EOS

Stake-Based Voting and Rewards Mechanism White Paper

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block.one

PRYSM GROUP
BLOCKCHAIN ECONOMICS & GOVERNANCE

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All quantitative results regarding future outcomes are intended as illustrative examples only and should not be interpreted as forecasts.

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I. Foreword by Block.one

A number of stakeholders and interested parties have conducted research into alternative mechanisms for distributing inflation on EOSIO-based blockchains. One mechanism that has been proposed is to allocate a portion of inflation as rewards to token-holders in exchange for staking their tokens. This paper contains an analysis by Prysm Group, a leading consulting firm specialized in the economics and governance of blockchain and digital assets, of a particular mechanism, for consideration by the EOS and EOSIO communities, by which inflation could be directed towards staking rewards. Prysm Group's findings, based on an empirical review of the EOS Public Blockchain, include potential ranges on the values of mechanism parameters as well as possible economic outcomes in the context of that network.

II. Executive Summary

Prysm Group was retained by Block.one to provide guidelines for certain economic parameters to be implemented in the event that the EOS Public Blockchain[1] chooses to migrate to the stake-based voting and rewards mechanism whose code has been released on the EOSIO Github.[2] In particular, Prysm Group was tasked with conducting economic modeling and empirical analysis to provide ranges for levels of overall inflation, distribution of inflationary benefits, and limitations on withdrawal consistent with that mechanism.[3]

[1] The analysis and recommended guidelines contained in this document pertain only to the EOS Public Blockchain, and not to any other networks that make use of the EOSIO software. Unless otherwise indicated, all references to the "EOS" community or network should be read as referring only to the EOS Public Blockchain. As discussed in Sections IV and V, appropriate ranges for inflation and distribution of inflationary tokens are contingent upon expectations for a range of economic values, including, for instance, the growth rate of economic activity. These expectations could vary widely from network to network. Because this paper only considers data from the EOS Public Blockchain, its analysis and suggested guidelines should not be assumed to apply across other EOSIO-based networks. Other EOSIO-based networks considering adoption of the stake-based voting and rewards mechanism are encouraged to undertake a separate analysis to arrive at appropriate parameter values.

[2] The EOSIO github page can be found at https://github.com/EOSIO/eosio.system/blob/main/contracts/eosio.system/src/staking_pool.cpp.

[3] Prysm Group was not retained for the purposes of designing or defining objectives for this staking mechanism. Instead, Prysm Group provided the analytical services described above within the context of the stake-based voting and rewards mechanism. Prysm Group was not provided, and did not review, the above-mentioned code prior to the completion of this analysis. All descriptions contained herein of the mechanism's parameters, design, and functionality reflect Prysm Group's best understanding based upon materials provided by Block.one, as well as our discussions with the Block.one team. Analysis of the technical feasibility, security implications, and overall costs and benefits to the EOS community of migrating to this mechanism is beyond the scope of this analysis, and nothing written here should be interpreted as evaluative of the overall merits of adopting the mechanism. EOS community members are encouraged to consult the above-referenced Github for a complete description of the mechanism's design and functionality.

On the basis of the analysis set forth below, and in the context of the design framework reflected in Section III, Prysm Group provides the following parameter range guidelines for consideration by the EOS community:[4]

- **Overall system inflation rate**: 1.2% to 3.8% annually.
- **Block Producer share of inflation**: At least 32% of total inflationary rewards, depending on rate of overall inflation, based on the above overall inflation range. Specifically, this share should represent 1.2% of EOS total supply annually. Both producing and standby Block Producers will share in these tokens.
- **Staker share of inflation**: At most 68% of total inflationary rewards, depending on rate of overall inflation, based on the above overall inflation range.
- **Withdrawal limitations**: To the extent the EOS community deems limitations on withdrawal beneficial, a withdrawal cadence of once every 7 days, with a per-withdrawal limit of 67% of staked funds; otherwise, a withdrawal cadence of once per day, with no per-withdrawal limit.

This paper proceeds as follows: first, we provide an overview of the EOS network's current staking architecture, and outline the key features of the alternative mechanism we have been asked to parameterize. Next, we turn to the analysis underlying our parameter range guidelines for levels of overall inflation, distribution of inflationary benefits, and withdrawal limits and cadence. Finally, we estimate the expected outcomes of the staking mechanism, and compare our parameter ranges with those applied by certain analogous blockchain networks. Further methodological details are provided in the *Appendix* section.

III. Background on EOS Delegation and Summary of Stake-based Voting and Rewards Mechanism

This paper assumes some familiarity with the existing operations of the EOS network, including the EOSIO software the EOS community has chosen to deploy. We provide below a brief overview of current delegation mechanics and benefits. Further details about EOSIO can be found at https://developers.eos.io/. This paper also assumes familiarity with basic blockchain concepts such as consensus mechanisms, system native tokens, and incentivization schemes, as well as governance and allocation of system resources in the context of permissionless, decentralized blockchains. The delegated-proof-of-stake mechanism and other aspects of EOSIO-based blockchains are set forth in the white paper available through the same link.

Currently, both voting rights and access to CPU and NET resources on the network are obtained by delegating EOS tokens—a mechanism similar to staking tokens. Tokens may be delegated by an account to itself, or by one account to another account. A given account's entitlement to

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[4] For a description of the function of each parameter within the stake-based voting and rewards mechanism, as well an analysis of the trade-offs and other considerations associated with each parameter range guideline, please consult the associated sections and *Appendix* of this document.

network CPU and/or NET resources at any time—which the account can use to conduct transactions—is dictated by the quantity of tokens delegated to that account, relative to the overall quantity of tokens delegated for that resource across all network accounts[5].

Delegation of tokens also entitles the delegating account to vote for up to 30 Block Producers (BPs), or else to proxy their voting power to another account. Lending tokens on the REX market similarly provides voting rights. Votes determine which BPs are scheduled to produce blocks, and therefore are a critical component of the delegated-proof-of-stake consensus mechanism that secures an EOS blockchain.

Currently, accounts that delegate tokens receive no rewards or remuneration from the network for this activity;[6] instead they receive the dual benefits of access to resources (for the account of their choosing) and voting. At the same time, delegated tokens can be withdrawn at any time and are returned as balances to the delegating account after three days.

As relevant to our analysis and suggested parameter guidelines, we understand that the stake-based voting and rewards mechanism detailed in the above-referenced Github code differs from the current token delegation mechanism in the following key ways:[7]

- Staking via this mechanism will not entitle accounts to network CPU and/or NET resources. Rather, access to network resources will be governed separately by whichever resource management system is in effect at the time.[8]
- Staking EOS tokens in this mechanism will entitle relevant accounts to vote for BPs, fully replacing (after an initial transition period) the current system by which users obtain voting power via delegation and REX.
- Rather than allowing full withdrawal with a 3-day delay, the staking mechanism limits both the frequency with which users can withdraw stake, as well as the proportion of staked funds that users can withdraw in any given period. Specifically, the amount of time that users must wait in between withdrawals is governed by the 'claim_period' parameter, which is measured in seconds;[9] and the maximum proportion of staked funds

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[5] At the time of writing, the EOS PowerUp Model had not been implemented. Please find more information at https://eos.io/news/eos-powerup-model-explained/.

[6] Further, there is no integrated mechanism by which the owner of account A who delegates tokens to account B receives rental payments from the owner of account B, though privately agreed and separately executed payments of this nature may occur. In contrast, lending tokens on REX entitles the lending account to a reward in the form of additional EOS tokens.

[7] Certain other key features of the stake-based voting and rewards mechanism that may be of interest to network participants are outlined in the *Appendix*. For a complete description of the mechanism, network participants should consult the above-mentioned Github page.

[8] For example, if the stake-based voting and rewards mechanism were to be implemented in April 2021, resources would continue to be allocated via the current delegation mechanism pending adoption by the EOS community of any new resource management system.

[9] For convenience, we treat the claim_period parameter as measured in days for the remainder of this report. We understand that 1 day (86,400 seconds) serves as a minimum value for this parameter for system implementation-related reasons.

that users can withdraw in any claim_period is given by the ratio between the 'claim_period' parameter and a variable labeled 'duration' (this ratio is referred to throughout this document as the 'withdrawal_limit'). Thus, during every claim_period, users may withdraw a proportion of their staked funds that does not exceed the withdrawal_limit.

- Finally, unlike the current delegation mechanism, the staking mechanism provides rewards to stakers. Every consensus round (252 blocks, or 126 seconds), inflationary tokens would be created by the system contract and awarded via this mechanism (the annualized rate of inflation is referred to as 'inflation_rate' throughout this document). Of those tokens, a proportion, 'voter_rate', would be awarded by the system contract collectively to the accounts that have staked tokens at that time, with each account receiving an amount of reward tokens proportional to the amount that account has staked relative to the total amount staked by all accounts.[10] Staker rewards are received as staked tokens, to which the withdrawal restrictions apply. The remaining proportion of inflationary tokens, 'prod_rate', would be awarded by the system contract to BPs, as described further below.

Under the existing EOS mechanisms, all inflationary tokens—currently 1% annually—are awarded by the system contract to BPs (both producing and standby) for their services of processing transactions and maintaining the EOS Public Blockchain. Of these tokens, 75% are awarded across both producing BPs (those in the top-21 in terms of votes received) and stand-by BPs (those outside the top-21 in terms of votes received), with each BP receiving an amount proportional to the vote share received by that BP. The remaining 25% are given as block rewards to producing BPs in proportion to the number of blocks they produce.

The proposed stake-based voting and rewards mechanism similarly would provide BPs (both producing and standby) with inflationary token rewards. All inflationary tokens not awarded to stakers would be earmarked for distribution to BPs by the system contract ($prod\_rate * inflation\_rate = (1 - voter\_rate) * inflation\_rate$). However, this mechanism would eliminate block rewards, instead distributing these collective rewards in proportion to the vote share of each BP.

The next three sections provide suggested guidelines for setting the inflation_rate, prod_rate, voter_rate, claim_period, and withdrawal_limit parameters discussed above.

IV. Inflation Level Analysis and Suggested Parameter Guidelines

EOS currently undergoes 1% inflation per year, which as discussed in the previous section is channeled by the system contract as rewards to producing and standby BPs. We analyze below the system-wide inflationary ranges we expect the EOS token would be able to sustain should the

[10] See *Appendix* for further details regarding the implementation of this mechanism.

network opt to expand inflationary rewards to accommodate rewards for stakers as well as BPs. As discussed further below, while rates of economic activity growth serve as inputs in this analysis, we do not express a view as to the likely future growth path of economic activity on the EOS network; rather, this analysis assumes, for illustrative purposes, that estimated historical network growth rates persist into the future. While growth rates under alternative scenarios are not explicitly considered here, similar analytical principles to those we describe would apply in the event, for instance, network participants believe that growth will accelerate considerably going forward.

The EOS token plays several key roles on the network. First, it is directed to BPs as inflationary rewards for their work producing blocks, updating the software, and scrutinizing activity on the network to monitor for attacks. Second, as described above it is the means by which network resources such as CPU and NET are allocated. Third, as relevant to this section, it acts as a medium of exchange, facilitating various types of transactions among participants on the network.

The monetary dynamics for any medium of exchange should ensure that market participants recognize it as a reliable and relatively stable means by which to engage in transactions. It is essential, for example, that inflation for a network's medium of exchange not be too high; otherwise, participants may refuse to accept it as a means of reward or payment.

In general, the fundamental economic value of any medium-of-exchange token is a function of the total economic activity it provisions, its circulating supply, and its velocity (e.g., the frequency with which a token is "spent", on average).[11] All else equal, an increase in economic activity increases a token's fundamental value, while an increase in circulating supply (e.g., through inflation) tends to diminish value. Whenever the growth rate of the number of tokens in the circulating supply (as a result of inflation) exceeds the rate of growth in economic activity, the token's fundamental economic value will be diminished. Thus, in order to maintain a stable fundamental token value, the rate of growth in the circulating supply of tokens must roughly track the rate of growth in economic activity.[12]

In order to estimate an upper bound on the EOS inflation rate, Prysm Group considered a range of economic activity growth scenarios from 2.4% to 5%. The upper bound on this range of scenarios reflects our analysis of the historical levels of economic activity on the EOS Public Blockchain implied by historical EOS token prices in the overall independent marketplace relative to the corresponding historical circulating supply of EOS tokens. While the implied

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[11] See Catalini, Christian & Joshua S. Gans. 2018. "Initial Coin Offerings and the Value of Crypto Tokens." MIT Sloan Research Paper No. 5347-18; and Athey, Susan, Ivo Parashkevov, Vishnu Sarukkai & Jing Xia. 2016. "Bitcoin Pricing, Adoption, and Usage: Theory and Evidence." Working Paper.

[12] As discussed in the *Appendix*, the circulating supply can grow for multiple reasons, including the release of newly minted tokens from inflation, stakeholder vesting, the release of tokens held by Block.one, and the unstaking of tokens that were previously delegated or staked. Therefore the bound on total token supply inflation may be lower than that on the growth of circulating supply.

historical annualized growth rate of economic activity has varied greatly, which is typical of rapidly developing economic systems, our analysis suggests that, should historical rates persist, 5% serves as a reasonable benchmark for the expected growth rate of economic activity going forward.[13] The lower bound on this range of scenarios, in turn, is in line with historical long-run GDP growth rates of developed countries. See the *Appendix* section for further discussion.

As with any economic system, historical rates of growth may be disrupted by a range of unpredictable factors, causing growth to either decelerate or accelerate. This is particularly so for rapidly developing blockchain networks such as EOS, whose full range of potential use cases continue to be explored. The addition of novel features or use cases for the EOS network, or increased interest in existing use cases, would likely have the effect of accelerating economic activity growth (just as a perceived decline in the value of existing features and use cases may cause it to decelerate). Given the considerable difficulties involved in forecasting growth rates for novel economic systems such as EOS, and because historical comparables for such systems are relatively scarce, we confine the range considered here to rates consistent with those observed over the network's relatively brief operation to date.

Based on this range of economic activity growth scenarios of 2.4% to 5%, we recommend that the stake-based voting and rewards mechanism initial parameters be set so that system inflation falls within the range of 1.2% and 3.8% per year.[14]

As discussed, there is inherent uncertainty regarding future economic activity growth. This directly implies that the inflation rate may need to be adjusted over time. For example, if the realized future growth rate in economic activity is in the range of 2.4% for an extended period, then an initial total token inflation rate of 3.5% may be adjusted downwards accordingly, in order to avoid significant risk to the EOS token's functioning as an effective medium of exchange. Similarly, should growth accelerate considerably from the level used to determine the implemented rate of inflation, an adjustment upward may be deemed desirable.

Inflation rates in this guideline range fall in line with those applied by a number of other blockchain networks that incorporate staking mechanisms, as described in Section VII below.[15] We believe it is reasonable to expect that, in the near term, these rates will not cause an increase in circulating token supply that differs sufficiently from the growth rate in economic activity so as to have a detrimental impact on the use of the EOS token as an effective medium of exchange.

V. Inflation Allocation Analysis and Suggested Parameter Guidelines

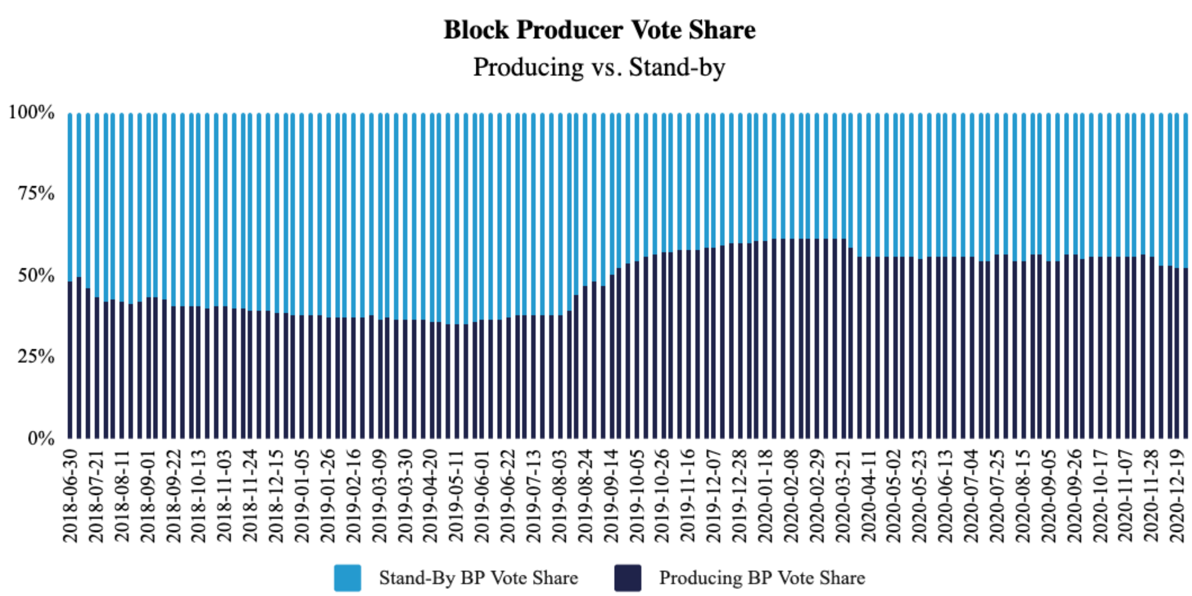
Block Producers are critical to the functioning of the EOS network. They are responsible for validating transactions, producing new blocks, and authorizing system contract upgrades. In

[13] Further details regarding the methodology underlying this analysis are presented in the *Appendix*.
[14] Further details regarding the methodology underlying this analysis are presented in the *Appendix*.
[15] Source: StakingRewards.

addition, many BPs are intimately involved in network development and growth, providing data feeds, proposal analyses, and other community services.

The costs faced by BPs derive from both their direct hosting and processing services as well as project development and marketing. These costs are considerably higher for producing BPs (i.e., those in the top-21 in terms of votes received) than for stand-by BPs (i.e., those outside the top-21). For instance, in an informal survey conducted in late-2018 of 9 producing BPs (at the time of the survey) and 18 stand-by BPs, producing BPs reported average annual operating expenses of roughly $1,046,428, while stand-by BPs reported average annual operating costs of roughly $377,000.[16] While these numbers are difficult to verify with precision, it is clear that the cost of serving as a BP is far from negligible, and producing BPs incur steeper costs than stand-by BPs.

As reward for their network contributions, BPs collectively currently receive 1% inflation per year. Of this amount, 25% (the "Block Reward") is channeled to producing Block Producers, who are responsible for validating new blocks, while the remaining 75% (the "Vote Reward") is distributed across all BPs in proportion to their respective vote-shares. The graph below depicts the distribution of vote share between producing BPs and stand-by BPs as of the end of each month between June 30, 2018 and the end of 2020:[17]



[16] altShiftDev. "Are EOS Block Producers Really as Well Off As We Think in the Current Crypto Market?" Dec. 4, 2018. Available at https://medium.com/coinmonks/survey-of-eos-block-producers-cf9677561db7. As noted in the survey, the average producing BP operating cost figure above omits a single anomalous response of $80,000.
[17] Data collected via dfuse.io.

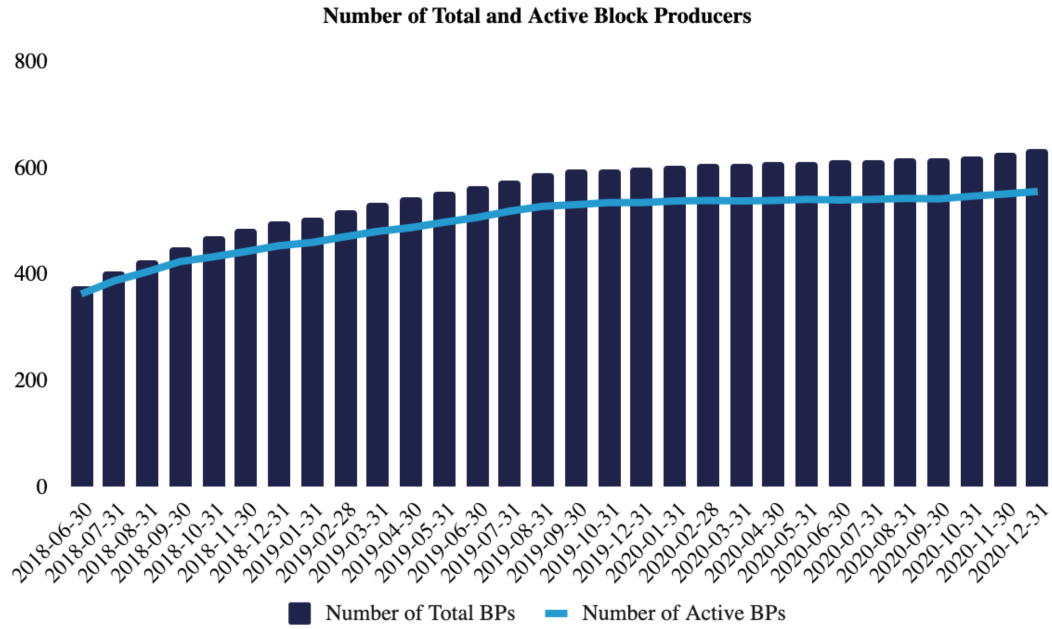
Over the 12 months beginning July 1, 2018, producing BPs received a monthly average of 39.9% of the total network vote share. Given prevailing $/EOS exchange rates over that period, we estimate that a typical producing BP that retained its producing status throughout that period would have earned rewards of approximately $1,274,071. Assuming the annual expenses described above, these rewards would have translated to a profit margin of 17.9%.[18]

Since this period, the total vote share dedicated to producing BPs has grown, reaching a stable average of approximately 55% between May 1, 2020 and December 31, 2020. However, real rewards to producing BPs have declined, largely driven by the decline in the market price of the EOS token. A typical producing BP that retained its producing status throughout 2020 would have earned estimated annual rewards of $954,239. In order for producing BPs to have continued to operate profitably, it is likely that producing BPs reduced costs during this time.

Under the stake-based voting and rewards mechanism we have been asked to analyze, all Block Producers would be compensated only through Vote Rewards - i.e., producing BPs would not receive compensation in excess of the overall proportion of the vote they receive. Thus, in order to maintain current levels of profitability, producing BPs would need to either increase their vote share by more than 10%, reduce costs, or a combination of both. Moreover, as described in Section IV, any increase in the rate of inflation, assuming constant growth in economic activity and a stable token velocity, will likely have the effect of slowing the growth of, and potentially eroding, the fundamental economic value of the EOS token as an incentive reward and medium of exchange. To the extent inflation tokens above the current 1% rate are issued under the mechanism and distributed only to stakers, this will further diminish the real returns to producing Block Producers at any given vote share.[19]

In addition to the expense figures outlined above, a review of historical numbers of BPs joining the network provides insight into the size of BP rewards required to maintain a robust set of BPs available to service the network. The chart below depicts the number of active (i.e., registered) Block Producers as of the end of each month between June 30, 2018 and December 31, 2021, as well as the cumulative number of Block Producers registered up to each point (whether they were registered in that month or not):[20]

[18] We have excluded rebates paid by block producers to token holders (for which there is no integrated mechanism) when calculating profit margins and profitability. The presence of rebates would decrease profit margins from the levels calculated here.
[19] It is possible that, to the extent certain Block Producers also stake tokens, their cumulative rewards will increase under the stake-based voting and rewards mechanism. We examine this possibility in Footnote 21, and describe why it does not alter the analysis and guidelines contained in this section.
[20] Data collected via dFuse.io.



The current Block Producer reward rate is sufficient to effectively maintain the current number of Block Producers while attracting a small number of new Block Producers to the network each month. The entrance of new BPs, in addition to increasing the overall number of BPs supporting the network, raises competition across existing BPs to retain their vote share, which may encourage a higher level of network service. While it may be possible to continue to maintain the number of Block Producers at a slightly lower reward level than currently prevails, reducing the compensation from current levels risks reducing Block Producer participation.

Given the network's interest in attracting and retaining Block Producers, we recommend that the inflationary rewards channeled to Block Producers under any alternative network arrangement, at the very least, not fall beneath currently-prevailing levels, particularly for producing Block Producers.

In order for the current level of producing Block Producer rewards to persist based solely on their average recent vote share, we recommend that BPs receive inflationary rewards of at least 1.2% of total EOS supply annually[21]. This implies that if the overall inflation rate were set to 3.8%, the upper bound of our guideline range, 32% of those inflationary funds should be directed

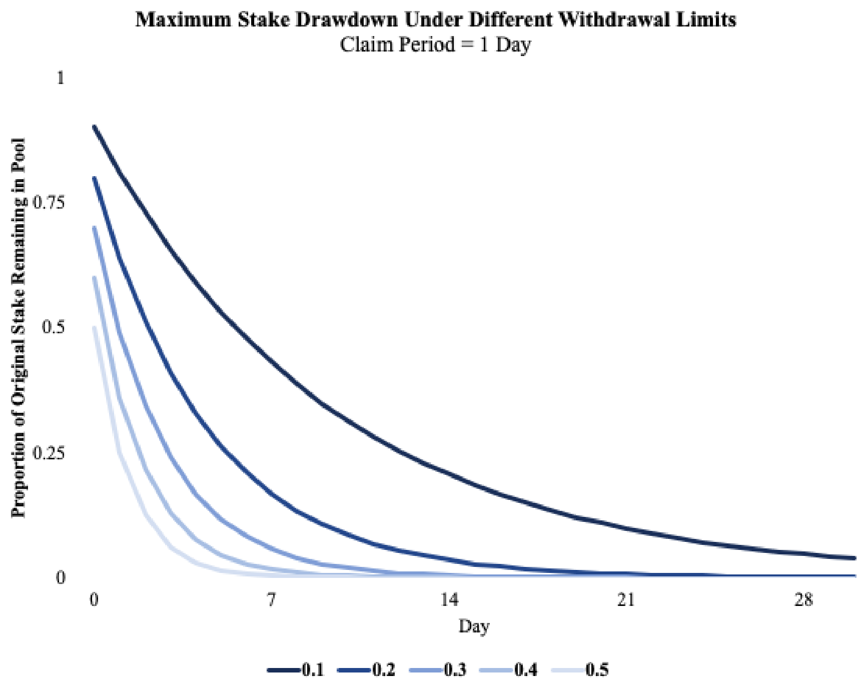
[21] It is possible that some BPs also participate in voting; under the stake-based voting and rewards mechanism these BPs would earn both BP rewards and staking rewards. However, the possibility of earning staking rewards does not imply that BP rewards can be lowered without affecting the level of service BPs render to the network. Total profits of a BP who also stakes can be written [BP operating profit] + [staking profit]. If, for example, the [BP operating profit] term of total profits was negative, the BP would clearly be able to increase overall profit by simply shutting down its node, or by reducing operating costs so that this term is no longer negative. Therefore, BP rewards alone must be sufficient to cover BP operating costs. As discussed above, although a lower level of BP rewards may be feasible, since the threshold for ensuring participation is not known, any decrease in BP rewards—particularly those directed toward producing BPs—is risky.

toward BPs. The remaining 68% of inflation could become rewards for stakers. Should a lower (or higher) inflation rate be implemented, we recommend the share given to BPs be increased (or decreased) accordingly in order to meet the recommended 1.2% of total EOS supply annually. For example, if overall inflation were set to 1.2%, then 100% of inflationary funds should be directed to BPs.

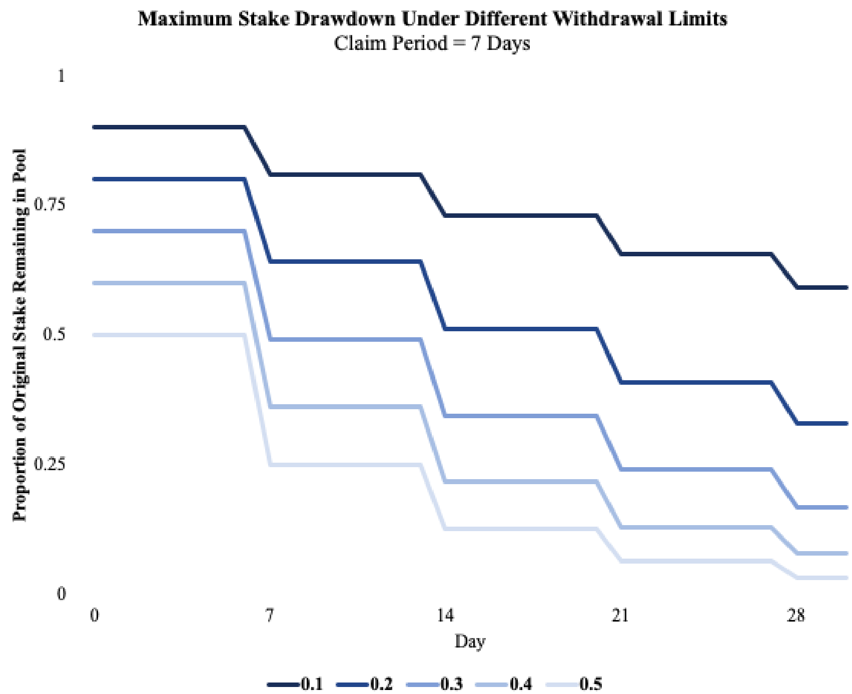
VI. Withdrawal Limit Analysis and Suggested Parameter Guidelines

The stake-based voting and rewards mechanism restricts withdrawals by stakers according to two key parameters. Specifically, stakers would be allowed to withdraw up to a proportion (withdrawal_limit) of their stake at a time, and each withdrawal must be at least claim_period after the previous withdrawal.

The parameters used in this mechanism design imply a draw down schedule. The graphs below illustrate, over a 30-day period, the maximum rates at which stakers could withdraw their stake under different values for withdrawal_limit; the first graph assumes a claim_period of 1 day, while the second assumes a claim_period of 7 days.[22]



[22] These graphs assume no rewards are added to the amount staked. Under the stake-based voting and rewards mechanism, rewards would be added to the amount staked as described in Section III, and would be subject to the same withdrawal limitations. Because annual returns are unlikely to exceed 5.9%, as discussed in Section VII, on a time horizon of one week or less, rewards on staked funds are under .1%. Therefore, these graphs approximate the percent of basis withdrawn including rewards to within .1 percentage points.

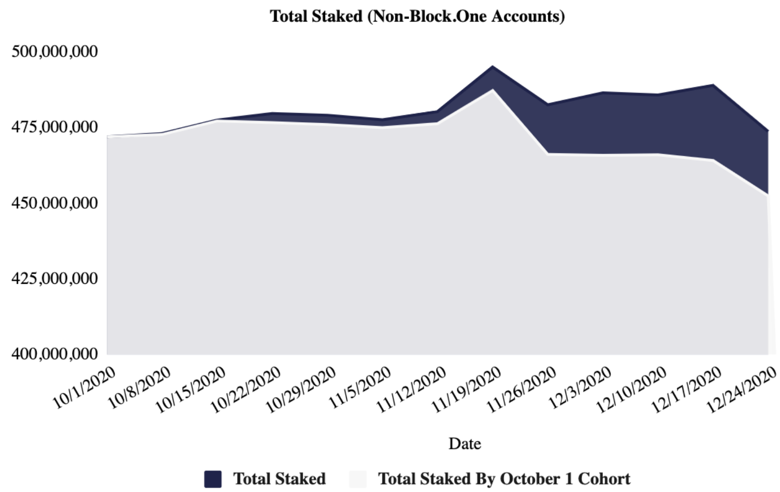


As the graphs illustrate, relatively lower withdrawal_limit values and higher claim_period values would result in a longer delay between the decision to unstake and liquidation of the same percentage of funds. For example, under a .2 withdrawal_limit and 1-day claim_period, a staker retrieves 95% of funds in just under 2 weeks (13 days); under a 7-day claim period, a withdrawal_limit of .64 is required to achieve the same approximate retrieval after 2 weeks.

Of note, there would be nothing preventing the withdrawal_limit parameter from being set to 1, allowing immediate full withdrawal of staked funds within any given claim_period. Whether this is advisable requires an assessment by the EOS community as to the potential benefits of limiting the rate at which stakers could withdraw, which might include:

1. Limiting voting rights to accounts with demonstrated commitment to the network's longer-term success and viability;
2. Mitigating short-term volatility in overall network staking; and
3. Allowing network participants to form more stable expectations as to the future circulating supply of tokens.

Under the current delegation infrastructure, which incorporates a 3-day delay in liquidations, EOS delegators have demonstrated a propensity to delegate tokens for lengthy periods. The chart below depicts the amounts delegated (including REX) by the cohort of delegators with positive delegation as of October 1, 2020 (omitting accounts controlled by Block.one) at the end of each of the following 12 weeks, as well as the total amount delegated across all delegators at each point (again omitting accounts controlled by Block.one):[23]



On October 29, 2020, the October 1 cohort had roughly 476 million EOS delegated, compared to 472 million delegated by this group on October 1. By the end of the 12-week period, the October 1 cohort's delegation had declined by only 4.1% from its starting amount, and continued to account for over 95% of the overall delegation in the network (less amounts delegated by accounts controlled by Block.one). This indicates that, even absent constraints that select for stakers dedicated to the network, EOS governance is currently driven by accounts with demonstrated network commitment.

While this historical behavior could suggest that parameters imposing a lengthy horizon that accounts must wait to retrieve their staked funds will not substantially reduce staking, it is important to recognize that certain stakers, even if they have historically demonstrated a propensity to delegate tokens for lengthy periods of time, may be unable or unwilling to stake tokens with added liquidity constraints, especially where staking does not allow for receipt of system resources.

Most prominently, cryptocurrency exchanges, for both regulatory and business reasons, are likely required to maintain a certain degree of liquidity in order to meet customer redemptions. Even if these exchanges have historically delegated tokens without interruption for lengthy periods, they may be unable or unwilling to commit to staking for lengthy periods in advance, knowing that they cannot simply unstake on 3 days notification. This is a factor that may need to be considered when establishing appropriate claim_period and withdrawal_limit parameters.

Limiting or delaying liquidation of staked tokens may also mitigate sudden exchange-rate collapse in the event of a negative market shock. In these scenarios large selloffs sometimes

[23] Data collected via dFuse.io.

cascade through a market, producing a downward price spiral driven by widespread fears of further sell-offs.[24] Constraining the ability of large stakers to immediately liquidate their tokens could supply market participants with greater confidence in the face of such shocks and thereby prevent widespread cascading liquidations. This feature of withdrawal limitations may explain why certain networks whose staking mechanisms do not confer voting rights nevertheless limit withdrawals, albeit typically with a shorter lock-up period than protocols whose staking mechanisms incorporate voting, as illustrated in the figure below:

Staking-Based Voting Rights

Lock-Up Period	Yes	No
Yes	- Polkadot (28 days) - Cosmos (21 days) - Celo (3 days)	- Ethereum 2.0 (18 hours) - Aave (10 days) - Elrond (10 days)
No	- Cardano - Tron - VeChain - Neo	- Synthetix Network - NEM

To the extent the EOS community opts to impose limitations on withdrawal, we recommend a claim_period value of 7 days (604,800 seconds) and a withdrawal_limit value of .67. These together would allow stakers to draw down up to 96.4% of their staking balance within two weeks of deciding to unstake (assuming that the first unstaking action is undertaken at the time this decision is made), 98.8% within 3 weeks, and 99.6% within 4 weeks.[25] This would put the stake-based voting and rewards mechanism in line with the staking mechanisms of other protocols that confer voting rights to stakers and implement a lock-up period, as illustrated in the figure above.

However, as noted in Section VII, there appears to be little relationship between willingness to stake and the imposition of withdrawal limitations. We do not see any obvious risks, other than the rare possibility of a selloff cascade discussed above, should the stake-based voting and rewards mechanism be implemented with a withdrawal limit of 100%. This would allow stakers to immediately withdraw all of their stake, which is in-line with what a number of networks have chosen to do, as reflected in the figure above.

VII. Expected Staking Outcomes and Comparables Analysis

The proposed stake-based voting and rewards mechanism would provide two types of benefits to potential stakers: rewards earned in EOS tokens which can then be used in the network or traded

[24] See, eg, “Bitcoin Loses More Than Half Its Value In Two Day Plunge.” CNBC, Mar. 13, 2020.
[25] Alternatively utilizing a claim_period of 1 day with a withdrawal_limit of .2 will achieve a similar draw-down schedule, but would require many more transactions in order to complete the same liquidation.

and voting rights which allow stakers to participate in governance, providing non-pecuniary benefits.

In order to estimate the equilibrium staking outcomes (i.e., those that will obtain such that no stakers have an incentive to increase or reduce their amount staked given the returns to staking), the value of the non-pecuniary, voting benefits to stakers must be estimated. To this end, Prysm Group conducted an analysis of historical delegating behavior on the EOS network. By observing the behavior of delegators, and their use, or not, of resource entitlements and voting rights, we estimated the quantity of tokens currently delegated solely for the purposes of voting.[26]

This estimate of tokens delegated solely for voting serves as a floor for an estimate of how many tokens we expect will be staked in the stake-based voting and rewards mechanism for two reasons:[27] [28]

1. Delegated tokens that are being used for resources also receive voting benefits, and therefore may still be staked in a future system that does not confer resource entitlements.
2. When rewarded, voting-motivated stakers would stake more because their total value from staking is higher than from delegating and receiving only voting rights.

We used these baseline figures to estimate the amount that would be staked by voting-motivated stakers under various inflationary reward levels. We then estimated the additional propensity for reward-motivated stakers to stake tokens in the new system. Altogether, these figures drove the total estimated tokens that are staked on the EOS network in the new system.

Moreover, the equilibrium staking outcomes—including the number of tokens staked, the percent of total token supply staked, and the estimated nominal yield to staking—directly depend on previously discussed assumptions and parameters such as estimated growth in economic activity, specified token inflation, and how the inflationary reward is split between stakers and BPs. The following chart depicts estimated outcomes under assumptions of 5% economic activity growth

[26] Further details regarding the methodology underlying this analysis are presented in the *Appendix*.
[27] This is the floor when all voting rights are allocated by the stake-based voting and rewards mechanism, after the transition period is complete.
[28] This figure is an estimate based on historical EOS network activity, and the baseline level may not persist due to the liquidity restrictions present in the new system. As noted in Section VI, past delegating behavior, particularly for liquidity-sensitive accounts, is not necessarily predictive of behavior under the stake-based voting and rewards mechanism due to the imposition of novel liquidity constraints. It is therefore possible that some proportion of current voting-motivated stakers reduce or eliminate their participation in the event the mechanism is implemented. Nevertheless, as discussed further in the *Appendix*, there is reason to believe that the lower bound of our estimate is quite conservative, including that it omits sizable categories of accounts that likely receive at least some benefit from voting (eg, REX holders). The inclusion of such accounts would likely compensate for any decline in staking by liquidity-sensitive accounts.

and 2.4% economic growth, as well as high and low estimates of the value delegators place on voting rights:[29]

Table 1

	Assumed Economic Activity Growth (Annual)	Value for Voting Rights	Total Token Inflation Rate (Annual)	% of Total Token Inflation Rate to Stakers	Implied Nominal Yield (1-Year, Annual)	Equilibrium Number of Tokens Staked	Equilibrium % of Available Tokens Staked
High Growth, Lower Vote Value	5.0%	Lower	3.8%	68%	5.9%	446M	48%
Low Growth, Lower Vote Value	2.4%	Lower	1.2%	0%	0.0%	189M	20%
High Growth, Higher Vote Value	5.0%	Higher	3.8%	68%	4.3%	614M	66%
Low Growth, Higher Vote Value	2.4%	Higher	1.2%	0%	0.0%	385M	41%

In *Table 2*, we have summarized the relevant statistics for comparable networks. Included are staking networks with market capitalizations > $1B as of February 3, 2021. The table lists the nominal reward rate, the percentage of eligible tokens staked, and the inflation rate for each network. These statistics were taken directly from Staking Rewards, a data provider focused on PoS networks.[30] Additionally, we provide for each network a description of staking lock-ups imposed (if any), and further classify each network by whether, and if so how, governance voting rights are earned via staking.[31]

[29] Similar to the above, this analysis assumes that the current level of rewards directed to producing Block Producers persists (based solely on their vote share). This analysis also assumes an opportunity cost of capital for participants who value voting of 12.0% and for participants who do not value voting of 6.0%.
[30] See https://www.stakingrewards.com/. We omitted Synthetix Network given it as an outlier in terms of both extreme nominal rewards and inflation.
[31] The first classification for networks that provide staking-based voting rights is whether they confer Direct or Indirect voting rights — direct voting rights allow stakers to vote directly on governance proposals while indirect voting rights allow stakers to delegate their voting rights to representatives who then vote on governance proposals (e.g. validators or councilmembers). The second classification defines the relationship between amount staked and voting power: Proportional networks give users voting power that is directly proportional to the amount staked, while Tiered networks have defined tiers for different staking amounts and corresponding voting rights (i.e. voting power is not a continuous function of the amount staked). Finally, Formula networks use a combination of variables, including amount staked, to determine voting power.

Table 2[32]

Network	Reward Rate (Nominal)	Inflation Rate	% of Eligible Tokens Staked	Voting-Based Staking Rights	Lock-up Period
Ethereum 2.0	9.40%	0.14%	2.17%	No	365 days for validators, 18 hour minimum for staking pools
Polkadot	13.67%	8.56%	60.58%	Direct, Formula	28 days
Cardano	4.26%	NA	71.34%	Direct, Proportional	None
Aave	4.46%	NA	26.54%	No	10 days
Tron	3.34%	0.90%	26.94%	Indirect, Proportional	None
NEM	4.83%	0.57%	36.99%	No	None
Tezos	5.32%	4.90%	78.92%	Indirect, Proportional	14 days for baking, none for delegating
Cosmos	9.29%	7.02%	67.54%	Direct, Proportional	21 days
VeChain	0.84%	NA	NA	Direct, Tiered	None
Neo	1.09%	NA	NA	Indirect, Proportional	None
Celo	11.76%	2.74%	5.69%	Direct, Proportional	3 days
Elrond	29.00%	11.30%	52.09%	No	10 days
Mean	**6.20%**	**4.82%**	**51.84%**	**Yes**	-
Median	**4.79%**	**4.9%**	**64.06%**		-
Mean	11.92%	4.0%	29.45%	No	-
Median	7.12%	.57%	36.99%		-

The 3.8% upper bound of our inflation guideline range is in line with average inflation rates for networks in which staking confers voting rights. The 1.2% lower bound of the range is consistent with most networks in which staking does not confer voting rights, and above the minimum rate for networks in which it does confer voting rights.

The nominal staking yields produced by the upper bound of the economic growth scenarios range (4.3% - 5.9%) are beneath the mean for voting-based staking networks (6.2%), but are in line with those offered by a number of both vote-based and non-vote-based protocols, including Cardano (4.26%) and Aave (4.46%). The range of equilibrium staking participation we expect across the four scenarios (20% to 66%) captures the majority of other networks, and would at its maximum exceed the average for voting-based staking protocols (51.84%).

[32] "NA" indicates that figures were not available for the network.

Of note, networks in which staking confers voting rights typically enjoy a higher mean staking participation rate (51.84%) than networks that do not confer voting rights to stakers (29.45%). This is consistent with the intuition discussed above that many users derive utility solely from the ability to participate in network governance. The provision of this non-pecuniary reward similarly leads to lower nominal staking yields across vote-based staking networks, again consistent with the intuition that stakers derive utility solely from governance participation, permitting for greater staking at lower explicit return rates.

Finally, there does not appear to be an obvious relationship between the imposition of lock-ups and the percent of eligible tokens staked, with Polkadot, for instance, imposing among the longest lock-up periods (28 days) while enjoying among the highest staking participation rates (60.58%), while multiple networks with no lock-up periods (Tron, NEM) or very brief ones (Celo) see participation rates considerably lower.

VIII. Conclusion by Block.one

The foregoing analysis conducted by Prysm Group, as supplemented by the *Appendix* below, examines many of the key features of the stake-based voting and rewards mechanism. As summarized in Section II above, in the event the EOS Public Blockchain chooses to adopt the mechanism, Prysm Group's recommended guidelines include (i) an overall system inflation rate of 1.2% to 3.8% annually; (ii) distribution of 1.2% of total EOS supply annually to Block Producers, with the remaining inflationary tokens eligible for distribution to stakers; and (iii) either a withdrawal cadence of once every 7 days, with a per-withdrawal limit of 67% of staked tokens, or a withdrawal cadence of once per day, with no per-withdrawal limit. These guidelines, together with Prysm Group's description of the stake-based voting and rewards mechanism, are presented for consideration by the EOS and EOSIO communities, and we encourage interested community-members to consult the relevant Github page for further information.

Appendix

Stake-based Voting and Rewards Mechanism

The stake-based voting and rewards mechanism contemplates a range of changes to the manner in which voters and Block Producers interact with the EOS network. The features described in Section III above are only those with direct bearing upon the economic analysis Prysm Group was tasked with conducting, and for ease of exposition, our descriptions abstract away from a number of more technical mechanism details.

We summarize below certain additional mechanism features that may be of interest to network participants. For a complete description of the mechanism, network participants should consult the EOS Github page at https://github.com/EOSIO/eos.

Further details concerning the processes by which accounts stake, unstake, and vote under the mechanism include:

- Staked tokens are pooled into a single pool account. Accounts stake their tokens to this staking pool via a 'stake2pool' action. This action transfers the account's newly staked tokens to the pool and records the account's claim on that pool as 'new_shares'. At the time of the stake2pool action, 'new_shares' is calculated as $\frac{(amount\_staked * total\_shares)}{token\_supply}$. These are added to the total 'owned_shares' held by the staking account.
- All staker rewards, including inflationary rewards, are simply added to the staking pool account balance.
- Unstaking is achieved via a 'claimstake' action. The action is successful if at least 'claim_period' has passed since the last 'claimstake' action undertaken by that account. The maximum number of EOS any user is entitled to unstake within any given claim_period is given by $\frac{owned\_shares * pool\_balance}{total\_shares} \cdot \frac{claim\_period}{duration}$, where pool_balance is equal to the total EOS staked to the pool.

Further details concerning the phase-in of the mechanism and dispersal of rewards to stakers and BPs include:

- Migration from the current architecture to the stake-based voting and rewards mechanism will begin at a time given by the 'begin_transition' parameter and will be completed at a time given by the 'end_transition' parameter. The 'transition' variable, which serves to modulate the rewards paid to stakers and Block Producers before the migration is complete, will be set to:

0 when $t \leq begin\_transition$,
1 when $t \geq end\_transition$, and
$\frac{(t - begin\_transition)}{(end\_transition - begin\_transition)}$ when $begin\_transition \leq t \leq end\_transition.$

- During this phase-in period, N producing Block Producers will be selected each round based on the number of votes received under the stake-based voting and rewards mechanism, and the remaining N-1 producing Block Producers will be selected based on the number of votes received under the existing voting infrastructure. N will stepwise increase linearly over the course of the phase-in period and reach 21 by 'end_transition.'
- The inflationary reward rates discussed in Sections IV and V are maximum rates that are attained if BPs are operating the blockchain properly by producing the maximum number of new blocks, 252, each consensus round. The mechanism reduces the amount that is actually paid, both to BPs and to stakers, if blocks are missed. Specifically:

  The total number of tokens channeled to BPs per consensus round is given by 'target_prod_pay', which is equal to

  $\frac{(pay\_scale * prod\_rate * token\_supply)}{rounds\_per\_year}$, where pay_scale is $10^{\frac{blocks\_produced\_in\_last\_round}{252}} * transition.$

  The total amount number of tokens channeled to stakers per consensus round is given by pool_pay, which is equal to

  $\frac{(pay\_scale * voter\_rate * token\_supply)}{rounds\_per\_year}$, where pay_scale is $10^{\frac{blocks\_produced\_in\_last\_round}{252}} * transition.$

Economic Activity Growth Estimates

The value of a token used as a medium of exchange for goods and services depends directly on the total amount of economic activity conducted in the token (or, put another way, that the token provisions). All goods and services that are paid for using the token are included in economic activity. Users purchase the token in order to purchase products and services that they want to buy (or receive utility from).

Economic activity is the fiat-measured value of products and services that are bought using the token. This is similar to how the Gross Domestic Product (GDP) of a country is measured as the total value of final goods and services produced. Note that this *excludes foreign exchange transactions*; economic activity includes goods and services purchased but includes neither speculative trading nor token transfers.

This equation illustrates the relationship between the economic activity (that consumers choose to use the token for) and the value of the token:[33]

$$Fundamental\ Token\ Value\ = \frac{Economic\ Activity}{(Circulating\ Token\ Supply)(Token\ Velocity)}$$

Tokens that are liquid and available to consumers to use in their purchases are included in the circulating supply. Tokens that remain held by Block.one, tokens that can't be used for purchases because of vesting schedule lock-up, tokens that are delegated or staked, and tokens that are unavailable for any other reason are excluded from circulating supply of tokens that are available to consumers because they do not provision economic activity.

Furthermore, because the value of the token is determined by the value of spending the token once, the economic activity per circulating token must be scaled by velocity. Velocity is defined as the number of times a token is spent during the time period over which the economic activity is conducted. For a means of payment token, velocity varies depending on the payment type. The quarterly velocity of the US dollar over the past three decades is between 1.1 and 2.2 and the quarterly velocity of Bitcoin has been estimated to be between 1.1 and 1.6.[34] We set quarterly velocity at 1.1.

To calculate implied historical economic activity for the EOS network (and rearranging) we have:

$$Market\ Implied\ Economic\ Activity\ = Token\ Price\ \bullet\ Circulating\ Token\ Supply\ \bullet\ Token\ Velocity$$

Thus, as of 1/31/2021, we estimate[35]:

$$Market\ Implied\ Economic\ Activity\ = \$2.91 \cdot 926M\ tokens \cdot 1.1\ = \$3.0B$$

We used this formula and historical data to inform the range of economic activity growth scenarios considered in our inflation rate analysis. In particular, we calculated the market implied economic activity on a historical basis monthly from the launch of the EOS mainnet in June 2018 through January 2021. While, as noted above, the historical market implied growth rate of economic activity has varied widely, our analysis suggested 5% as a reasonable upper bound on the range of annual growth rate scenarios to consider.

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[33] See Catalini, Christian, and Joshua S. Gans. 2018. "Initial Coin Offerings and the Value of Crypto Tokens." NBER Working Paper No. 24418. Revised March 5, 2019; and Athey, Susan, Ivo Parashkevov, Vishnu Sarukkai & Jing Xia. 2016. "Bitcoin Pricing, Adoption, and Usage: Theory and Evidence." Working Paper.
[34] Source: USD quarterly velocity, Bitcoin's annualized velocity, Woobull Charts.
[35] Source: CoinMarketCap, Prysm Group analysis and estimates.

To specify a lower bound for the range of economic activity growth rate scenarios, we assume that the EOS network economic activity grows at 2.4%, within range of the long-term historical average GDP growth rates of the United States (~3.0%) and other developed countries (EU at ~2.2%, OECD at ~3.0%).[36]

Staking Model

The EOS token has additional uses beyond the typical currency uses when it is staked under the stake-based voting and rewards mechanism. In particular, staked tokens are used:

- To obtain voting rights to participate in network governance.
- To earn staking rewards.

The demand for these uses, and therefore the likely outcomes of the mechanism, depend on the value that network participants place on them.

Economic models of staking behavior typically focus only on mechanisms that grant stakers rewards and no other benefits.[37] Typically, these models determine demand for staking by equating the opportunity cost of the capital staked with the rewards granted in exchange for staking. Because entry into staking in these mechanisms is free, a competitive equilibrium in which zero profits are earned is assumed. These models cannot apply directly to the stake-based voting and rewards mechanism because they do not account for the benefits participants receive from the voting rights they acquire through staking.

While rewards have an objective value that is common to all potential stakers, voting rights do not. All participants can redeem rewards for the same market price, but different network participants will value the right to vote differently. Furthermore, the same participant may value voting rights over different networks differently. For this reason, estimating uptake of a staking mechanism that incorporates voting rights can be difficult to do in advance.

However, the value that EOS network participants place on voting rights can be estimated because the existing delegation mechanism also confers voting rights over the same network. We use this fact to incorporate the value for voting rights into a model of demand for staking.

Delegated tokens can be used:

- To obtain resources for processing transactions.
- To obtain voting rights to participate in network governance.
- To earn rewards (via REX only).

[36] Source: World Bank, Trading Economics, IHS Markit, MacroTrends.
[37] See, for example, Fanti, Giulia, Leonid Kogan, & Pramod Viswanath. 2019. "Economics of Proof-of-Stake Payment Systems." Working Paper.

In order to estimate the value for voting rights, we sought to isolate the proportion of tokens currently delegated for which the delegator received, and made use, *only* of voting benefits, and either did not receive, or did not make use, of any remaining benefits. Of the total amount delegated to the network, this includes only delegated tokens:

1. Whose delegators either vote, or proxy their voting power to another account;
2. That do not earn financial rewards (i.e., omitting REX); and
3. Whose stakers do not make use of the network resources to which they are entitled as a result of staking.

We collected resource usage data for a sample of accounts over a four-week period between December 2020 and January 2021 that together represented more than 95% of the total amount staked to the system as of the analysis start date. Based on this data, we estimated that just under 5% of the tokens held by self-delegating accounts in our sample that voted or proxied (omitting accounts controlled by Block.one) were staked for the purpose of consuming network resources. We concluded that the remaining self-delegated tokens staked by voting or proxying accounts, representing roughly 43% of all delegated tokens in our sample, set a minimum threshold for the proportion of network-wide staked tokens motivated exclusively by a desire to vote.

Note that this 43% figure is likely quite conservative as a measure of overall vote-based staking motivation for a number of reasons, including that it assumes any amounts delegated by one user to another are dedicated 100% to resource usage.[38] More generally, this analysis assumes that amounts staked that entitle their stakers to *any* benefit apart from voting are valued for that benefit alone, to the complete exclusion of voting; the true proportion of currently staked amounts that are at least *partially* motivated by voting is likely significantly higher. For instance, as of February 4, 2021, roughly 88% of all tokens staked were staked by accounts who either voted or proxied their vote, and these accounts likely received at least *some* utility from doing so.

Based on these figures, we estimate that in the absence of any rewards or other benefits, current delegators would be willing to stake 189M to 385M EOS tokens in the stake-based voting and rewards mechanism in order to access voting rights.[39]

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[38] This assumption was based on empirical analysis suggesting high levels of resource usage among accounts to whom tokens had been delegated, as well as the general intuition that, because delegating accounts retain the voting rights conferred by delegation regardless of whether the tokens are self-delegated or delegated to another account, the only available motivator for delegating to another account is to allow that account to make use of the delegated tokens' resource entitlement.

[39] These figures would apply once the transition is complete and all voting rights are allocated via the stake-based voting and rewards mechanism. Further, we have assumed that the selected parameters imposing limitations on withdrawal (see Section VI) will not be sufficiently onerous as to significantly inhibit participation by liquidity-sensitive accounts, such as exchanges. However, as noted above, there is reason to believe that the lower bound of our estimate for voting-motivated staking is quite conservative, and inclusion of additional accounts likely motivated by voting would likely compensate for any decline in staking by liquidity-sensitive accounts.

Delegation and staking are costly to participants because the delegated or staked capital could otherwise be invested. Any positive reward stream granted in addition to voting rights would increase the amount staked by these participants because it would defer some of that opportunity cost.

The cost to an investor of forgoing available investment opportunities in favor of some particular investment is referred to as the 'opportunity cost of capital.' Because different investors have different sets of investment opportunities available to them, their opportunity costs of capital will differ; for instance, large investors with access to sophisticated investment vehicles (such as venture capital and private equity) have a wider, and typically more lucrative, set of investment opportunities available to them at any given time than retail investors, who may be limited to returns driven by traditional and broadly available instruments, such as equities.

In the case of EOS, the opportunity cost of staking tokens for any given stakeholder is specified by the alternative set of opportunities for capital deployment available to that staker. Because stakers whose primary interest is influencing network governance are typically larger, more sophisticated accounts, they can be expected to have access to a relatively higher opportunity cost of capital—i.e., a more lucrative set of alternative opportunities for capital deployment—compared to smaller, less sophisticated stakers. For this reason, we assumed that the voting delegators, many of whose delegation balances tend to be significant, have an opportunity cost of between 10% and 15%, with an approximate midpoint at 12%; this is slightly higher than the long-run historical annualized average return of the S&P index of 10%.[40]

The estimated range of vote-motivated staking, together with the assumptions regarding the opportunity cost of capital for voting stakers implies a nominal, EOS-denominated annual value of voting between 9.5M EOS and 57.8M EOS. This is a private benefit which these specific participants, who highly value voting, would receive in addition to any token rewards. These same participants, then, will be willing to stake a number of tokens which results in their new opportunity cost equaling the voting benefit plus the reward benefit.

$$(Voter\ OCC)\cdot(Tokens\ Staked\ by\ Voters)\ =\ (Rewards\ to\ Voters)\ +\ (Value\ of\ Voting)$$

If the benefits, including reward benefits, exceeded the costs borne by these participants, any one of them could increase their net gain by staking additional tokens—thereby earning additional rewards.

This equation implies that any network participant who does not value voting, but may be interested in staking in order to receive rewards cannot benefit from the stake-based voting and rewards mechanism unless their opportunity cost of capital is lower than the opportunity cost of

[40] See Nerdwallet.

capital of voters. If a participant who did not value voting and had an opportunity cost of capital at least as high as that of voters was able to obtain a non-negative net benefit from staking, that would imply that voters received a strictly positive net benefit, violating the competitive market condition. For this reason, participants who value voting effectively crowd out participation by those who do not value voting. The larger the value of voting by voting-motivated participants, the more these actors crowd out participation by others.

If there are participants who do not value voting, and those participants have a lower cost of capital than voters, *and* the private value of voting to voters is sufficiently low, then some non-voters may stake to this system for rewards. To account for this scenario we assumed there is a group of potential stakers with an opportunity cost of capital of 3% to 8%.

We produced a model based on the reasoning and equations presented in this section and the previous section, that incorporates the following inputs:

1. Economic activity growth (Assumption, Range: 2.4% - 5%)
2. Tokens delegated solely for voting (Assumption, Range: 43.2% - 88.0%)
3. Opportunity cost of capital to vote-motivated stakers (Assumption, Range: 10.0% - 15.0%)
4. Opportunity cost of capital to other stakers (Assumption, Range: 3.0% - 8.0%)
5. Overall inflation (Parameter)
6. Inflation share rewarded to BPs (Parameter)

The model produces the following outputs:

1. Quantity of tokens staked by voters
2. Quantity of tokens staked by others
3. Growth in circulating supply of tokens
4. Nominal yield to staking

In Section VII we summarize certain outputs of this model, and compare them to alternative staking networks.