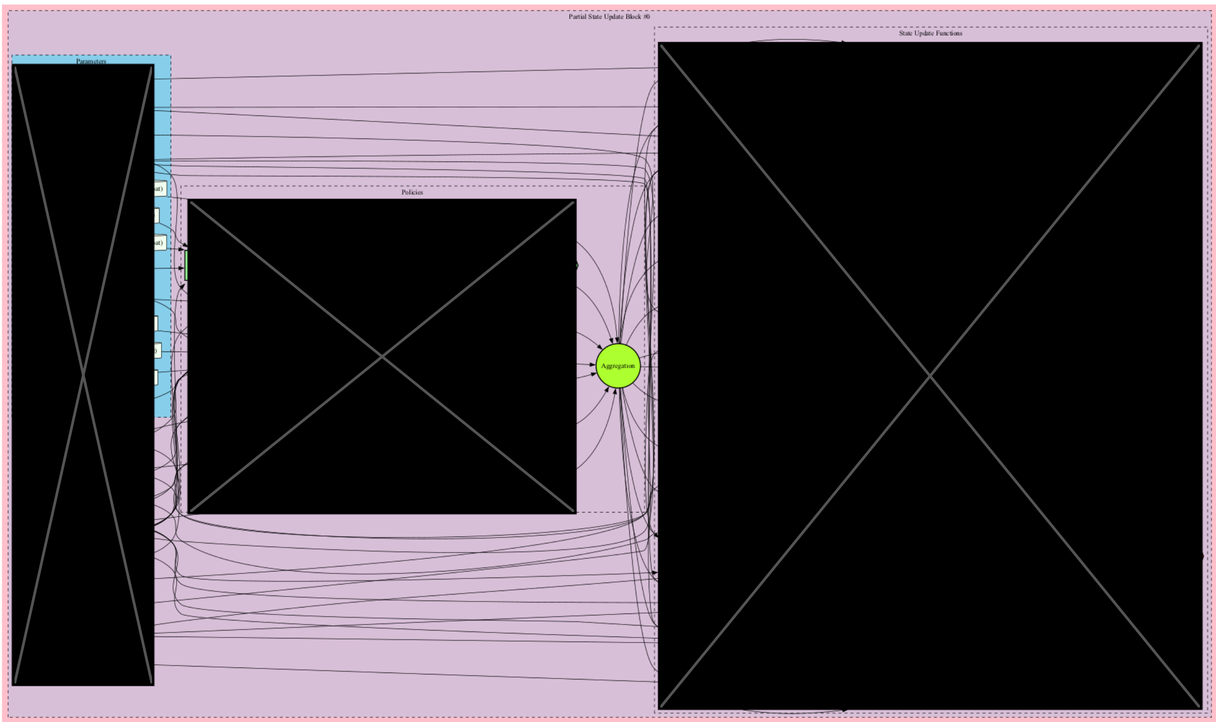


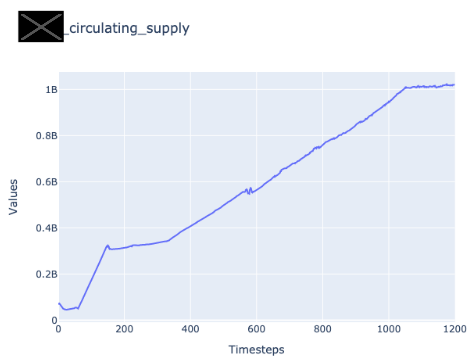
Figure 3: Differential Specification of ∗∗∗ Network model utilised in the simulation process

B Simulation Output Plots For Recommended Parameter Set

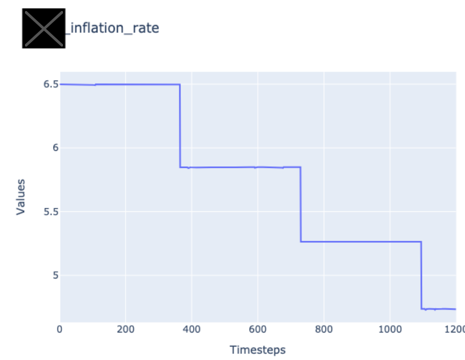
The following clarifications are presented for an appropriate plot interpretation:

- *PoS module ∗∗∗ stake* represents the total unlocked staked amount that is staked by delegators (and not by verifiers).
  - *PoS module ∗∗∗ stake* is not a subset of circulating supply.

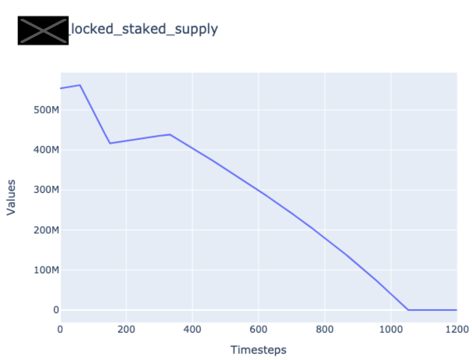
Low Transaction Activity and Low Staking Activity



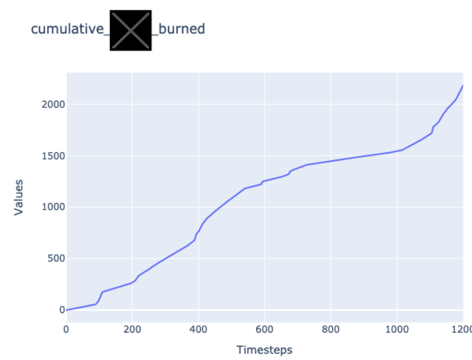
(a) Circulating supply



(b) Net inflation

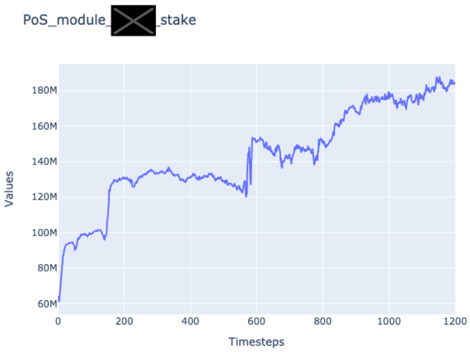


(c) Locked supply that is staked

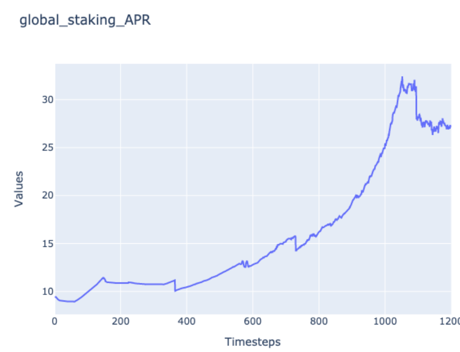


(d) Cumulative *** burned

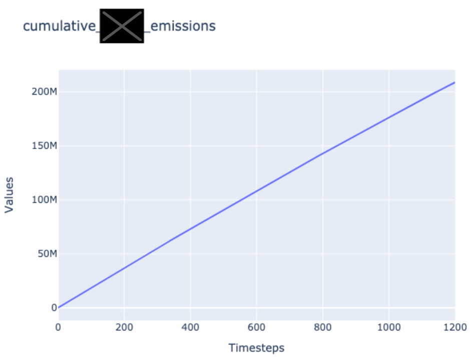
Figure 4: Quantities from simulation output - part I



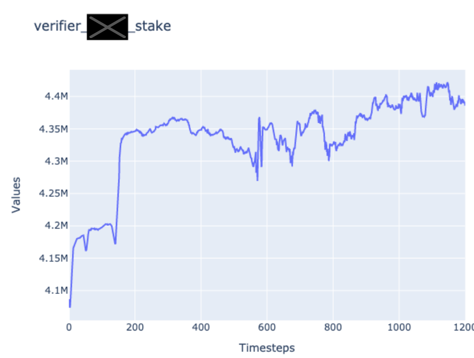
(a) Delegators' stake



(b) Global staking APR



(c) Cumulative total *** emissions



(d) Verifiers' stake

Figure 5: Quantities from simulation output - part II

Figure 6: Cumulative *** emissions to delegators, verifiers and locked staked.

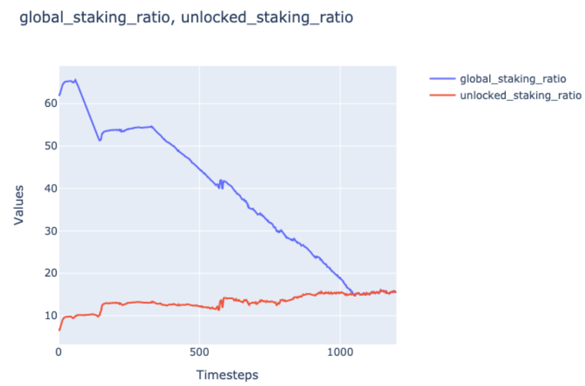


Figure 7: Global staking ratio and unlocked staking ratio

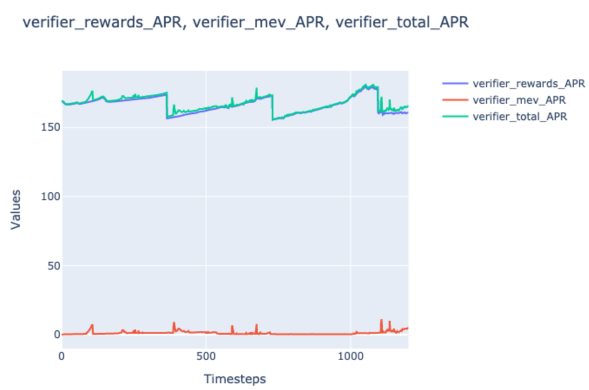
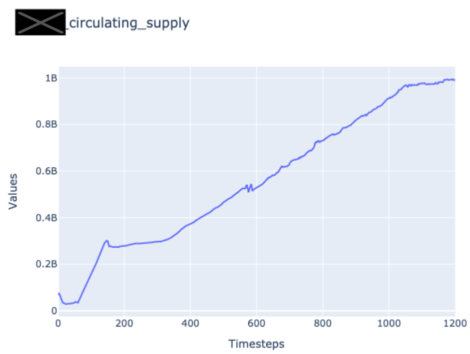
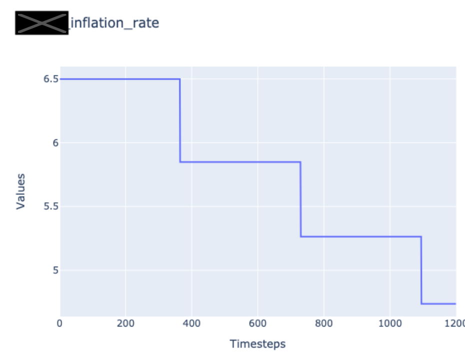


Figure 8: Verifiers APRs

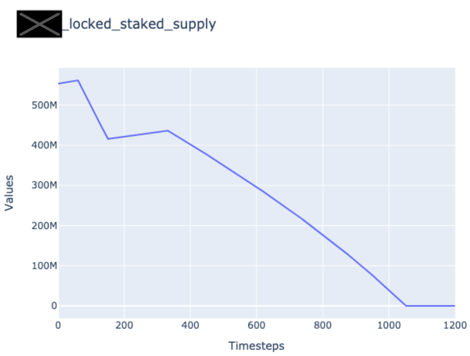
Moderate Transaction Activity and Moderate Staking Activity



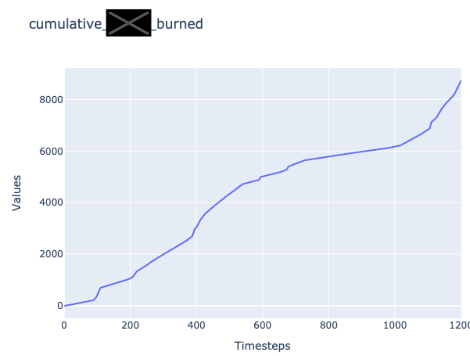
(a) Circulating supply



(b) Net inflation

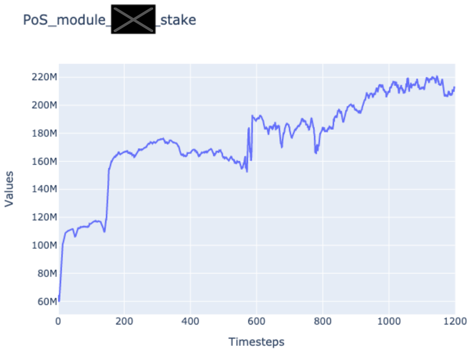


(c) Locked supply that is staked

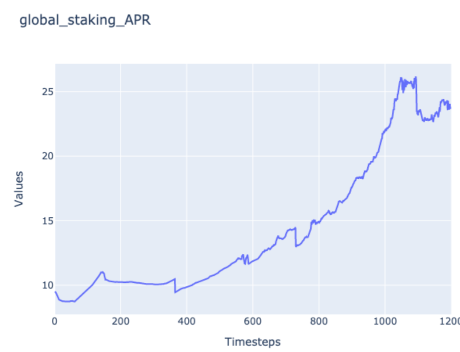


(d) Cumulative *** burned

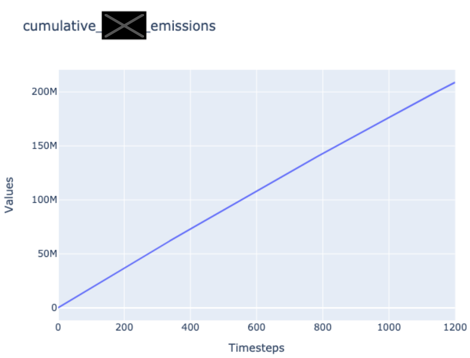
Figure 9: Quantities from simulation output - part I



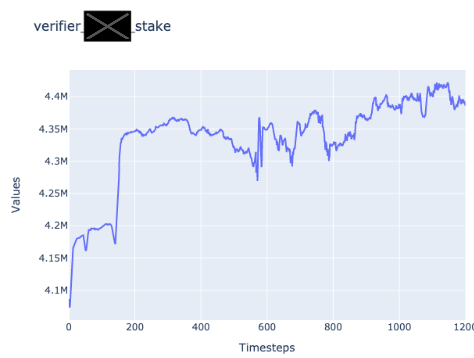
(a) Delegators' stake



(b) Global staking APR



(c) Cumulative total *** emissions



(d) Verifiers' stake

Figure 10: Quantities from simulation output - part II

Figure 11: Cumulative *** emissions to delegators, verifiers and locked staked.

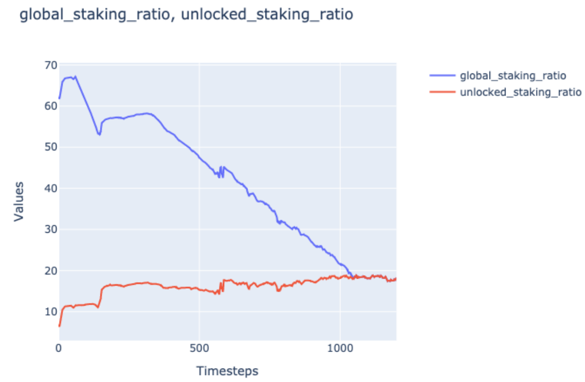


Figure 12: Global staking ratio and unlocked staking ratio

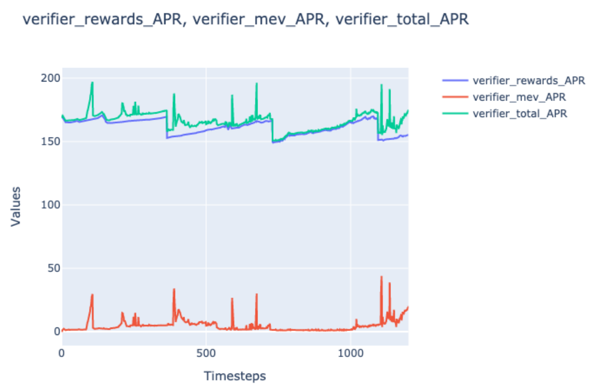
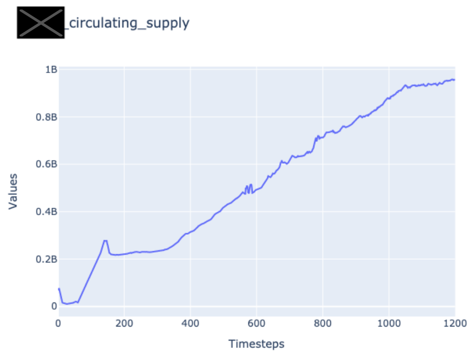
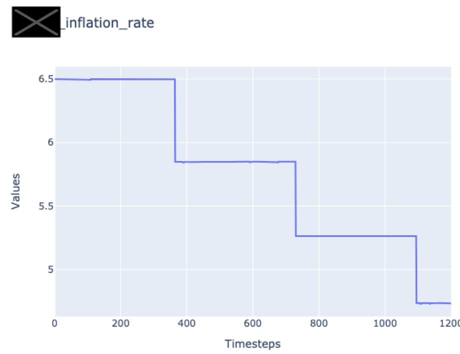


Figure 13: Verifiers APRs

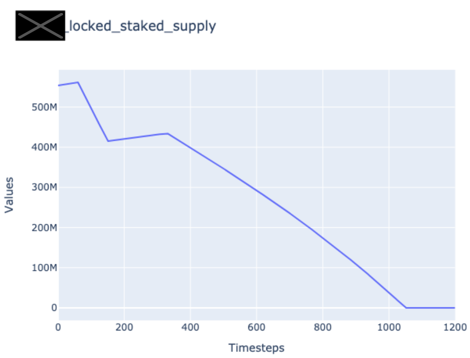
High Transaction Activity and High Staking Activity



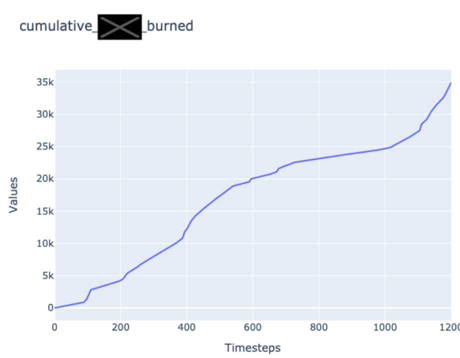
(a) Circulating supply



(b) Net inflation

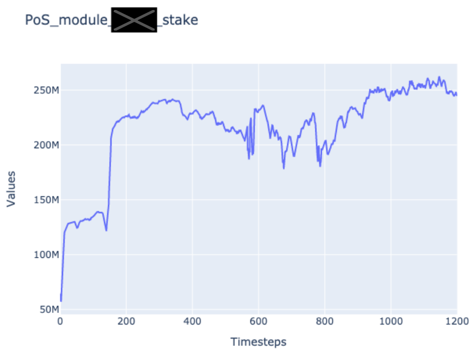


(c) Locked supply that is staked

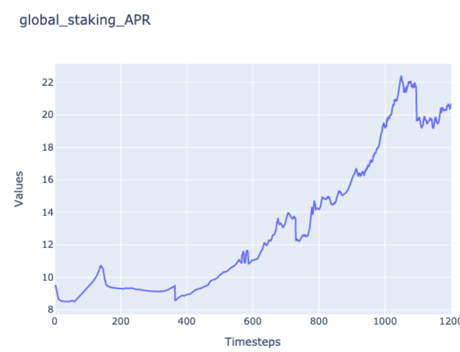


(d) Cumulative ∗∗∗ burned

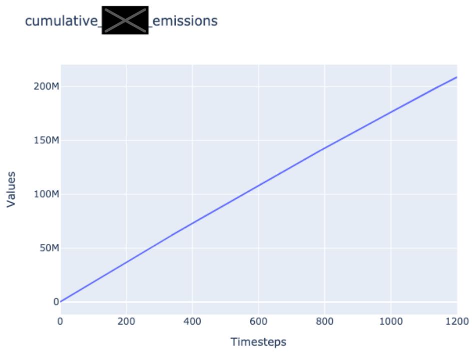
Figure 14: Quantities from simulation output - part I



(a) Delegators' stake



(b) Global staking APR



(c) Cumulative total *** emissions

(d) Verifiers' stake

Figure 15: Quantities from simulation output - part II

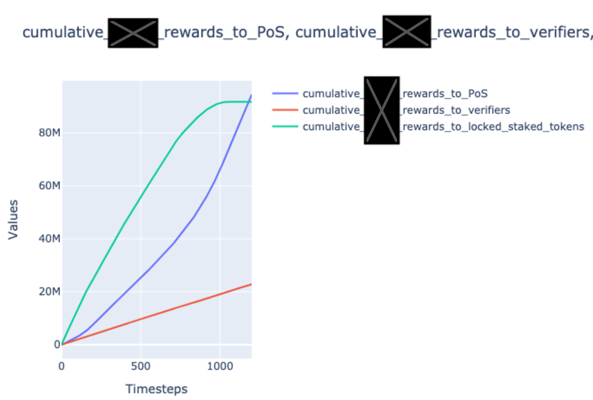


Figure 16: Cumulative *** emissions to delegators, verifiers and locked staked.

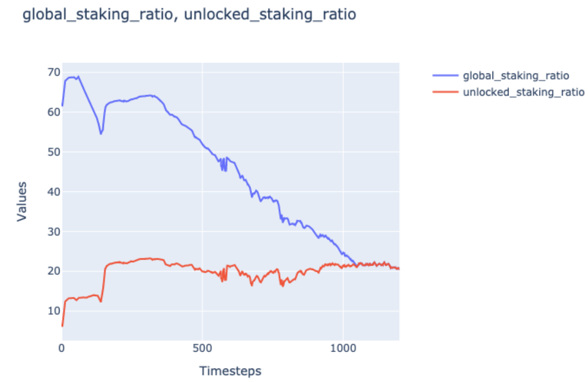


Figure 17: Global staking ratio and unlocked staking ratio

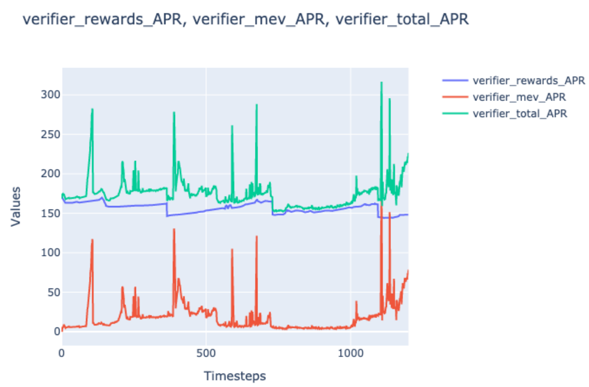


Figure 18: Verifiers APRs