Liquid Staking and the Limits of Policy

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ABSTRACT

We study the role of liquid staking and how it affects the interaction between issuance policy, economic productivity, and security in proof-of-stake blockchains. In a dynamic macro-finance framework, we show that issuance redistributes resources from productive on-chain activity to validators, which effectively acts as a tax on productive capital. This mechanism generates a Laffer-curve-type tradeoff: beyond an interior optimum, higher issuance weakens the productive base that finances security and reduces staking rewards. We then introduce liquid staking, which allows users to earn staking rewards while retaining liquidity for productive use. Liquid staking collapses the traditional tradeoff between staking and DeFi. When liquid staking tokens (LSTs) closely substitute for the native asset and benefit from strategic complementarities, issuance reallocates productive activity toward LSTs, compresses the feasible policy space, and can render issuance and slashing ineffective as policy instruments.

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I. Introduction

The defining feature of blockchain platforms is decentralized security: transactions are certified through a consensus of validators rather than by a central authority. Proof-of-stake platforms ensure security by requiring validators to lock ("stake") native tokens, which can be reduced ("slashed") if validators misbehave, and augmented with newly issued tokens if validators are honest. Besides staking, blockchains support a wide range of productive financial activities, collectively referred to as decentralized finance (DeFi). Because staking requires locking tokens that could otherwise be deployed in DeFi, platform policies manage a tradeoff: stronger staking incentives increase security, but at the cost of price dilution and reduced productive DeFi activity.

However, a new form of staking is beginning to reshape this tradeoff: liquid staking. Under this arrangement, users delegate staking to an intermediary, who passes the resulting issuance rewards through to the user, and issues a liquid token which can be used for DeFi. Liquid staking appears to solve a central inefficiency of proof-of-stake by eliminating the opportunity cost of staking. Our analysis shows, however, that by allowing users to stake without forgoing DeFi, liquid staking dissolves the traditional tradeoff at the heart of platform policy.

Our paper studies the consequences of this innovation through a macro-finance model that explicitly incorporates liquid staking. Our analysis yields three main results. First, higher issuance rewards no longer primarily harm DeFi productivity; instead, issuance harms decentralization by encouraging liquid staking through a central intermediary. Second, issuance leads more DeFi users to favor the liquid staking token (LST) over the native token. This effect is amplified when LSTs provide access to the same investment opportunities as the native token. Third, strategic complementarities arising from endogenous token liquidity can amplify this shift, replacing the native token in DeFi entirely and rendering issuance powerless to shape user incentives.

As a benchmark, we begin with a dynamic equilibrium model of a proof-of-stake blockchain without liquid staking. Users are endowed with dollar wealth, and they allocate that wealth dynamically between consumption, blockchain staking, and blockchain DeFi investment. Investment in DeFi generates productive stochastic returns, whereas staking earns platform rewards in the form of issued native tokens. In equilibrium, staking issuance has an indirect effect on user incentives because it dilutes the dollar value of DeFi tokens. This structure yields a tight link between productivity, issuance, and staking incentives: issuance directly shapes portfolio allocations, token prices, and the growth rate of aggregate on-chain wealth.

The baseline model yields the following results. Because issuance redistributes value rather than creating it, it acts as a distortionary tax on DeFi production. Thus, higher issuance raises staking rewards per unit of productive output but simultaneously discourages productive investment, shrinking the tax base that finances staking incentives. As a result, dollar staking revenues exhibit a Laffer-curve-type relationship with issuance. At low levels, higher issuance increases staking returns. Beyond an interior optimum, further issuance contracts the productive base so sharply that total staking revenues fall. In equilibrium, sufficiently aggressive issuance weakens the economic incentives that support security provision.

We then extend the model to incorporate liquid staking. Users can deploy both the native token and liquid staking tokens in DeFi, while liquid staking simultaneously earns issuance rewards. Issuance continues to tax productive use of the native token, but liquid staking tokens partially or fully avoid this tax. This asymmetry matters. Instead of mainly crowding out productive DeFi activity and pay for security, higher issuance pushes DeFi users away from native token and toward liquid staking tokens, which combine productivity with staking exposure.

The central implication is a breakdown of policy transmission. When liquid staking tokens are close substitutes for the native token for use on DeFi, equilibrium allocations can become largely insensitive to issuance, even to negative issuance. Defi activity migrates toward liquid staking tokens, which leaves most native tokens to be staked through the liquid staking intermediary. Issuance then loses its redistributive bite, even slashing can lose its deterrent force. Policy still affects token prices via dilution, but it no longer affects user behavior.

Whether this outcome arises depends on two economic forces. The first is correlation. When the productivity returns of LSTs closely track those of the native token, liquid staking replicates native token exposure while avoiding issuance taxation, which encourages widespread adoption. The second is strategic complementarity. As one type of token become more widely used as productive capital, its liquidity improves. Because issuance directly weakens returns to native tokens, it reduces their scale and raises usage costs, turning what is a first-order tax into a higher-order distortion once liquidity effects are anticipated. This feedback reinforces LST adoption and makes corner outcomes, such as near-universal liquid staking, more likely. When these forces are weak, issuance retains traction. When they are strong, issuance becomes powerless.

These results have direct implications for decentralization and security. High aggregate staking can coexist with reduced accountability, weakened incentives, and concentrated control over validation. Liquid staking intermediaries may come to dominate consensus even as measured staking levels rise. More broadly, the analysis highlights a limit of monetary policy in decentralized systems: when financial innovation allows users to evade policy-induced distortions, traditional incentive tools lose their force. Understanding this limit is central to the design of secure and genuinely decentralized blockchains.

A. Literature

Our paper is part of a recent literature that uses dynamic models to study the effects of staking rewards. Cong, He, and Tang (2025) provide a foundational equilibrium framework for understanding how staking rewards affect platform productivity and token price. Jermann (2023) uses a dynamic equilibrium macro model to study how issuance, fees, and Layer 2 (L2) activity affect the money supply and price dynamics, and Jermann (2024) characterizes the optimal issuance policy. A central ingredient of these models is the natural assumption, motivated by the historical realities of proof-of-stake platforms, that users must choose between staking and DeFi.

Our paper builds on these dynamic frameworks by incorporating the increasingly popular choice to liquid stake. We show that liquid staking dissolves the classic staking-DeFi tradeoff, reducing issuance policy's ability to influence equilibrium outcomes, and centralizing power in the liquid staking intermediary.

A recent note, Jermann (2025), extends the model of Jermann (2024) to include intermediated staking. In this setup, stakers can choose between solo staking and using an intermediary, which entails lower fixed costs but higher variable costs than solo staking. By contrast, our paper focuses on a specific and transformative form of intermediation: liquid staking. In our model, liquid staking dominates solo staking because it offers not only staking rewards but also a liquid token which can be used on DeFi.

In recent work, Harvey, John, and Saleh (2025) study settlement security in proof-of-stake blockchains, showing how higher productive value from blockchain execution increases staking investment, reduces circulating supply, and raises the cost of attacks through endogenous price impact. Like our paper, their framework recognizes that staking rewards are ultimately financed by users and that issuance functions as a transfer from productive activity to security provision, creating a tension between productivity and staking incentives. Our contribution builds on this insight by making this tension explicit as a Laffer-curve–type tradeoff: beyond a point, higher issuance weakens the productive base that finances security. We then show how the introduction of liquid staking alters this tradeoff by allowing staking rewards to be earned without a corresponding reduction in productive liquidity, changing the transmission of issuance and slashing and weakening the link between productivity and security.

A related body of work emphasizes security and incentive provision in proof-of-stake systems. Saleh (2021) provides a foundational economic analysis of proof-of-stake consensus, highlighting how staking incentives replace the resource expenditure of proof-of-work. Subsequent work with coauthors, including John, Rivera, and Saleh (2025), studies equilibrium staking levels under heterogeneous horizons and block reward policies, clarifying how security depends on both participation and incentive design. Together, these papers establish the economic logic of staking as a mechanism for decentralized security.

A growing recent literature studies liquid staking and liquid staking derivatives as financial instruments and institutional arrangements within proof-of-stake blockchains. Theoretical literature examines liquid staking in general equilibrium, emphasizing conditions under which liquid staking improves capital efficiency or, conversely, weakens security incentives (e.g., Carré and Gabriel (2024)). Several papers analyze the pricing, liquidity, and market behavior of liquid staking tokens, documenting deviations from parity with the underlying staked asset, the role of arbitrage frictions, and the contribution of liquid staking derivatives to price discovery and on-chain liquidity (e.g., Scharnowski and Jahanshahloo (2025); Xiong, Wang, and Wang (2024); Kraner, Pennella, Vallarano, and Tessone (2025)). Complementary work studies leveraged positions and rehypothecation chains built on liquid staking tokens, highlighting their intensive reuse in DeFi and the potential amplification of shocks (e.g., Xiong, Wang, Chen, Knottenbelt, and Huth (2025)). Finally, systematization and survey work documents the institutional design of liquid staking and related innovations such as restaking, clarifying protocol mechanics, risk channels, and emerging market structures (e.g.,Gogol, Velner, Kraner, and Tessone (2024)). Relative to this literature, our contribution is to embed liquid staking directly into a macro-style model of proof-of-stake policy, showing how liquid staking alters the transmission of issuance and slashing by relaxing the traditional tradeoff between staking and productive activity, and thereby reshapes the effectiveness of protocol-level security incentives.

Section II presents the baseline model, characterizes the equilibrium allocation of security and productivity, and demonstrates monetary non-neutrality of the issuance policy. Section III extends the model to incorporate liquid staking and shows how it can lead to monetary neutrality of the issuance policy, especially when strategic complementarities accelerate LST dominance on DeFi. Section IV concludes.

II. Productivity, issuance, and security

In a blockchain economy without liquid staking, the distribution of wealth between (i) productive users who generate value through financial activity and (ii) users who provide security through staking is central. In our model, issuance acts as a policy instrument that redistributes wealth from productive activity to security provision, effectively taxing DeFi productivity to finance consensus. Productivity generates dollar returns that expand the economic base of the blockchain, while issuance determines how these returns are shared between productive users and stakers. Through this channel, issuance shapes user portfolio incentives, the allocation of native tokens between productive use and staking, and ultimately the joint determination of blockchain productivity and security.

In our baseline model, the blockchain ecosystem is a small open economy embedded within the broader dollar economy. Section II.A presents the general features of the baseline model, Section II.B frames the problem of a blockchain user as a portfolio problem, Section II.C describes the equilibrium allocation to productivity and security under a given issuance policy and discusses blockchain monetary non-neutrality, and Section II.D derives native token prices.

A. General features

There is a continuum of homogeneous users with unit mass, and time is continuous. The dollar economy features a representative consumption good, whose price is constant and normalized to one. Each user $i \in [0,1]$ in the blockchain economy chooses a lifetime consumption stream $\{c_t^i\}_{t=0}^{\infty}$ to maximize

$$\mathbb{E}_0\left[\int_0^{\infty} e^{-\beta t}\log(c_t^i)\,dt\right], \tag{1}$$

where $\beta > 0$ is the discount, or impatience, parameter. Importantly, agents consume dollars rather than native tokens.

Each user is endowed with initial wealth x_0 in dollars. At each time $t \geq 0$, users allocate their wealth between consumption and two blockchain investments: DeFi and staking. Both investments require users to lock wealth on the blockchain and hold the native token. Below, we describe the components of dollar returns associated with each investment.

Productivity. The blockchain economy offers financial and monetary services that generate real economic value in dollar terms. Productivity arises from attracting inflows through user adoption or from the creation of new services and technologies that increase the blockchain's fundamental value.

We assume that blockchain productivity is proportional to the dollar value of wealth locked and circulating within the blockchain's DeFi protocols. Hereafter, we refer to the value generated by the blockchain through these channels as *DeFi productivity.*

The return to one dollar due to DeFi productivity is stochastic and follows the process

$$\mu_D\, dt + \sigma_D\, dW_{D,t}\,, \tag{2}$$

where $\mu_D > 0$ is a known deterministic drift capturing the expected growth of the blockchain economy due to wealth locked in DeFi protocols, $W_{D,t}$ is a Brownian motion representing productivity shocks, and σ_D scales the magnitude of these shocks. Shocks include exogenous demand shocks as well as shocks to the fundamental value of the blockchain, including hacks and political risk.

Issuance as a tax. When assessing the profitability of each option, each infinitesimal blockchain user i takes as given the dollar price P_t of the native token, the supply Q_t of the native token, the issuance policy I_t of the blockchain, and the relevant aggregate states of the economy. Specifically, users take as given the dollar value of productive tokens, D_t, and of staked tokens, S_t. As described below, individual blockchain participants take prices as given, while as a group they affect them.

We assume that issuance takes the form of a proportional rate, denoted by dI_t/I_t, applied to the number of staked tokens. Accordingly, the number of tokens issued at time t is

$$\underbrace{\frac{S_t}{P_t}}_{\text{number of staked tokens}} \times \underbrace{\frac{dI_t}{I_t}}_{\text{issuance policy}}\,. \tag{3}$$

Issuance I_t is interpreted as an *average* issuance rate received by each staker. We do not explicitly model the mechanism that selects individual consensus participants and the resulting idiosyncratic realization of validation rewards at a given point in time. The model can be extended to incorporate idiosyncratic issuance risk at the user level and canceling out in the aggregate, as is standard in continuous-time macro-finance models; see, for example, Brunnermeier and Sannikov (2014).

Users value newly issued native tokens at the current price and therefore perceive issuance revenues in dollar terms as riskless.[1] Specifically, the dollar value of wealth distributed to stakers at time t is

$$\underbrace{\frac{S_t}{P_t}\frac{dI_t}{I_t}}_{\text{tokens issued}} \times \underbrace{P_t}_{\text{token price}}\,. \tag{4}$$

[1]See Appendix B for an alternative formulation in which staking earns returns from both issuance and token price changes, with prices acting as the (endogenous) channel through which issuance taxes DeFi activity.

The return to staking, per dollar locked in staking, is therefore

$$\frac{d\nu_{S,t}}{\nu_{S,t}} = \underbrace{S_t \frac{dI_t}{I_t}}_{\text{dollars distributed to stakers}} \times \underbrace{\frac{1}{S_t}}_{\substack{\text{normalized by dollar} \\ \text{value of staked tokens}}} = \frac{dI_t}{I_t} \,. \tag{5}$$

In our model, at any given point in time t, native-token issuance neither creates nor destroys dollar wealth in the blockchain economy and therefore does not affect the market capitalization of the native token. Instead, issuance operates as a transfer of wealth from productive users to stakers.[2] As a result, issuance enters as a negative component of returns to productive tokens and can be interpreted as a tax on productive capital.

Specifically, the issuance-related tax per dollar invested in DeFi protocols is

$$- \underbrace{S_t \frac{dI_t}{I_t}}_{\text{dollars distributed to stakers}} \times \underbrace{\frac{1}{D_t}}_{\substack{\text{normalized by dollar} \\ \text{tokens}}} \,.$$

Combining this issuance tax with stochastic productivity yields the return to DeFi:

$$\frac{d\nu_{D,t}}{\nu_{D,t}} = \mu_D \, dt + \sigma_D \, dW_{D,t} - \frac{S_t}{D_t} \frac{dI_t}{I_t} \,. \tag{6}$$

Appendix B presents an alternative formulation of our model in which issuance is not modeled as an explicit tax in DeFi returns but instead issuance affects incentives endogenously through native-token price changes. In the setting of Appendix B, staking earns returns both from issuance and from price changes. The appendix shows that our results continue to hold when prices—rather than explicit transfers—are the channel through which issuance operates as a tax on productive activity.

B. *Blockchain user portfolio problem*

The blockchain protocol chooses and publicly commits to an issuance rule dI_t/I_t that determines the flow of newly issued tokens and we write

$$\frac{dI_t}{I_t} = \mu_{I,t} \, dt \,, \tag{7}$$

[2]As we show below, although issuance is a transfer of wealth between user types at any given instant, it affects allocations of users between productive activity and consensus and therefore influences the dynamics of the market capitalization of the native token over time.

where $\mu_{I,t}$ governs the baseline issuance stance of the protocol.

Let x_t^i denote the dollar net worth of user $i \in [0,1]$ at time t. Each user allocates a fraction θ_t^i of wealth to DeFi protocols, with the remaining share $1-\theta_t^i$ invested in staking. We rule out borrowing and short selling and restrict θ_t^i to lie in $[0,1]$.

Users take as given the dollar value of productive tokens D_t, staked tokens S_t, and the blockchain's issuance policy. Given these objects, individual wealth evolves according to

$$\frac{dx_t^i}{x_t^i} = \theta_t^i \frac{d\nu_{D,t}}{\nu_{D,t}} + \left(1-\theta_t^i\right) \frac{d\nu_{S,t}}{\nu_{S,t}} - \frac{c_t^i}{x_t^i}\, dt, \tag{8}$$

where asset returns are in (5) and (6).

Users have logarithmic preferences over consumption. The next result characterizes optimal consumption and portfolio choice.

PROPOSITION 1: *Assume $D_t, S_t > 0$. For each user i, optimal consumption satisfies*

$$c_t^{i\star} = \beta\, x_t^i.$$

The optimal share of wealth invested in DeFi protocols is

$$\theta_t^{i\star} = 0 \quad \text{if} \quad \mu_{I,t} \geq \frac{\mu_D}{1+\dfrac{S_t}{D_t}},$$

and

$$\theta_t^{i\star} = 1 \quad \text{if} \quad \mu_{I,t} \leq \frac{\mu_D - \sigma_D^2}{1+\dfrac{S_t}{D_t}}.$$

Otherwise, the optimal portfolio share is given by

$$\theta_t^{i\star} = \frac{\mu_D - \left(1+\dfrac{S_t}{D_t}\right)\mu_{I,t}}{\sigma_D^2}. \tag{9}$$

Proposition 1 shows that, for given aggregate allocations D_t and S_t, the individual share of productive tokens is decreasing in the issuance tax. The result further identifies an upper threshold of issuance beyond which all users optimally stake, and a lower threshold below which all users optimally allocate their wealth to productive activity.

C. Equilibrium

This section studies the equilibrium properties of proof-of-stake blockchains without liquid staking tokens. Given exogenous productivity shocks, issuance policy, and initial conditions for $\{P_t, Q_t, D_t, S_t\}$, a competitive equilibrium consists of portfolio allocations $(\theta_t^i)_{t\geq 0}$, consumption plans $(c_t^i)_{t\geq 0}$, and prices $(P_t)_{t\geq 0}$ such that all users maximize utility and markets clear.

Aggregate user wealth equals the market capitalization of native tokens, and we write

$$x_t = \int_0^1 x_t^i \, di = P_t \, Q_t. \tag{10}$$

Moreover, portfolio choices clear the DeFi and staking markets:

$$D_t = \theta_t \, x_t \qquad \text{and} \qquad S_t = (1 - \theta_t) \, x_t. \tag{11}$$

The following proposition characterizes the symmetric equilibrium.

PROPOSITION 2: *If the issuance rate $\mu_{I,t}$ is above the threshold*

$$\overline{\mu}_I = \frac{\mu_D^2}{4\,\sigma_D^2}\,, \tag{12}$$

then the equilibrium allocation to DeFi is $\theta^\star = 0$. If the issuance rate $\mu_{I,t}$ is below the threshold

$$\underline{\mu}_I = \mu_D - \sigma_D^2 \leq \overline{\mu}_I\,, \tag{13}$$

then the equilibrium allocation to DeFi is $\theta^\star = 1$. Otherwise,

$$\theta_t^\star = \frac{\mu_D}{2\,\sigma_D^2} + \frac{1}{\sigma_D}\sqrt{\overline{\mu}_I - \mu_{I,t}}\,, \tag{14}$$

which is the unique equilibrium that is continuous in $\mu_{I,t}$ and which maximizes blockchain-user welfare. Aggregate net worth of blockchain users, or equivalently, the market capitalization of the native token, evolves according to

$$\frac{d(P_t Q_t)}{P_t Q_t} = \theta_t^\star\big(\mu_D \, dt + \sigma_D \, dW_{D,t}\big) - \beta \, dt. \tag{15}$$

Equation (15) highlights that the instantaneous change in the native token's market capitalization is driven by returns on productive tokens and by consumption. Issuance acts as a pure redistribution of wealth from productive users to stakers and therefore washes out in the aggregate, neither creating nor destroying dollars in the blockchain economy. However, issuance influences market capitalization by determining the equilibrium share $\theta_t^\star$ of tokens allocated to productive uses versus consensus, thereby shaping the growth rate of aggregate wealth over time.

The equilibrium allocation (14) is jointly determined by expected productivity, risk, and issuance. To better illustrate the role of issuance, we can rewrite the equilibrium allocation to DeFi as

$$\theta_t^\star = \frac{\mu_D}{\sigma_D^2} - \frac{\mu_D}{2\,\sigma_D^2}\left(1 - \sqrt{1 - \frac{\mu_{I,t}}{\overline{\mu}_I}}\right). \tag{16}$$

This representation makes clear that the equilibrium allocation takes as a benchmark the optimal DeFi portfolio share μ_D/σ_D^2 in the absence of issuance and applies an issuance-based discount. The discount is increasing in the issuance rate: for low issuance, it converges to zero, while as issuance approaches its upper bound $\overline{\mu}_I$, the discount reaches its maximum value $\mu_D/(2\,\sigma_D^2)$. Beyond this threshold, users optimally refrain from allocating wealth to DeFi in order to avoid an excessively high issuance tax.

Therefore, a mixed allocation between consensus and productivity is only possible when the issuance rate lies within the range $[\underline{\mu}_I, \overline{\mu}_I]$. The threshold $\overline{\mu}$ in (12) represents the maximum sustainable issuance rate compatible with a positive allocation to DeFi in equilibrium. This threshold admits a simple interpretation: it corresponds to the maximal attainable log-growth rate of wealth from productive activity,

$$\theta_t\,\mu_D - \tfrac{1}{2}\,\sigma_D^2\,\theta_t^2.$$

As such, $\overline{\mu}$ is the highest issuance rate that DeFi can ever compete with. When issuance exceeds this threshold, productive activity becomes dominated by staking, all users optimally allocate their wealth to staking, and DeFi activity ceases. In this case, as we show below, the equilibrium return to staking converges to zero and the blockchain would effectively shut down.

The threshold $\underline{\mu}_I$ in (13) is the issuance rate below which full adoption of DeFi is optimal in equilibrium. This threshold can be interpreted as the marginal welfare loss from reducing the DeFi share θ_t, measured by the derivative of the equilibrium log-growth rate of wealth:

$$\partial_\theta\left(\theta_t\,\mu_D - \tfrac{1}{2}\,\sigma_D^2\,\theta_t^2\right),$$

and evaluated at $\theta_t = 1$, that is, when the blockchain operates at maximum productivity. If issuance delivers a lower return than this benchmark, any infinitesimal shift away from full DeFi reduces utility, and full DeFi adoption is optimal.

The corner cases described above should not be interpreted literally. In practice, there exists a minimum level of security, or equivalently, a lower bound on S_t, below which the blockchain becomes insecure. Users investing in the blockchain anticipate this constraint, and as a result productive activity may cease in equilibrium before the optimal allocation to DeFi reaches $\theta_t^\star = 1$. Similarly, there exists a minimum level of productivity below which staking returns effectively approach zero, prompting users to reallocate wealth to an outside investment option before $\theta_t^\star$ reaches zero. Thus, the blockchain would fail before either extreme allocation is attained. A straightforward extension of the model would impose endogenous bounds on equilibrium allocations, yielding $\theta_t^\star \in [\underline{\theta}, \overline{\theta}]$, where $\underline{\theta} > 0$ reflects the minimum productivity required to sustain economic activity and $\overline{\theta} < 1$ reflects the minimum staking required to ensure economic security $(1 - \overline{\theta}) P_t Q_t$.

D. *Native token supply and prices*

In our framework, the price of native tokens reflects the demand for it as a necessary resource to access and use the blockchain, either for DeFi or for staking. Assume the dynamics of the native token are

$$\frac{dP_t}{P_t} = \mu_{P,t}\, dt + \sigma_{P,t}\, dW_{D,t}\,, \tag{17}$$

where we solve for μ_P and σ_P below.

By market clearing, the total dollar value of productive and staked native tokens equals their market capitalization,

$$D_t + S_t = P_t\, Q_t\,. \tag{18}$$

Moreover, the supply Q_t of the native token evolves due to issuance, which applies the rate dI_t/I_t to the number of staked tokens, S_t/P_t. Accordingly,

$$dQ_t = \frac{S_t}{P_t} \frac{dI_t}{I_t}\,. \tag{19}$$

Using the issuance rule (7) together with the clearing conditions (10) and (11), the equilibrium dynamics of the native token supply can be written as

$$\frac{dQ_t}{Q_t} = (1 - \theta_t^\star) \left(\mu_{I,t}\, dt + \sigma_{I,t}\, dW_{D,t}\right)\,. \tag{20}$$

The following result characterizes token price dynamics.

PROPOSITION 3: *In equilibrium, token prices follow the dynamics* (17)*, with loadings*

$$\mu_{P,t} = \theta_t^\star \, \mu_D - \beta - (1 - \theta_t^\star) \; \mu_{I,t}, \tag{21}$$

$$\sigma_{P,t} = \theta_t^\star \, \sigma_D \,. \tag{22}$$

Expected token price growth reflects the discounted value of productive blockchain activity, $\theta_t^\star \mu_D - \beta$. DeFi productivity μ_D is scaled by the endogenous share $\theta_t^\star$ of wealth allocated to productive uses, which is itself shaped by issuance policy. Issuance therefore affects native token prices by distorting portfolio choices and reducing the fraction of tokens engaged in productive activity. Issuance also dilutes native token returns through an inflationary effect captured by the term $-(1 - \theta_t^\star)\, \mu_{I,t}$, which scales with the proportion of user wealth allocated to staking.

As a result, native token price drift is driven by productive output subject to distortionary taxation used to finance security. Finally, token price volatility (21) reflects fundamental productivity risk, scaled by the equilibrium share of productive native tokens.

Policy and monetary non-neutrality. Importantly, in our baseline model, issuance policy directly affects users' incentives to engage in productive activity or to participate in consensus, and thereby influences native-token prices, reflecting monetary non-neutrality. Issuance can thus be used as a policy instrument to shape the allocation of native tokens between productive uses and staking, allowing the protocol to jointly determine equilibrium blockchain productivity and economic security for a given policy objective. Appendix A illustrates an issuance policy that targets long-run blockchain growth while incentivizing a desired level of security.

As we show below, when blockchain economies allow liquid staking tokens to be used for productive activity, an equilibrium may emerge in which users optimally rely exclusively on LSTs to generate value on the blockchain. In this scenario, issuance becomes ineffective as a policy instrument, since it no longer influences user incentives or portfolio choices. In Section III, we show that issuance, the expanding use of LSTs that replicate native-token investment opportunities, and additional forces arising from strategic complementarities jointly push the economy toward this equilibrium.

Designing optimal issuance policies is beyond the scope of this paper. We refer the reader to Cong, Li, and Wang (2021); Jermann (2023); Jermann and Xiang (2025) for complementary approaches to optimal policy design in tokenized economies.

E. Equilibrium staking rewards

Blockchains rely on productivity to finance security. Issuance effectively taxes DeFi users and redistributes generated wealth toward stakers, thereby making staking profitable in dollar terms rather than solely in native token terms. In this environment, where staking is financed by a tax on productive activity, issuance and productivity jointly determine the dollar returns to staking.

To illustrate this mechanism, consider the simple case in which the issuance rate is constant, $\mu_{I,t} = \mu_I$, so that the equilibrium portfolio allocation (14) is also constant, $\theta_t^\star = \theta^\star$. In this case, the dollar value distributed to stakers in equilibrium evolves according to

$$dS_t = d\big((1-\theta^\star)\, P_t\, Q_t\big) = P_t\, Q_t \left[(1-\theta^\star)\, \theta^\star \big(\mu_D\, dt + \sigma_D\, dW_{D,t}\big) - (1-\theta^\star)\, \beta\, dt\right], \tag{23}$$

where we use the law of motion of token market capitalization in (15). Recall that $\theta^\star \equiv \theta^\star(\mu_I)$ is a decreasing function of the issuance rate μ_I. As a result, the instantaneous profitability of staking,

$$\mu_S(\mu_I) = (1-\theta^\star(\mu_I))\ (\mu_D\, \theta^\star(\mu_I) - \beta)\,,$$

is itself a function of issuance.

This profitability is increasing for low issuance rates and decreasing for high issuance rates, attaining an interior maximum at the issuance level satisfying $\theta^\star = 1/2$, that is, at $\mu_I = \theta^{\star\,-1}(1/2)$. The intuition is as follows. While a higher issuance rate raises the tax applied to productive output, it simultaneously reduces the equilibrium amount of productive tokens. Beyond a certain point, the contraction of the tax base dominates the increase in the tax rate, so that total issuance revenues, and hence staking returns, fall.

This result can be interpreted as a Laffer curve for protocol revenues. Issuance acts as a distortionary tax on productive blockchain activity: low issuance fails to generate sufficient staking rewards, while excessive issuance discourages production and erodes the tax base. As a consequence, staking revenues are maximized at an interior level of issuance.

More broadly, our analysis shows that achieving economic security through issuance alone is more difficult than commonly assumed. Security policies that rely exclusively on higher issuance may therefore become self-defeating beyond a certain point. In particular, long-run economic security may require an initial phase in which productivity is incentivized and security is temporarily relaxed in order to expand the tax base from which staking rewards are drawn, followed by a phase in which issuance targets a given dollar value of staking.

Another risk of issuance is that it can hinder blockchain adoption. A natural extension of the model allows users to allocate wealth to an outside investment opportunity, such as a risk-free dollar asset. In this case, as issuance increases and productive activity contracts, the resulting rise in the staking share reduces equilibrium staking returns, which eventually converge to zero. Once staking returns fall below the outside option, users optimally withdraw capital from the blockchain altogether. This mechanism implies that sufficiently aggressive issuance policies can reduce on-chain participation and, ultimately, blockchain adoption.

III. Liquid staking and the limits of issuance

Liquid staking allows proof-of-stake users to delegate consensus work to specialized operators while receiving a derivative token that represents their staked position. Unlike solo staking, which requires dedicated hardware, technical expertise, and a significant minimum stake, liquid staking lowers participation costs and abstracts away operational complexity. The resulting liquid staking tokens (LSTs) are fully transferable and can be used in DeFi. This feature makes staked capital productive while still earning staking rewards. As a result, liquid staking has become one of the dominant forms of staking, and it accounts for a large and growing share of both total staked tokens and on-chain economic activity.

In a blockchain economy with liquid staking, users can be productive using both the native token and LSTs. The distribution of wealth between (i) productive users who generate value with native tokens, (ii) productive users who provide security while generating value with LSTs, and (iii) users who only provide security through staking (pure staking) becomes central.[3]

Section III.A presents the general features of the baseline model, Section III.B frames the problem of a blockchain user as a portfolio problem, Section III.C characterizes the equilibrium allocation between DeFi protocols and staking under a given issuance policy and discusses how the adoption of LSTs can undermine policy effectiveness and lead to monetary neutrality. Section III.D derives the law of motion of the native token's price and supply. Finally, Section III.E shows how issuance and the adoption of LSTs shift the blockchain economy toward an equilibrium in which LSTs are the sole vehicle for productive activity and issuance loses policy effectiveness, and Section III.F demonstrates how strategic complementarities amplify and accelerate this shift.

[3]Our model does not differentiate between staker types. Staking can occur either through passive (not used on DeFi) holding of LSTs or through solo staking. Analyzing the composition and diversity of the staking pool is beyond the scope of this paper.

A. General features

As in Section II, a continuum of homogeneous blockchain users chooses a lifetime consumption stream $c^{i\infty}_{tt=0}$ to maximize logarithmic utility over dollar consumption. At each time $t \geq 0$, users allocate wealth between consumption and three blockchain investments: DeFi with native tokens, DeFi with LSTs, and staking. We next describe the return structure associated with each investment.

Returns to DeFi with native tokens. Let D_t denote the dollar value of productive native tokens, L_t the dollar value of productive LSTs, and S_t the dollar value of staked tokens.

Issuance revenues are distributed to all users who provide security, either directly through pure staking or through holding LSTs in DeFi. From the perspective of productive native token holders engaged in DeFi, issuance acts as a pure tax, as these users are the only agents who do not receive issuance revenues.

As in the baseline model, issuance is paid proportionally to staked capital. At time t, the total dollar value of issuance distributed to stakers and liquid stakers is $(S_t + L_t)\, dI_t/I_t$, which is redistributed away from productive native-token holders. Normalizing by the aggregate dollar value of productive native tokens, D_t, yields the per-dollar issuance tax. As in Section II.A, DeFi activity using native tokens also generates stochastic productivity. Combining these two components, the return to DeFi with native tokens is therefore

$$\frac{d\nu_{D,t}}{\nu_{D,t}} = \mu_D\, dt + \sigma_D\, dW_{D,t} - \frac{S_t + L_t}{D_t} \frac{dI_t}{I_t}, \tag{24}$$

where issuance now finances both pure staking and LSTs engaged in DeFi.

Returns to DeFi with LSTs. We next consider DeFi activity conducted using LSTs. In contrast to native tokens, LST-based DeFi positions generate both stochastic productivity and issuance revenues, as LST holders are effectively staking. We model the return to DeFi with LSTs as

$$\frac{d\nu_{L,t}}{\nu_{L,t}} = \mu_L\, dt + \xi_L\, dW_{L,t} + \frac{dI_t}{I_t}, \tag{25}$$

where μ_L captures the expected productivity of LST-based DeFi activity and ξ_L its volatility.

We allow productivity shocks to DeFi with native tokens and with LSTs to be correlated,

$$\langle W_D, W_L \rangle_t = \rho\, t, \qquad \rho > 0,$$

where ρ measures the extent to which LSTs provide access to the same DeFi investment opportunities as native tokens. A higher correlation corresponds to LSTs being closer substitutes for the native token in DeFi, while a lower correlation reflects frictions or limitations in LST usability.

Returns to staking. The return to staking, whether through solo staking or passive holding of LSTs, is

$$\frac{d\nu_{S,t}}{\nu_{S,t}} = \frac{dI_t}{I_t}\,. \tag{26}$$

B. Blockchain user portfolio problem

This section studies the equilibrium properties of proof-of-stake blockchains in the presence of liquid staking tokens as a means to generate value. The protocol commits to the issuance rule dI_t/I_t in (7).

Let x_t^i denote the dollar net worth of user $i \in [0,1]$ at time t. Each user allocates a fraction θ_t^i of wealth to DeFi using the native blockchain token, a fraction φ_t^i to DeFi using LSTs, and the remaining share $1-\theta_t^i-\varphi_t^i$ to pure staking. We rule out borrowing and short selling and restrict allocations to lie in $[0,1]$.

Users take as given the dollar value of productive native tokens D_t, productive LSTs L_t, staked tokens S_t, and the blockchain's issuance policy. Given these objects, individual wealth evolves according to

$$\frac{dx_t^i}{x_t^i} = \theta_t^i\,\frac{d\nu_{D,t}}{\nu_{D,t}} + \varphi_t^i\,\frac{d\nu_{L,t}}{\nu_{L,t}} + \left(1-\theta_t^i-\varphi_t^i\right)\frac{d\nu_{S,t}}{\nu_{S,t}} - \frac{c_t^i}{x_t^i}\,dt, \tag{27}$$

where asset returns are in (24), (25), and (26). The next result characterizes optimal consumption and portfolio choice.

PROPOSITION 4: *Fix a user i, aggregates $\{D_t, S_t, L_t\}$, and correlation $|\rho|<1$. The optimal consumption rule is*

$$c_t^{i,\star} = \beta\, x_t^i\,.$$

If the interior solution

$$\theta_t^i = \frac{\left(\mu_D - \frac{P_t\,Q_t}{D_t}\mu_{I,t}\right)\xi_L^2 - \mu_L\,\sigma_D\xi_L\rho}{\sigma_D^2\xi_L^2(1-\rho^2)}, \qquad \varphi_t^i = \frac{\mu_L\,\sigma_D^2 - \left(\mu_D - \frac{P_t\,Q_t}{D_t}\mu_{I,t}\right)\sigma_D\xi_L\rho}{\sigma_D^2\xi_L^2(1-\rho^2)} \tag{28}$$

lies in the feasible set $\{(\theta,\varphi):\ 0\le\theta,\ 0\le\varphi,\ \theta+\varphi\le 1\}$, then it is the unique optimal portfolio allocation. If the interior solution is not feasible, then the solution is the maximizer $(\theta,\varphi)\in\{(\theta^{i\star},0),(0,\varphi^{i\star}),(\theta^{i\star},1-\theta^{i\star})\}$ which attains the largest objective value among the *following edge cases.*

1. *The share in productive native tokens is* $\theta_t^{i\star} = 0$ *and the share in productive LSTs is*

$$\varphi_t^{i\star} = \min\left\{ \max\left\{ \frac{\mu_L}{\xi_L^2},\, 0 \right\},\, 1 \right\}\,, \tag{29}$$

with objective $\varphi^{i\star}\mu_L + \mu_{I,t} - \frac{1}{2}\varphi^{i\star 2}\xi_L^2$.

2. *The share in productive LSTs is* $\varphi_t^{i\star} = 0$*, and the share in productive native tokens is*

$$\theta_t^{i\star} = \min\left\{ \max\left\{ \frac{\mu_D - \left(1 + \frac{S_t + L_t}{D_t}\right)\mu_{I,t}}{\sigma_D^2},\, 0 \right\},\, 1 \right\},$$

with objective $\mu_{I,t} + \theta_t^{i\star}\left(\mu_D - \left(1 + \frac{S_t+L_t}{D_t}\right)\mu_{I,t}\right) - \frac{1}{2}\,\theta_t^{i\star 2}\,\sigma_D^2$.

3. *The share in pure staking is* $1 - \theta_t^{i\star} - \varphi_t^{i\star} = 0$*, and the share in productive native tokens is*

$$\theta_t^{i\star} = 1 - \varphi_t^{i\star} = \frac{\mu_D - \mu_L - \left(1 + \dfrac{S_t + L_t}{D_t}\right)\mu_{I,t} + \xi_L^2 - \sigma_D \xi_L \rho}{\sigma_D^2 + \xi_L^2 - 2\sigma_D \xi_L \rho}, \tag{30}$$

with objective

$$\theta^\star\left(\mu_D - \frac{S_t + L_t}{D_t}\mu_{I,t}\right) + (1-\theta^\star)(\mu_L + \mu_{I,t}) - \frac{1}{2}\left(\theta^{\star 2}\sigma_D^2 + (1-\theta^\star)^2\xi_L^2 + 2\,\theta^\star\,(1-\theta^\star)\sigma_D\xi_L\rho\right). \tag{31}$$

In the interior solution (28), individual portfolio allocations respond to changes in risk-adjusted productivity. An increase in the expected productivity of DeFi protocols that use native tokens raises the optimal allocation to productive native tokens, and similarly, an increase in the expected productivity of DeFi protocols that use LSTs raises the allocation to productive LSTs.

Issuance enters the portfolio problem asymmetrically. Because issuance dilutes only non-staked tokens, it acts as a tax only on holders of productive native tokens who do not stake. As a result, an increase in the issuance rate strictly reduces the allocation to productive native tokens, while increasing the relative attractiveness of both productive LSTs and pure staking. Consequently, higher issuance reallocates wealth away from productive native tokens and toward productive LSTs and staking, rather than crowding out all DeFi activity uniformly as in Section II.

The marginal effect of issuance on portfolio reallocation depends on the aggregate composition of the economy. Specifically, the sensitivity of individual allocations to changes in issuance is inversely related to the aggregate share of native tokens in DeFi, measured by $D_t/P_t\,Q_t$. When a larger share of native tokens is engaged in DeFi, the issuance tax is spread over a broader base, dampening the impact of a marginal increase in issuance on individual portfolio choices. Conversely, when productive native tokens are fewer relative to aggregate tokens, issuance is concentrated on a narrow set of holders, making portfolio allocations more sensitive to changes in issuance.

Next, we describe the role of correlation ρ between the productivity of native tokens and that of LSTs. When correlation is low and tends to zero, issuance reallocates wealth away from native-token DeFi toward pure staking rather than toward LSTs, since the excess return of LSTs over staking is driven solely by LST productivity. Positive correlation reintroduces an indirect effect of issuance on φ through diversification motives. Issuance-induced reductions in productive native tokens affect the optimal diversification allocation to LST-based DeFi. In this case, issuance reallocates wealth away from native-token DeFi toward both productive LSTs and pure staking.

C. *Equilibrium*

Given exogenous productivity shocks W_D and W_L, issuance policy I, and initial conditions for $\{P_t, Q_t, D_t, L_t, S_t\}$, a competitive equilibrium consists of portfolio allocations $\{(\theta_t^i)_{t\geq 0}, (\varphi_t^i)_{t\geq 0}\}$, consumption plans $(c_t^i)_{t\geq 0}$, and prices $(P_t)_{t\geq 0}$ such that all users maximize utility and markets clear.

Aggregate user wealth equals the market capitalization of the native token,

$$x_t = \int_0^1 x_t^i\, di = P_t\, Q_t, \tag{32}$$

and portfolio choices clear the native DeFi, LST DeFi, and staking markets:

$$D_t = \theta_t\, x_t, \qquad L_t = \varphi_t\, x_t \qquad \text{and} \qquad S_t = (1 - \theta_t - \varphi_t)\, x_t. \tag{33}$$

The following result, which uses similar arguments to those of Proposition 2, characterizes the symmetric equilibrium.

PROPOSITION 5: *Fix primitives $(\mu_D, \mu_L, \sigma_D, \xi_L, \rho, \beta)$ and an issuance rate $\mu_{I,t}$. Define the threshold*

$$\overline{\mu}_I = \frac{\left(\rho\, \sigma_D\, \mu_L/\xi_L - \mu_D\right)^2}{4\,\sigma_D^2(1-\rho^2)}\,. \tag{34}$$

If $\mu_{I,t} \le \overline{\mu}_I$ *and the allocation*

$$\theta = \frac{\mu_D\,\xi_L - \mu_L\,\sigma_D\,\rho + \sqrt{\big(\mu_D\,\xi_L - \mu_L\,\sigma_D\,\rho\big)^2 - 4\,\sigma_D^2\,\xi_L^2(1-\rho^2)\,\mu_{I,t}}}{2\,\sigma_D^2\,\xi_L(1-\rho^2)}, \qquad \varphi = \frac{\mu_L}{\xi_L^2} - \frac{\rho\,\sigma_D}{\xi_L}\,\theta \tag{35}$$

satisfies $0 < \theta$, $0 < \varphi$, *and* $\theta + \varphi < 1$, *then this allocation constitutes the unique equilibrium. If the interior allocation is not feasible or if* $\mu_{I,t} > \overline{\mu}_I$, *the equilibrium allocation is the maximizer of the objective among the following candidates:*

1. *(no DeFi with native tokens)* $\theta^\star = 0$ *and* $\varphi^\star = \min\Big\{\max\Big\{\frac{\mu_L}{\xi_L^2}, 0\Big\}, 1\Big\}$.
2. *(no DeFi with LSTs)* $\varphi^\star = 0$ *and* $\theta^\star$ *corresponds to the equilibrium described in Proposition 2.*
3. *(no pure staking)* $\theta^\star = \frac{\mu_D - \mu_L + \xi_L^2 - \sigma_D\xi_L\rho + \sqrt{\Delta}}{2\left(\sigma_D^2 + \xi_L^2 - 2\sigma_D\xi_L\rho\right)}$, *and* $\varphi^\star = 1 - \theta^\star$.

where $\Delta = \big(\mu_D - \mu_L + \xi_L^2 - \sigma_D\xi_L\rho\big)^2 - 4\big(\sigma_D^2 + \xi_L^2 - 2\sigma_D\xi_L\rho\big)\mu_{I,t}$. *Finally, the market capitalization of the native token evolves as*

$$\frac{d(P_tQ_t)}{P_tQ_t} = \theta_t^\star\big(\mu_D\,dt + \sigma_D\,dW_{D,t}\big) + \varphi_t^\star\big(\mu_L\,dt + \xi_L\,dW_{L,t}\big) - \beta\,dt\,. \tag{36}$$

The equilibrium allocation of dollar wealth across native token, LSTs, and staking is determined by the productivity and risk of DeFi, as well as by issuance policy. Higher risk-adjusted productivity of either asset increases its use in DeFi.

The key novelty relative to Proposition 2, where LSTs were not productive, is the emergence of a corner equilibrium (case 1 in Proposition 5). In this equilibrium, DeFi activity using native tokens vanishes, and user allocations between LST-based DeFi and staking become independent of issuance. As a result, the evolution of market capitalization (32) is also independent of issuance.

In this regime, issuance delivers zero returns to pure staking and no longer affects incentives, rendering the equilibrium insensitive to issuance.[4] Moreover, in a blockchain economy where only LSTs are used for productive activity, there is no mechanism through which the protocol can restore monetary non-neutrality, as any issuance fails to affect dollar returns. This outcome is natural: issuance in this regime creates new tokens that are distributed symmetrically across users, eliminating the redistribution channel through which issuance influenced portfolio choices in Section II.

[4] In an extended model with slashing applied to staking returns, even slashing would be ineffective at affecting incentives when all productive activity is conducted via LSTs.

In a blockchain economy with LSTs, security is provided through both LST-based and pure staking. Our model does not distinguish between solo staking and delegated liquid staking (i.e., holding LSTs outside of DeFi). However, if the convenience of LSTs leads delegated staking to dominate solo staking, security provision and consensus may become concentrated in the hands of liquid staking protocols, which are centralized entities. In the equilibrium described above, issuance plays no role in attracting stakers, who provide security solely to gain exposure to DeFi productivity rather than to gain exposure to issuance rewards.

As discussed below in Section III.E, issuance reduces the attractiveness of native-token DeFi and encourages the adoption of LSTs as the primary vehicle for productive activity. This effect is amplified when the productivity of LSTs and native tokens is highly correlated—when DeFi activity using both becomes increasingly similar—at which point issuance ceases to function as an effective policy instrument. We further show that strategic complementarities introduce higher-order effects of issuance that push the economy toward full adoption of LST-based DeFi and towards monetary neutrality.

D. *Native token supply and prices*

In our framework, the price of the native token reflects demand for it as a necessary resource to access and use the blockchain, whether for DeFi with native tokens, DeFi with LSTs, or pure staking. We assume that token price dynamics inherit productivity shocks from both sources and follow

$$\frac{dP_t}{P_t} = \mu_{P,t}\,dt + \sigma_{P,t}\,dW_{D,t} + \xi_{P,t}\,dW_{D,t}\,, \tag{37}$$

where we solve for μ_P, σ_P, and ξ_P below.

By market clearing, the total dollar value of productive and staked tokens equals the market capitalization of native tokens,

$$D_t + S_t + L_t = P_t\,Q_t\,. \tag{38}$$

Moreover, the supply Q_t of native tokens changes due to issuance distributed to LST holder and pure stakers. Issuance here is a rate dI_t/I_t applied to the number $(L_t + S_t)/P_t$ of tokens staked, and we write

$$dQ_t = \frac{S_t + L_t}{P_t}\,\frac{dI_t}{I_t}\,. \tag{39}$$

Use the issuance form (7) and the clearing conditions (32) and (33) to write the equilibrium dynamics of native token supply as

$$dQ_t = \frac{S_t + L_t}{P_t} \frac{dI_t}{I_t} = (1 - \theta_t^\star)\; Q_t\, \mu_{I,t}\, dt\,. \tag{40}$$

The following result characterizes equilibrium token price dynamics.

PROPOSITION 6: *In equilibrium, token prices follow the dynamics* (37)*, with loadings*

$$\mu_{P,t} = \theta_t^\star\, \mu_D + \varphi_t^\star\, \mu_L - \beta - (1 - \theta_t^\star)\; \mu_{I,t}\,, \tag{41}$$

$$\sigma_{P,t} = \theta_t^\star\, \sigma_D + \varphi_t^\star\, \xi_D\,. \tag{42}$$

In equilibrium, prices reflect the discounted value of productive native tokens and productive LSTs. Price volatility (21) inherits fundamental productivity risk of both tokens, scaled by the share of wealth invested in each vehicle. Similar to a blockchain economy without liquid staking tokens, expected price growth (21) is driven by DeFi productivity μ_D and μ_L, scaled by the share $\theta^\star$ and $\varphi^\star$ of wealth allocated to productive native tokens, and productiove LSTs, respectively.

E. Policy and LSTs

Effect of issuance. Figure 1 illustrates the equilibrium allocation between native tokens and LSTs as vehicles for productive activity when both options have identical risk-adjusted productivity. At low issuance rates, the imperfect correlation between productivity shocks induces users to diversify across the two tokens. Issuance enters returns positively for LST-based DeFi and pure staking, but negatively for native token DeFi who incur the issuance tax. Thus, as issuance increases, DeFi with native tokens becomes progressively less attractive.

Beyond a threshold, the equilibrium shifts to full adoption of LSTs as the sole productive asset. In this regime, as discussed above, issuance policy no longer affects equilibrium outcomes, and security provision may become increasingly centralized. This effect persists even when native tokens are more productive; it simply requires a higher issuance rate for full adoption of LSTs. This is illustrated in Figure 2, where native tokens exhibit higher risk-adjusted productivity.

Effect of correlation. As correlation increases, the diversification benefit between native tokens and LSTs weakens. When productivity shocks become more similar, exposure to both assets provides less risk reduction, leading to a decline in equilibrium allocations to each. We interpret a higher correlation as LSTs granting access to an increasingly broad set of DeFi investment opportunities, potentially even expanding them, for instance through restaking.

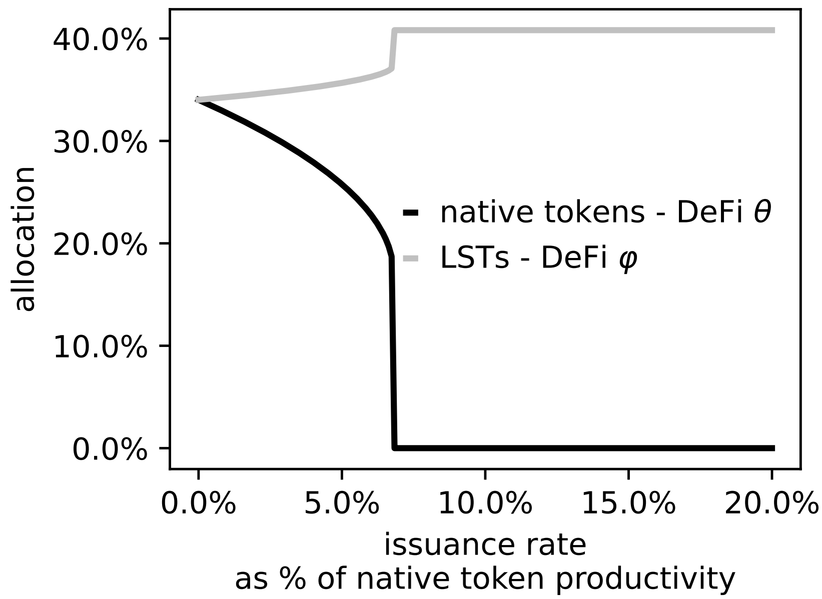

Figure 1. Equilibrium allocations to DeFi using native tokens, $\theta^{\star}$, and to DeFi using LSTs, $\varphi^{\star}$, as functions of the issuance rate. The issuance rate is expressed relative to native-token productivity, μ_I/μ_D. Model parameters are $\mu_D = \mu_L = 5\%$, $\sigma_D = \xi_L = 35\%$, $\beta = 1\%$, and $\rho = 20\%$.

Figure 3 illustrates this mechanism when native tokens and LSTs have identical risk-adjusted productivity. When correlation is low, users allocate more to LSTs than to native tokens due to issuance. As correlation rises, the equilibrium allocation to DeFi with both tokens initially declines as diversification benefits erode. Beyond a threshold, users optimally concentrate their productive investment entirely in LSTs. Past this point, users increase their exposure to DeFi with LSTs to attain their desired level of risk, as native tokens no longer provide additional diversification benefits and are abandoned.

However, when the risk-adjusted return of DeFi with native tokens is sufficiently higher than that of DeFi with LSTs and issuance is low, an increase in correlation has the opposite effect, as illustrated in Figure 4. In this case, higher correlation shifts the equilibrium toward full adoption of native tokens as a productive tool, as characterized in Proposition 5. This does not imply that liquid staking protocols cease to exist, but rather that LSTs are used solely as delegated staking instruments, not as derivative tokens for generating value.

More generally, Proposition 5 provides conditions that are useful for blockchain governance to assess when increased adoption of LSTs in DeFi, captured in our model by rising correlation, poses a threat to the effectiveness of issuance-based policy.

Finally, Figure 5 illustrates a key implication of increased LST adoption in DeFi. As LSTs

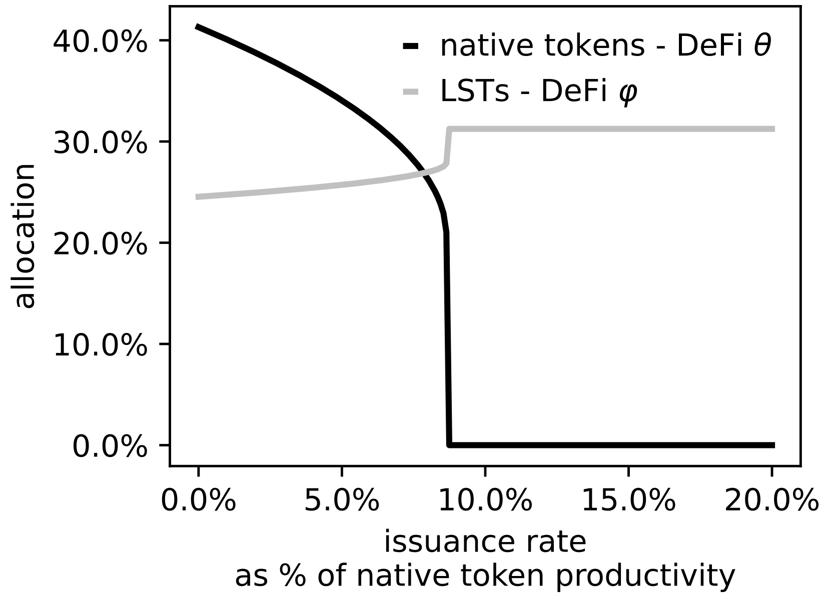

Figure 2. Equilibrium allocations to DeFi using native tokens, $\theta^{\star}$, and to DeFi using LSTs, $\varphi^{\star}$, as functions of the issuance rate. The issuance rate is expressed relative to native-token productivity, μ_I/μ_D. Model parameters are $\mu_D = \mu_L = 5\%$, $\sigma_D = 30\%$, $\xi_L = 40\%$, $\beta = 1\%$, and $\rho = 20\%$.

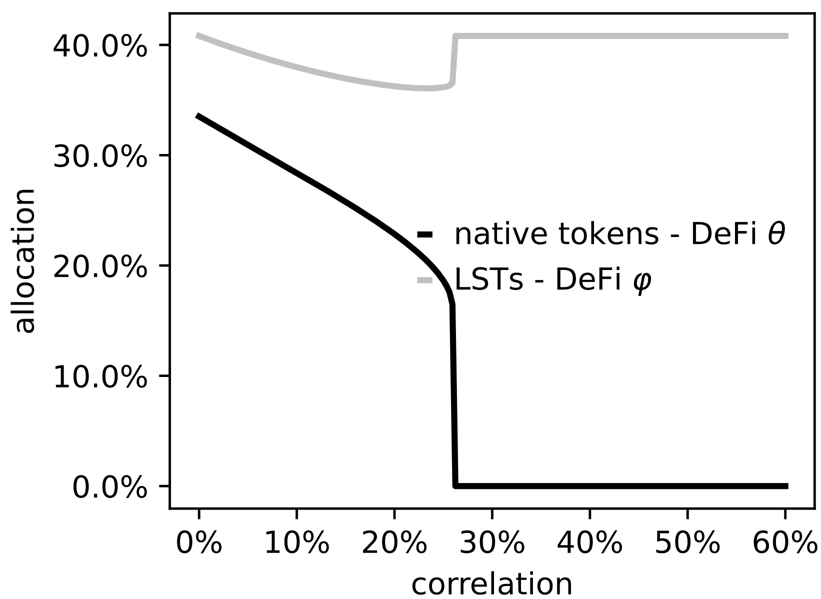

Figure 3. Equilibrium allocations to DeFi using native tokens, $\theta^{\star}$, and to DeFi using LSTs, $\varphi^{\star}$, as functions of the correlation ρ of the productivity rates of both token types. Model parameters are $\mu_D = \mu_L = 5\%$, $\sigma_D = \xi_L = 35\%$, $\beta = 1\%$, and $\mu_I = 0.3\%$.

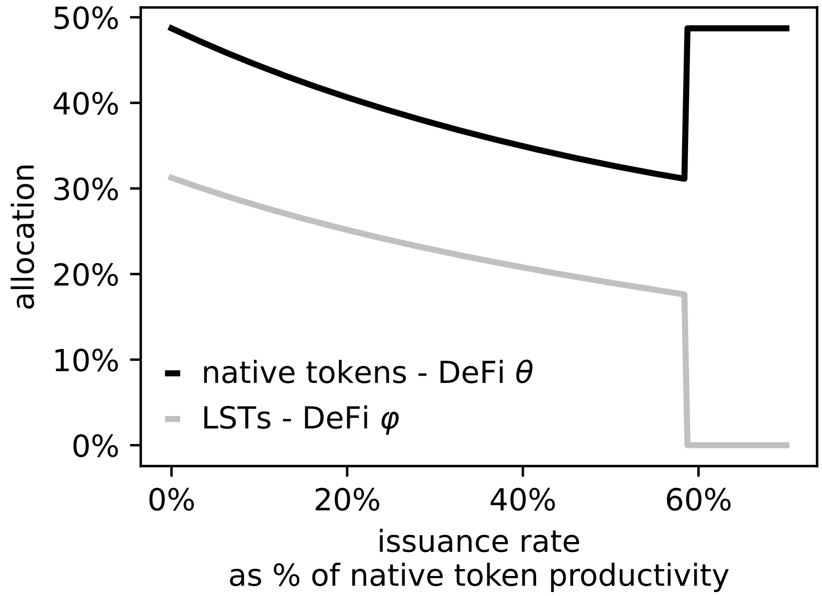

Figure 4. Equilibrium allocations to DeFi using native tokens, $\theta^{\star}$, and to DeFi using LSTs, $\varphi^{\star}$, as functions of the correlation ρ of the productivity rates of both token types. Model parameters are $\mu_D = \mu_L = 5\%$, $\sigma_D = 30\%$, $\xi_L = 40\%$, $\beta = 1\%$, and $\mu_I = 0.3\%$.

become more widely used for productive activity, the correlation between LST and native-token productivity rises, shrinking the set of issuance policies that can be implemented in equilibrium. Intuitively, as productive opportunities migrate toward LSTs, issuance becomes the primary, and eventually the only, dimension along which native tokens differ from LSTs. Since issuance weakens incentives to hold native tokens in DeFi, higher correlation compresses the feasible range of issuance rates, forcing the protocol to operate within a narrower policy space.

F. Strategic complementarity and the cost of liquidity

In this section, we assume that each infinitesimal user anticipates that the cost of using DeFi with either native tokens or LSTs is decreasing in the aggregate dollar scale of each activity, measured by D_t and L_t. Let $c : [0, \infty) \to [0, 1)$ denote a cost function that maps the aggregate scale of circulating tokens (native tokens or LSTs) into an effective proportional cost wedge associated with using that option for productive activity.

As before, let D_t denote the dollar value of productive native tokens, L_t the dollar value of productive LSTs, and S_t the dollar value of staked tokens. DeFi activity using native tokens generates stochastic dollar productivity and is subject to issuance taxation. Its dollar

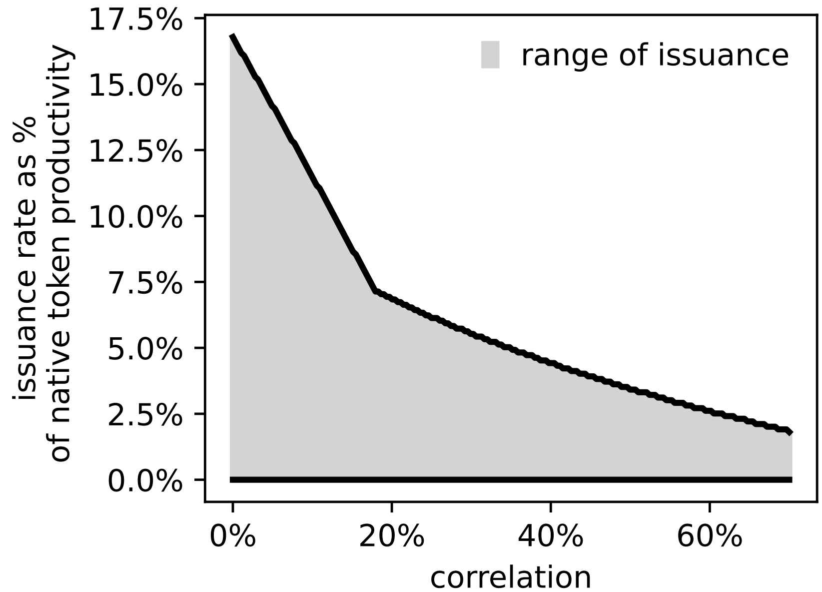

Figure 5. Range of possible implementable issuance by the blockchain which lead to non-zero native token holdings and monetary non-neutrality. This range is shown as function of the correlation ρ of the productivity rates of both token types. Model parameters are $\mu_D = \mu_L = 5\%$, $\sigma_D = \xi_L = 35\%$, and $\beta = 1\%$.

return is given by

$$\frac{d\nu_{D,t}}{\nu_{D,t}} = \underbrace{\mu_D, dt + \sigma_D, dW_{D,t}}_{\text{productivity}} - \underbrace{c\left(\frac{D_t}{P_t Q_t}\right)}_{\text{costs}} - \underbrace{\frac{S_t + L_t}{D_t}\frac{dI_t}{I_t}}_{\text{issuance tax}} . \tag{43}$$

Similarly, the return to DeFi activity conducted with LSTs is

$$\frac{d\nu_{L,t}}{\nu_{L,t}} = \underbrace{\mu_L, dt + \xi_L, dW_{L,t}}_{\text{productivity}} - \underbrace{c\left(\frac{L_t}{P_t Q_t}\right)}_{\text{costs}} + \underbrace{\frac{dI_t}{I_t}}_{\text{issuance revenue}} , \tag{44}$$

while the return to pure staking is as defined in (26).

The interior solution, subject to feasibility, of user i, then becomes

$$\theta_t^i = \frac{\left(\mu_D - c(\frac{D_t}{P_t Q_t}) - \frac{P_t Q_t}{D_t}\mu_{I,t}\right)\xi_L^2 - \left(\mu_L - c(\frac{L_t}{P_t Q_t})\right)\sigma_D \xi_L \rho}{\sigma_D^2 \xi_L^2 (1-\rho^2)}, \tag{45}$$

$$\varphi_t^i = \frac{\left(\mu_L - c(\frac{L_t}{P_t Q_t})\right)\sigma_D^2 - \left(\mu_D - c(\frac{D_t}{P_t Q_t}) - \frac{P_t Q_t}{D_t}\mu_{I,t}\right)\sigma_D \xi_L \rho}{\sigma_D^2 \xi_L^2 (1-\rho^2)} . \tag{46}$$

Assume the parametric form $c(x) = a(b - x)$ for the cost function. Following the same steps as above, we obtain the interior equilibrium

$$\theta = \frac{-B_\theta + \sqrt{B_\theta^2 + 4\,A_\theta\,\mu_{I,t}\,D}}{2\,A_\theta} \qquad \text{and} \qquad \varphi = \frac{\mu_L - ab - \sigma_D \xi_L \rho\,\theta}{\xi_L^2 - a},$$

where

$$A_\theta = (a - \sigma_D^2)D - B_1^2, \quad B_\theta = (\mu_D - ab)D + B_1(\mu_L - ab), \quad B_1 = \sigma_D \xi_L \rho, \quad D := a - \xi_L^2.$$

These expressions show that users optimally condition their portfolio choices on the aggregate scale of productive native tokens and productive LSTs. Anticipated token usage costs therefore generate strategic complementarities: as more users concentrate on one productive option, its effective cost declines, reinforcing further adoption.

To assess the quantitative implications of this complementarity, we solve for the full equilibrium as in Proposition 5 and reproduce Figures 1 and 3, now incorporating liquidity costs. Strategic complementarities amplify the effects of issuance and correlation, making the equilibrium in which no user employs native tokens for productive activity easier to reach. Recall that in such a regime, issuance no longer affects incentives.

Figure 6 illustrates how anticipated usage costs alter equilibrium allocations between native tokens and LSTs in DeFi. In particular, users become less tolerant to issuance. This occurs for two related reasons. First, issuance directly weakens the returns to native-token DeFi and, by reducing its scale, endogenously raises usage costs $c(\theta_t)$. What is a first-order tax in the baseline model therefore becomes a higher-order distortion once liquidity effects are anticipated. As a result, usage costs more rapidly erode the diversification benefits of native tokens.

Figure 7 shows that users are substantially less tolerant to increases in correlation between the productivity of the two tokens, as higher correlation further weakens diversification benefits. As a result, strategic complementarities further shrink the set of issuance policies that can be implemented in equilibrium.

IV. Conclusion

This paper studies issuance policy in proof-of-stake blockchains through the lens of a dynamic equilibrium model that makes explicit the interaction between productivity, security incentives, and financial innovation. In the absence of liquid staking, issuance redistributes value from productive on-chain activity to validators and thereby finances security through

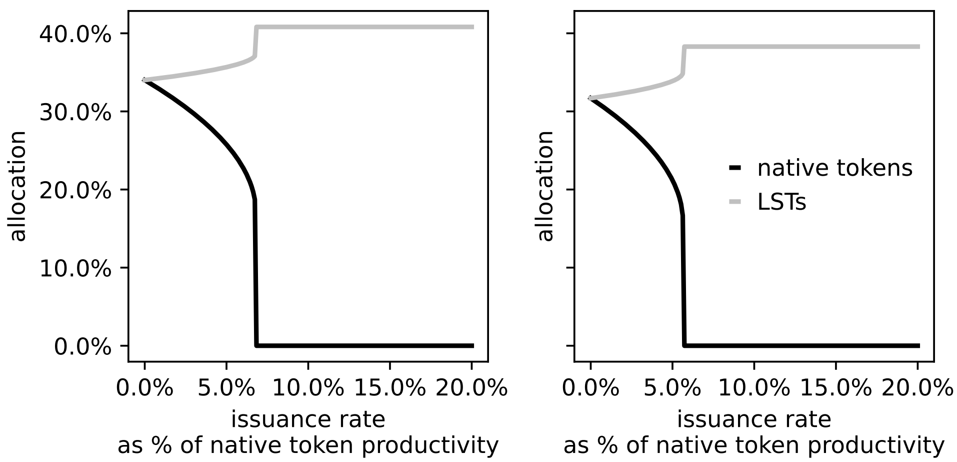

Figure 6. Equilibrium allocations to DeFi using native tokens, $\theta^{\star}$, and to DeFi using LSTs, $\varphi^{\star}$, as functions of the issuance rate. The issuance rate is expressed relative to native-token productivity, μ_I/μ_D. Model parameters are $\mu_D = \mu_L = 5\%$, $\sigma_D = \xi_L = 35\%$, $\beta = 1\%$, $\rho = 20\%$, $a = 0.005$, and $b = 1$. Left panel: without liquidity costs. Right panel: with liquidity costs.

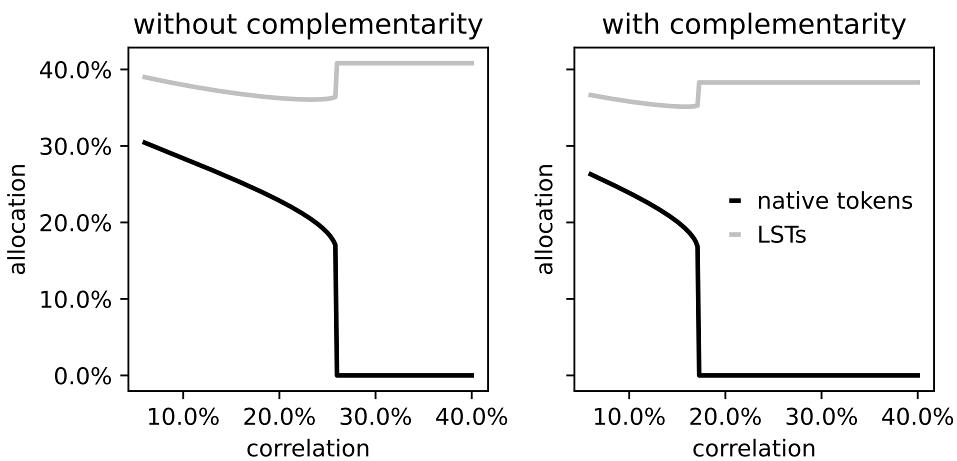

Figure 7. Equilibrium allocations to DeFi using native tokens, $\theta^{\star}$, and to DeFi using LSTs, $\varphi^{\star}$, as functions of the correlation ρ of the productivity rates of both token types. Model parameters are $\mu_D = \mu_L = 5\%$, $\sigma_D = \xi_L = 35\%$, $\beta = 1\%$, $\mu_I = 0.3\%$, $a = 0.005$, and $b = 1$. Left panel: without liquidity costs. Right panel: with liquidity costs.

a distortionary tax on production. This structure imposes an endogenous constraint on issuance-based policy: while higher issuance can initially raise staking revenues, excessive issuance contracts the productive base that sustains them. The resulting Laffer-curve relationship highlights that staking incentives are ultimately anchored in economic activity rather than created mechanically through token supply expansion.

Introducing liquid staking fundamentally alters this transmission mechanism. By allowing users to earn staking rewards while remaining productive, liquid staking weakens the link between issuance and portfolio choice and shifts adjustment away from the level of on-chain activity toward its composition. When liquid staking tokens are close substitutes for the native asset and benefit from endogenous liquidity effects, equilibrium allocations can become largely insensitive to issuance and slashing, with productive activity migrating away from the native token and security provision becoming increasingly intermediated. More broadly, the analysis illustrates a general limit of decentralized monetary policy: when financial innovation allows agents to bypass policy-induced distortions, traditional incentive tools lose traction. Understanding this interaction between protocol design, financial structure, and policy effectiveness is central to the long-run security and decentralization of proof-of-stake systems.

Appendix A. An Example of Issuance Policy without Liquid Staking

Consider the model of Section II. Suppose blockchain governance aims to maximize the long-run growth of the native token's market capitalization subject to a security constraint. The objective is to foster productivity and growth while ensuring that a target level of economic security, $\overline{S}$ (expressed in dollars), is maintained.

Formally, the blockchain chooses the issuance rate to maximize

$$V(\mu_I) = \mathbb{E}\left[\int_0^\infty d(P_t Q_t) - \phi \int_0^\infty (S_t - \overline{S})^2 \, dt\right],$$

where $\phi > 0$ scales the quadratic penalty associated with deviations of actual economic security S_t from the target $\overline{S}$.

Using the equilibrium dynamics of market capitalization (15), this problem is equivalent to maximizing instantaneous growth,

$$\theta_t^\star \mu_D - \beta - \phi \, P_t Q_t \left((1 - \theta_t^\star) - \frac{\overline{S}}{P_t Q_t}\right)^2 .$$

We first compute the optimal share of wealth allocated to productive activity that governance would like to implement. The first-order condition with respect to $\theta_t^\star$ yields

$$\theta_t^\star = 1 - \frac{2\phi \, \overline{S} - \mu_D}{P_t Q_t}.$$

Using the equilibrium relationship (14), the corresponding optimal issuance rate is then given by

$$\mu_{I,t} = \overline{\mu}_I - \left(\sigma_D - \frac{2\phi\overline{S} - \mu_D}{P_t Q_t}\sigma_D - \frac{\mu_D}{2\,\sigma_D}\right)^2 ,$$

subject to feasibility constraints.

This expression highlights the central trade-off faced by blockchain governance in our example: issuance policy balances long-run growth against economic security by adjusting incentives for productive activity and staking.

Appendix B. Token prices as an issuance tax channel

This appendix presents an alternative formulation of the baseline model in which issuance affects incentives of staking and DeFi through native token prices. The purpose is to make explicit that, even when issuance does not enter returns directly as a transfer as in our model, it still operates as a tax on productive activity through equilibrium price dynamics.

As in the core model, there is a continuum of homogeneous users with unit mass and continuous time. The dollar economy features a representative consumption good with price normalized to one. Each blockchain user $i \in [0,1]$ chooses a lifetime consumption stream $\{c_t^i\}_{t=0}^{\infty}$ to maximize

$$\mathbb{E}_0\left[\int_0^\infty e^{-\beta t}\log(c_t^i)\,dt\right]. \tag{B1}$$

At each time $t \geq 0$, users allocate wealth between consumption and two blockchain investments: DeFi and staking. Both investments require holding the native token, so returns depend on token price dynamics.

Returns. The return to one dollar invested in DeFi reflects both stochastic productivity and changes in the native token price:

$$\frac{d\nu_{D,t}}{\nu_{D,t}} = \mu_D\,dt + \sigma_D\,dW_{D,t} + \frac{dP_t}{P_t}. \tag{B2}$$

Similarly, staking earns issuance rewards in addition to token price appreciation,

$$\frac{d\nu_{S,t}}{\nu_{S,t}} = \mu_{I,t}\,dt + \frac{dP_t}{P_t}. \tag{B3}$$

Let x_t^i denote the dollar net worth of user i. Each user allocates a fraction θ_t^i of wealth to DeFi, with the remaining share $1-\theta_t^i$ invested in staking. Borrowing and short selling are ruled out. The native token price follows

$$\frac{dP_t}{P_t} = \mu_{P,t}\,dt + \sigma_{P,t}\,dW_{D,t}, \tag{B4}$$

where equilibrium loadings are determined below.

User optimization. Proceeding as in the baseline model, optimal consumption satisfies $c_t^{i\star} = \beta x_t^i$, and the optimal portfolio share is common across users,

$$\theta_t = \frac{\mu_D - \mu_{I,t} - \sigma_D\sigma_{P,t}}{\sigma_D^2}. \tag{B5}$$

Aggregation and market clearing. Aggregate wealth equals the market capitalization of the native token. As before, aggregate productivity drives market capitalization dynamics,

$$\frac{d(P_t Q_t)}{P_t Q_t} = \theta_t\big(\mu_D\, dt + \sigma_D\, dW_{D,t}\big) - \beta\, dt. \tag{B6}$$

Native token supply evolves through issuance applied to staked tokens,

$$dQ_t = \frac{S_t}{P_t}\frac{dI_t}{I_t}, \tag{B7}$$

and market clearing implies

$$D_t = \theta_t P_t Q_t, \qquad S_t = (1-\theta_t) P_t Q_t.$$

Hence, in equilibrium, the dynamics of the token supply are

$$\frac{dQ_t}{Q_t} = (1-\theta_t)\, \mu_{I,t}\, dt. \tag{B8}$$

Applying Itô's lemma to $P_t Q_t$ yields

$$\frac{d(P_t Q_t)}{P_t Q_t} = \mu_{P,t}\, dt + \sigma_{P,t}\, dW_{D,t} + (1-\theta_t)\mu_{I,t}\, dt. \tag{B9}$$

Matching with (B6) gives the equilibrium price loadings

$$\mu_{P,t} = \frac{\mu_D^2 - \mu_{I,t}^2}{2\sigma_D^2} - \beta - \mu_{I,t}, \qquad \sigma_{P,t} = \frac{\mu_D - \mu_{I,t}}{2\sigma_D}.$$

Substituting back into (B5) yields the equilibrium portfolio allocation

$$\theta_t = \frac{\mu_D - \mu_{I,t}}{2\sigma_D^2}. \tag{B10}$$

Equilibrium dollar returns. Substituting equilibrium price dynamics into asset returns yields transparent expressions for dollar returns. In equilibrium, the dollar expected return of DeFi is

$$P_t\, Q_t\, \frac{\mu_D - \mu_{I,t}}{2\,\sigma_D^2} \left(\mu_D + \frac{\mu_D^2 - \mu_{I,t}^2}{2\sigma_D^2} - \beta - \mu_{I,t}\right)$$

while the dollar return to staking is

$$P_t\, Q_t \left(1 - \frac{\mu_D - \mu_{I,t}}{2\,\sigma_D^2}\right)\left(\frac{\mu_D^2 - \mu_{I,t}^2}{2\sigma_D^2} - \beta\right).$$

Even though issuance is not modeled as an explicit tax in the returns of DeFi users, the tax is a consequence of equilibrium token prices in this formulation: it generates the same qualitative forces as in the baseline model. Higher issuance depresses productive allocations by reducing the expected growth of the token price, shrinking the productive base that finances security. Staking rewards initially increase with issuance but eventually decline as productive activity contracts, generating a Laffer-curve–type relationship between issuance and security incentives.

Appendix C. Proofs

Appendix A. Proof of Proposition 1

Fix a user i. The budget law and asset returns (given D_t, S_t and the issuance process) are

$$\frac{dx_t^i}{x_t^i} = \theta_t^i \frac{d\nu_{D,t}}{\nu_{D,t}} + \left(1 - \theta_t^i\right) \frac{d\nu_{S,t}}{\nu_{S,t}} - \frac{c_t^i}{x_t^i}\, dt. \tag{C1}$$

Collecting drift and diffusion terms in (C1) yields

$$\begin{aligned} \frac{dx_t^i}{x_t^i} = &\left(\mu_{I,t} + \theta_t^i\big(\mu_D - (1 + \tfrac{S_t}{D_t})\mu_{I,t}\big)\right) dt - \frac{c_t^i}{x_t^i}\, dt \\ &+ \theta_t^i \,\sigma_D\, dW_{D,t}. \end{aligned} \tag{C2}$$

The value function $V(x)$ satisfies the Hamilton–Jacobi–Bellman equation

$$\begin{aligned} \beta V(x) = \max_{c \geq 0,\, \theta} \Big\{ &\log c + V_x x \Big(\mu_I + \theta(\mu_D - (1 + \tfrac{S}{D})\mu_I) - \tfrac{c}{x}\Big) \\ &+ \tfrac{1}{2} V_{xx} x^2 \big(\theta \sigma_D\big)^2 \Big\}, \end{aligned} \tag{C3}$$

for state variables $D = D_t$, $S = S_t$, and $\mu_I = \mu_{I,t}$.
Use the standard log-utility ansatz

$$V(x) = K + \frac{1}{\beta} \log x.$$

Then $V_x = \frac{1}{\beta x}$ and $V_{xx} = -\frac{1}{\beta x^2}$.

Optimizing (C3) with respect to c, the first-order condition is

$$\frac{1}{c} - \frac{1}{\beta x} = 0,$$

so the optimal consumption rule is

$$c_t^{i\star} = \beta\, x_t^i.$$

Substituting $c = c^{i\star}$, the remaining maximization problem over θ is equivalent to maximizing

$$\mathcal{G}(\theta) = \mu_I + \theta(\mu_D - (1 + \tfrac{S}{D})\mu_I) - \tfrac{1}{2}\,\sigma_D^2\,\theta^2 \tag{C4}$$

over $\theta \in [0, 1]$. Since

$$\frac{\partial^2 \mathcal{G}}{\partial \theta^2} = -\sigma_D^2 < 0,$$

the objective (C4) is strictly concave in θ and admits at most one stationary point $\theta^\star \in \mathbb{R}$. Hence the constrained optimum is

$$\theta_t^{i\star} = \min\{\max\{\theta^\star, 0\}, 1\}.$$

For an interior solution, the first-order condition is

$$0 = \mu_D - (1 + \tfrac{S}{D})\mu_I - \sigma_D^2\,\theta. \tag{C5}$$

Rearranging yields

$$\theta\,\sigma_D^2 = \mu_D - (1 + \tfrac{S}{D})\mu_I,$$

which gives the interior solution stated in the proposition.

Finally, substituting $c^{i\star}$ and $\theta^{i\star}$ back into the HJB equation and canceling $\log x$ terms yields

$$\beta K = \log\beta - 1 + \frac{1}{\beta}\mu_p(\theta^{i\star}) - \frac{1}{2\beta}\sigma_p(\theta^{i\star})^2,$$

where

$$\mu_p(\theta) = \mu_I + \theta(\mu_D - (1 + \tfrac{S}{D})\mu_I), \qquad \sigma_p(\theta) = \theta\,\sigma_D.$$

Since the second derivative of $\mathcal{G}$ is strictly negative, the solution is a maximum. This completes the proof. $\square$

Appendix B. Staking share elasticity of issuance

Given aggregate share Θ, the individual's marginal net benefit of investing more in DeFi is

$$\mu_D - \tfrac{S}{D}\mu_I - \mu_I - \sigma_D^2\theta,$$

As functions of the aggregate DeFi share,

$$1 + S/D = 1 + (1 - \Theta)/\Theta = 1/\Theta,$$

Appendix C. Proof of Proposition 2

Start from the individual portfolio first-order condition; see Proposition 1 and (C5):

$$0 \;=\; \mu_D - \Big(1 + \frac{S}{D}\Big)\mu_I - \sigma_D^2\,\theta,$$

which holds for any interior optimum θ before imposing market clearing. Impose the market-clearing relation

$$\frac{S}{D} = \frac{1-\theta}{\theta} \quad\Longrightarrow\quad 1 + \frac{S}{D} = \frac{1}{\theta}.$$

Substituting $1 + S/D = 1/\theta$ into the FOC and multiplying by θ yields the quadratic equation for an equilibrium θ:

$$\sigma_D^2\theta^2 - \mu_D\theta + \mu_I = 0.$$

The discriminant of this quadratic is

$$\Delta = \mu_D^2 - 4\sigma_D^2\mu_I.$$

Corner $\theta^\star = 0$ and the upper threshold $\underline{\mu}_I$. If $\mu_I \geq \dfrac{\mu_D^2}{4\sigma_D^2}$ then $\Delta \leq 0$ and there is no real interior root. In this case the polynomial

$$\mu_D\theta - \sigma_D^2\theta^2$$

attains its global maximum at $\theta = \dfrac{\mu_D}{2\sigma_D^2}$ with maximum value $\dfrac{\mu_D^2}{4\sigma_D^2}$. Hence for every $\theta \in (0, 1]$

$$\mu_D\theta - \sigma_D^2\theta^2 - \mu_I \leq \frac{\mu_D^2}{4\sigma_D^2} - \mu_I \leq 0,$$

so the best-response mapping is downward on $(0, 1]$ and the only tâtonnement-stable feasible outcome is the boundary $\theta^\star = 0$. This proves the claim about the upper threshold

$$\overline{\mu}_I = \frac{\mu_D^2}{4\sigma_D^2}.$$

Corner $\theta^\star = 1$ and the lower threshold $\underline{\mu}_I$. To check whether full DeFi adoption $\theta = 1$ is an equilibrium, evaluate the individual corner condition at $S/D = 0$ (which corresponds to $\theta = 1$). The individual condition for $\theta = 1$ is

$$\mu_D - (1 + \tfrac{S}{D})\mu_I \geq \sigma_D^2.$$

With $S/D = 0$ this reduces to

$$\mu_D - \mu_I \geq \sigma_D^2,$$

or equivalently

$$\mu_I \leq \mu_D - \sigma_D^2.$$

Thus the lower threshold

$$\underline{\mu}_I = \mu_D - \sigma_D^2$$

characterizes the parameter region where $\theta^\star = 1$ is an equilibrium (users prefer no infinitesimal deviation toward staking). Note that $\underline{\mu}_I \leq \overline{\mu}_I$. Thus, when $\mu_I \leq \underline{\mu}_I$ users optimally only invest in DeFi.

Interior case. If $\underline{\mu}_I < \mu_I < \overline{\mu}_I$ then $\Delta > 0$ and the quadratic admits two distinct real roots

$$\theta_\pm = \frac{\mu_D \pm \sqrt{\mu_D^2 - 4\sigma_D^2\mu_I}}{2\sigma_D^2}, \qquad \theta_+ \geq \theta_-.$$

We select the economically relevant one as follows.

(i) *Continuity (Kelly limit).* As $\mu_I \downarrow 0$,

$$\theta_+ \longrightarrow \frac{\mu_D}{\sigma_D^2}, \qquad \theta_- \longrightarrow 0.$$

Therefore the "+" root θ_+ is the continuous continuation of the Kelly/Merton fraction μ_D/σ_D^2 as issuance vanishes, making it the natural candidate on continuity grounds.

(ii) *Welfare selection.* With log utility and $c_t = \beta x_t$ the welfare ordering coincides with the long-run expected log-growth

$$g(\theta) = \mu_p(\theta) - \tfrac{1}{2}\sigma_p(\theta)^2.$$

On the equilibrium manifold (where $1 + S/D = 1/\theta$) issuance terms cancel and

$$\mu_p(\theta) = \theta\mu_D, \qquad \sigma_p(\theta) = \theta\sigma_D,$$

so

$$g(\theta) = \theta\mu_D - \tfrac{1}{2}\sigma_D^2\theta^2.$$

For any algebraic root θ^* the fixed-point equation gives $\mu_I = \mu_D\theta^* - \sigma_D^2\theta^{*2}$, hence

$$g(\theta^*) = \mu_I + \tfrac{1}{2}\sigma_D^2\theta^{*2}.$$

Because $\sigma_D^2 > 0$, $g(\theta^*)$ is strictly increasing in θ^*. Therefore between the two algebraic roots $\theta_- < \theta_+$ the larger root θ_+ yields strictly higher long-run growth and thus strictly higher discounted log-utility. Together with continuity, this selects θ_+ as the unique interior equilibrium root that is both continuous in μ_I and welfare-maximising.

The closed-form representation given in the proposition follows by algebra:

$$\theta^\star = \theta_+ = \frac{\mu_D + \sqrt{\mu_D^2 - 4\sigma_D^2\mu_I}}{2\sigma_D^2} = \frac{\mu_D}{2\sigma_D^2} + \frac{1}{\sigma_D}\sqrt{\overline{\mu}_I - \mu_I},$$

valid for $\underline{\mu}_I < \mu_I < \overline{\mu}_I$ (and subject to feasibility $0 < \theta^\star < 1$).

Aggregate net worth. Aggregate net worth of blockchain users (equivalently market capitalisation P_tQ_t) evolves according to the equilibrium portfolio returns net of aggregate consumption. On the equilibrium manifold the portfolio drift and diffusion are $\mu_p(\theta^\star) = \theta^\star\mu_D$ and $\sigma_p(\theta^\star) = \theta^\star\sigma_D$. Since each user consumes $c_t = \beta x_t$, aggregate consumption removes rate β from log-wealth growth. Therefore the aggregate wealth process satisfies

$$\frac{d(P_tQ_t)}{P_tQ_t} = \mu_p(\theta^\star)\,dt + \sigma_p(\theta^\star)\,dW_{D,t} - \beta\,dt = \theta^\star\big(\mu_D\,dt + \sigma_D\,dW_{D,t}\big) - \beta\,dt,$$

which is (36) in the proposition. This completes the proof. $\square$

Appendix D. Proof of Proposition 3

Prices follow the dynamics (17). Use the dynamics of the supply (20) and Ito's lemma to write

$$\frac{d(P_tQ_t)}{P_tQ_t} = \mu_{P,t}\,dt + \sigma_{P,t}\,dW_{D,t} + (1-\theta_t^\star)\;\mu_{I,t}\,dt\,.$$

By the equilibrium law of motion of the market capitalization in (36), we have

$$\frac{d(P_tQ_t)}{P_tQ_t} = \theta_t^\star\left(\mu_D\,dt + \sigma_D\,dW_{D,t}\right) - \beta\,dt\,.$$

By identification of the drift and volatility loadings, the proof is complete.

Appendix E. Proof of Proposition 4.

Fix a user i and hold the aggregates D_t, S_t, L_t and $\mu_{I,t}$ fixed. For notational simplicity, time subscripts are omitted when no confusion arises.

Wealth dynamics and HJB. The wealth process of user $i \in [0,1]$ satisfies

$$\frac{dx_t^i}{x_t^i} = \theta_t^i \frac{d\nu_{D,t}}{\nu_{D,t}} + \varphi_t^i \frac{d\nu_{L,t}}{\nu_{L,t}} + (1 - \theta_t^i - \varphi_t^i)\frac{d\nu_{S,t}}{\nu_{S,t}} - \frac{c_t^i}{x_t^i}\, dt.$$

Using $\frac{dI_t}{I_t} = \mu_{I,t}\, dt$ and the asset returns, wealth dynamics can be written as

$$\frac{dx_t^i}{x_t^i} = \Big(\theta(\mu_D - (1 + \tfrac{S+L}{D})\mu_I) + \varphi\mu_L + \mu_I - \tfrac{c}{x}\Big)\, dt + \theta\sigma_D\, dW_D + \varphi\xi_L\, dW_L.$$

The Hamilton–Jacobi–Bellman equation is therefore

$$\beta V(x) = \max_{c \geq 0,\, \theta, \varphi} \Big\{ \log c + V_x x \Big(\theta(\mu_D - (1 + \tfrac{S+L}{D})\mu_I) + \varphi\mu_L + \mu_I - \tfrac{c}{x}\Big) \\ + \tfrac{1}{2} V_{xx} x^2 \big(\theta^2\sigma_D^2 + \varphi^2\xi_L^2 + 2\theta\varphi\sigma_D\xi_L\rho\big)\Big\}.$$

Consumption. Using the standard log-utility ansatz $V(x) = K + \frac{1}{\beta}\log x$, we have $V_x = 1/(\beta x)$ and $V_{xx} = -1/(\beta x^2)$. The first-order condition for c is $1/c - 1/(\beta x) = 0$, which yields

$$c_t^{i,\star} = \beta\, x_t^i.$$

Reduced portfolio problem. Substituting $c = \beta x$ into the HJB reduces the remaining problem to

$$\max_{(\theta,\varphi)\in\mathcal{S}} \mathcal{G}(\theta, \varphi),$$

where

$$\mathcal{G}(\theta,\varphi) = \theta\Big(\mu_D - \Big(1 + \frac{S+L}{D}\Big)\mu_I\Big) + \varphi\mu_L + \mu_I - \tfrac{1}{2}\Big(\theta^2\sigma_D^2 + \varphi^2\xi_L^2 + 2\theta\varphi\sigma_D\xi_L\rho\Big),$$

and $\mathcal{S} = \{(\theta,\varphi) : 0 \leq \theta,\, 0 \leq \varphi,\, \theta + \varphi \leq 1\}$. Since $|\rho| < 1$, the quadratic form in the variance term is positive definite, hence $\mathcal{G}$ is strictly concave and the maximiser over $\mathcal{S}$ is unique.

Interior solution. If an interior maximiser satisfies $\theta > 0$, $\varphi > 0$, and $\theta + \varphi < 1$, the first-order conditions $\partial_\theta \mathcal{G} = 0$ and $\partial_\varphi \mathcal{G} = 0$ give the linear system

$$\begin{pmatrix} \sigma_D^2 & \sigma_D \xi_L \rho \\ \sigma_D \xi_L \rho & \xi_L^2 \end{pmatrix} \begin{pmatrix} \theta \\ \varphi \end{pmatrix} = \begin{pmatrix} \mu_D - (1 + \frac{S+L}{D})\mu_I \\ \mu_L \end{pmatrix}.$$

Because the determinant equals $\sigma_D^2 \xi_L^2 (1 - \rho^2) > 0$, this system has a unique solution, which coincides with the interior candidate stated in the proposition. If this solution lies in $\mathcal{S}$, strict concavity implies that it is the unique global optimum.

Faces $\theta = 0$ and $\varphi = 0$. If the interior candidate is not feasible, the maximiser must lie on the boundary of $\mathcal{S}$. On the face $\theta = 0$, the problem reduces to

$$\max_{0 \le \varphi \le 1} \varphi \mu_L + \mu_I - \tfrac{1}{2} \varphi^2 \xi_L^2,$$

whose first-order condition yields $\varphi = \mu_L / \xi_L^2$. Restricting to $[0, 1]$ gives

$$\varphi_t^{i,\star} = \min\{\max\{\mu_L / \xi_L^2, 0\}, 1\}.$$

Similarly, on the face $\varphi = 0$ the reduced problem is

$$\max_{0 \le \theta \le 1} \theta \big(\mu_D - (1 + \tfrac{S+L}{D})\mu_I\big) + \mu_I - \tfrac{1}{2} \theta^2 \sigma_D^2,$$

with first-order condition $\theta = (\mu_D - (1 + \frac{S+L}{D})\mu_I)/\sigma_D^2$. Restricting to $[0, 1]$ yields the expression for $\theta_t^{i,\star}$ in the proposition.

Face $\theta + \varphi = 1$. On the face $\theta + \varphi = 1$, set $\varphi = 1 - \theta$. The objective becomes

$$\begin{aligned} \mathcal{G}(\theta, 1-\theta) = \theta \Big(\mu_D - \frac{S+L}{D}\mu_I\Big) + (1-\theta)(\mu_L + \mu_I) \\ - \tfrac{1}{2}\Big(\theta^2 \sigma_D^2 + (1-\theta)^2 \xi_L^2 + 2\theta(1-\theta)\sigma_D \xi_L \rho\Big). \end{aligned}$$

Differentiating and setting the derivative equal to zero gives

$$0 = \mu_D - \mu_L - \Big(1 + \frac{S+L}{D}\Big)\mu_I - \theta(\sigma_D^2 + \xi_L^2 - 2\sigma_D \xi_L \rho) + (\xi_L^2 - \sigma_D \xi_L \rho),$$

which yields the solution for $\theta_t^{i,\star}$ in the proposition. Restricting this value to $[0, 1]$ gives the maximizer on the face $\theta + \varphi = 1$.

Corners and selection. Finally, evaluate $\mathcal{G}$ at the pure corners

$$(0,0), \quad (1,0), \quad (0,1),$$

which yields

$$\mathcal{G}(0,0) = \mu_I, \qquad \mathcal{G}(1,0) = \mu_D - \frac{S+L}{D}\mu_I - \tfrac{1}{2}\sigma_D^2, \qquad \mathcal{G}(0,1) = \mu_L + \mu_I - \tfrac{1}{2}\xi_L^2,$$

and compare these values with the value attained on the face $\theta + \varphi = 1$. Because $\mathcal{G}$ is strictly concave and $\mathcal{S}$ is compact, if the interior solution is infeasible the global maximiser must be attained at one of these boundary candidates. This completes the proof. □

Appendix F. Proof of Proposition 6

The equilibrium law of motion of token supply is

$$dQ_t = \frac{S_t + L_t}{P_t}\frac{dI_t}{I_t} = (1 - \theta_t^\star)\, Q_t\, \mu_{I,t}\, dt\,.$$

Prices follow the dynamics (37). Use the dynamics of the supply above and Ito's lemma to write

$$\frac{d(P_tQ_t)}{P_tQ_t} = \mu_{P,t}\, dt + \sigma_{P,t}\, dW_{D,t} + \xi_{P,t}\, dW_{L,t} + (1 - \theta_t^\star)\, \mu_{I,t}\, dt\,.$$

By the equilibrium law of motion of the market capitalization in (36), we have

$$\frac{d(P_tQ_t)}{P_tQ_t} = \theta_t^\star \left(\mu_D\, dt + \sigma_D\, dW_{D,t}\right) + \varphi_t^\star \left(\mu_L\, dt + \sigma_L\, dW_{L,t}\right) - \beta\, dt\,.$$

By identification of the drift and volatility loadings, the proof is complete.

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