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Strategic validator liquidation in Proof-of-Stake tokenomics explainer

In a Proof-of-Stake (PoS) network, validators are participants or nodes responsible for verifying transactions and ensuring they are added correctly to the chain. They lock in collateral to the network and earn rewards for their valuable role in securing the chain. However, what they do with these rewards creates a feedback loop: selling them can put downward pressure on the token price, which can ripple back through the network's economy.

Treating validator selling as a fixed input can miss how incentives differ across market conditions. This study instead examines liquidation as a strategic choice whose payoff depends on the behavior of other validators. Validators don't sell at a constant rate regardless of conditions. How much they liquidate should be treated as a strategy, one that shifts depending on the market and the protocol's own settings.

Modeling the feedback loop

This research builds a simulation of a token economy. Everything moves together, epoch by epoch: user demand, perceived security, validator participation, staked tokens, committee selection, rewards, liquidation, and token price. The simulation captures how these elements interact and influence one another from one epoch to the next. Market scenarios specify how the underlying value of using the network evolves, while token prices emerge from user buying pressure and validator selling.

Validators could choose any liquidation rate between zero and 100%, but testing every option isn't practical. So the team narrowed it down to three approaches: low, medium, and high liquidation. They then used empirical game-theoretic analysis, coupled with an algorithm called Alpha-Rank, to identify which liquidation approaches would be more stable under strategic behavior for different market and protocol conditions. This technique helps predict how validators adapt over time.

Testing across markets and protocol settings

The team tested this setup across 81 scenarios. Three market conditions (bear, sideways, and bull) were combined with a range of protocol settings. These settings included how rewards are split, how fast new tokens are issued, and how much fee revenue the reserve retains.

Here is what they found

Market conditions call the shots, mattering more than protocol settings in deciding which liquidation approach wins. Bear and sideways markets settle into high liquidation. Bull markets settle into medium liquidation.

Participation and price follow the market. Across the one-year simulations, average validator participation is around 69% in bear scenarios, 77% in sideways scenarios, and 86% in bull scenarios. Median final token prices are roughly 60% below the initial price in bear scenarios, remain close to the initial price in sideways scenarios, and more than double in bull scenarios.

High security doesn't mean a healthy network. Even in bear scenarios, the model's stake-based security indicator stays close to its maximum. But the researchers also tracked fragility, a combined measure of price, participation, and security, and by that measure every bear scenario is fragile despite the high security reading. The weak point isn't security. It's the loop between price, demand, and participation. High staking levels alone don't guarantee a healthy network.

Why this research matters

The findings suggest that protocol designers should assess reward and issuance policies across different market conditions. Within the tested parameter range, these settings did not change the dominant liquidation category. However, token issuance influenced how many tokens users acquired, while reward allocation influenced the model’s stake-based security indicator. The study also shows why stake-based security should be considered alongside prices, user demand and validator participation when assessing economic health.

Learn more

For a deeper dive into the tokenomics behind validator liquidation, read the 'Strategic Validator Liquidation in Proof-of-Stake Tokenomics' paper by Lingxiao Zhao, Madalina Sas, and Carmine Ventre.