Lux Tokenomics: Economic Design for Multi-Chain Consensus Networks

Token Distribution, Staking Economics, Fee Burning, and Inflation–Deflation Mechanics for Sustainable Network Growth

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Abstract

We present the complete tokenomic framework for Lux Network, a multi-consensus blockchain platform supporting heterogeneous appchains with independent virtual machines. The Lux token (LUX) serves simultaneously as the staking asset for Proof-of-Stake consensus, the gas token for transaction fees on the primary network, and the economic coordination mechanism across sovereign appchains. This paper formalizes the token supply schedule, derives optimal staking reward functions under rational validator assumptions, introduces an adaptive fee-burning mechanism that targets long-run deflation proportional to network utilization, and analyzes the game-theoretic equilibrium of validator participation. We prove that the proposed reward function satisfies incentive compatibility under a Byzantine adversary controlling up to one-third of stake, and we show via simulation that the fee-burning mechanism converges to a stable equilibrium supply within 200 epochs under realistic transaction volume growth. Finally, we compare the Lux tokenomic model against Ethereum EIP-1559, Cosmos ATOM inflation, and Polkadot DOT mechanics, demonstrating superior capital efficiency and lower variance in validator returns.

1 Introduction

The design of a token economy for a multi-chain blockchain platform presents unique challenges that do not arise in single-chain systems. In a multi-chain architecture such as Lux Network, the native token must serve several distinct economic functions simultaneously: securing consensus through staking, pricing computational resources through transaction fees, coordinating economic activity across sovereign appchains, and providing a store of value for long-term network participants [1, 2].

Traditional tokenomic models, such as Bitcoin's fixed-supply halving schedule [1] or Ethereum's EIP-1559 base fee mechanism [3], are designed for single-chain environments and do not account for the cross-chain dynamics inherent in multi-appchain architectures. The Cosmos model [4] addresses multi-chain economics through the ATOM staking token but relies on inflationary rewards that dilute non-staking holders. Polkadot's candle auction mechanism [5] ties parachain access to token lockup, creating capital inefficiency.

This paper introduces a unified tokenomic framework for Lux Network that addresses these limitations through three key innovations:

(i) **Adaptive reward functions**: Staking rewards adjust dynamically based on the ratio of staked to circulating supply, targeting an optimal staking ratio that balances network security with liquidity.

(ii) **Multi-tier fee burning**: Transaction fees are partially burned at rates that vary by appchain type, creating deflationary pressure proportional to network utilization.

(iii) **Appchain economic coupling**: A portion of appchain validator rewards derives from primary network activity, creating positive-sum economic incentives for ecosystem growth.

The remainder of this paper is organized as follows. Section 2 defines the token supply model and distribution schedule. Section 3 formalizes the staking reward mechanism. Section 4 introduces the adaptive fee-burning protocol. Section 5 presents game-theoretic analysis of validator behavior. Section 6 discusses appchain economic coupling. Section 7 provides simulation results. Section 8 compares with existing systems. Section 11 concludes.

2 Token Supply Model

2.1 Initial Distribution

The Lux token (LUX) has a genesis supply of $S_0 = 500{,}000{,}000$ tokens distributed according to the allocation in Table 1.

Table 1: Genesis token distribution for Lux Network.

Category	Allocation (%)	Tokens	Vesting
Validator Rewards	35.0	175,000,000	Released per epoch over 10 years
Foundation Reserve	15.0	75,000,000	4-year linear with 1-year cliff
Core Contributors	15.0	75,000,000	4-year linear with 1-year cliff
Ecosystem Fund	12.0	60,000,000	Governed by DAO
Public Sale	10.0	50,000,000	25% at TGE, 12-month linear
Strategic Partners	8.0	40,000,000	3-year linear with 6-month cliff
Community Airdrops	5.0	25,000,000	Distributed over 24 months

2.2 Supply Dynamics

Let S_t denote the circulating supply at epoch t, R_t the rewards emitted, B_t the tokens burned from fees, and V_t the tokens vested from locked allocations. The supply evolves as:

$$S_{t+1} = S_t + R_t + V_t - B_t \tag{1}$$

Definition 1 (Net Emission Rate)**.** *The net emission rate at epoch t is defined as $\eta_t = (R_t + V_t - B_t)/S_t$. The network is deflationary when $\eta_t < 0$.*

The vesting schedule V_t is deterministic and decays to zero after all allocations unlock. The reward emission R_t follows a decreasing schedule defined in Section 3. The burn B_t depends on transaction volume. The design target is $\eta_t < 0$ once vesting completes and network utilization exceeds a threshold.

2.3 Maximum Supply and Asymptotic Behavior

Theorem 1 (Bounded Supply)**.** *Under the reward schedule defined in equation (3) and assuming transaction volume grows at rate $g > 0$ per epoch, the total supply S_t is bounded above by $S_{\max} = 720{,}000{,}000$ LUX and converges to a stable equilibrium $S^* < S_{\max}$ as $t \to \infty$.*

Proof. The reward emission $R_t = R_0 \cdot \alpha^t$ with decay factor $\alpha \in (0, 1)$ forms a geometric series with sum $R_0/(1-\alpha)$. Vesting V_t is finite and terminates at epoch T_v. The cumulative maximum supply is:

$$S_{\max} = S_0 + \sum_{t=0}^{\infty} R_t + \sum_{t=0}^{T_v} V_t = S_0 + \frac{R_0}{1-\alpha} + V_{\text{total}} \tag{2}$$

With $R_0 = 5{,}000{,}000$, $\alpha = 0.97$, and $V_{\text{total}} = 175{,}000{,}000$, we get $S_{\max} \approx 720{,}000{,}000$. Since $B_t > 0$ for all t with positive transaction volume, the actual supply $S_t < S_{\max}$ for all t. For the convergence, observe that $R_t \to 0$ while B_t grows with transaction volume, so there exists t^* such that $B_t > R_t + V_t$ for all $t > t^*$, after which S_t is strictly decreasing and bounded below by zero. The sequence converges by the monotone convergence theorem. □

3 Staking Reward Mechanism

3.1 Reward Schedule

The per-epoch reward emission follows an exponentially decaying schedule:

$$R_t = R_0 \cdot \alpha^t \cdot f(\sigma_t) \tag{3}$$

where $R_0 = 5{,}000{,}000$ LUX is the initial epoch reward, $\alpha = 0.97$ is the annual decay factor, and $f(\sigma_t)$ is a staking ratio adjustment function.

3.2 Staking Ratio Adjustment

Let $\sigma_t = \text{Staked}_t / S_t$ denote the staking ratio at epoch t, and let $\sigma^* = 0.67$ be the target staking ratio. The adjustment function is:

$$f(\sigma_t) = \begin{cases} 1 + \beta \cdot (\sigma^* - \sigma_t) & \text{if } \sigma_t < \sigma^* \\ 1 - \gamma \cdot (\sigma_t - \sigma^*) & \text{if } \sigma_t \geq \sigma^* \end{cases} \tag{4}$$

where $\beta = 2.0$ and $\gamma = 1.5$ are elasticity parameters. When staking is below target, rewards increase to attract stakers. When above target, rewards decrease to release liquidity.

Proposition 2 (Staking Ratio Convergence)**.** *Under rational validator assumptions, the staking ratio σ_t converges to σ^* as $t \to \infty$.*

Proof. A rational validator stakes if the expected staking yield $y_t = R_t \cdot f(\sigma_t)/(\sigma_t \cdot S_t)$ exceeds the opportunity cost r_t of capital. If $\sigma_t < \sigma^*$, then $f(\sigma_t) > 1$, increasing y_t and attracting additional stake. If $\sigma_t > \sigma^*$, then $f(\sigma_t) < 1$, decreasing y_t below r_t for marginal validators, causing unstaking. The unique fixed point is $\sigma_t = \sigma^*$ where $f(\sigma^*) = 1$. □

3.3 Individual Validator Rewards

For a validator i with stake s_i in epoch t, the reward is:

$$r_{i,t} = R_t \cdot \frac{s_i \cdot u_i}{\sum_{j \in \mathcal{V}_t} s_j \cdot u_j} \tag{5}$$

where $u_i \in [0, 1]$ is the uptime factor for validator i and $\mathcal{V}_t$ is the active validator set. The uptime factor is computed as $u_i = \min(1, T_{\text{online},i}/T_{\text{epoch}})$, where $T_{\text{online},i}$ is the number of slots in which validator i participated in consensus.

Algorithm 1 Per-Epoch Reward Distribution

Require: Active validators $\mathcal{V}_t$, stakes $\{s_i\}$, uptimes $\{u_i\}$
Ensure: Reward allocations $\{r_{i,t}\}$

$\sigma_t \leftarrow \sum_{i \in \mathcal{V}_t} s_i / S_t$
$R_t \leftarrow R_0 \cdot \alpha^t \cdot f(\sigma_t)$
$W \leftarrow \sum_{i \in \mathcal{V}_t} s_i \cdot u_i$
for each validator $i \in \mathcal{V}_t$ **do**
    $r_{i,t} \leftarrow R_t \cdot (s_i \cdot u_i)/W$
    $r_{i,\text{self}} \leftarrow r_{i,t} \cdot c_i$ ▷ Commission portion
    $r_{i,\text{delegators}} \leftarrow r_{i,t} - r_{i,\text{self}}$ ▷ Delegator portion
    Distribute $r_{i,\text{delegators}}$ pro-rata to delegators of i
end for

3.4 Delegation Mechanics

Delegators select a validator and stake tokens through delegation contracts. Each validator sets a commission rate $c_i \in [0.05, 0.25]$ with a minimum of 5% and maximum of 25%. Delegators receive rewards proportional to their delegated stake, net of commission:

$$r_{d,t} = r_{i,t} \cdot (1 - c_i) \cdot \frac{s_d}{\sum_{d' \in \mathcal{D}_i} s_{d'}} \tag{6}$$

where $\mathcal{D}_i$ is the set of delegators to validator i and s_d is delegator d's stake.

4 Adaptive Fee-Burning Protocol

4.1 Transaction Fee Structure

Lux Network uses a two-component fee model inspired by EIP-1559 [3] but extended for multi-chain environments:

$$\text{Fee}(\text{tx}) = \text{BaseFee}_t \cdot \text{GasUsed}(\text{tx}) + \text{PriorityFee}(\text{tx}) \tag{7}$$

The base fee adjusts per block according to utilization:

$$\text{BaseFee}_{t+1} = \text{BaseFee}_t \cdot \left(1 + \frac{1}{8} \cdot \frac{G_t - G^*}{G^*}\right) \tag{8}$$

where G_t is the gas used in block t and $G^* = 15{,}000{,}000$ is the target gas per block.

4.2 Burn Rate Function

The burn rate ϕ_t determines the fraction of base fees burned versus distributed to validators:

$$\phi_t = \phi_{\min} + (\phi_{\max} - \phi_{\min}) \cdot \min\left(1, \frac{G_t}{G_{\text{cap}}}\right) \tag{9}$$

where $\phi_{\min} = 0.50$, $\phi_{\max} = 0.90$, and $G_{\text{cap}} = 30{,}000{,}000$. Under light load, 50% of base fees are burned. Under maximum load, 90% are burned. The total burn in epoch t is:

$$B_t = \sum_{\text{blocks } b \in t} \phi_b \cdot \text{BaseFee}_b \cdot G_b \tag{10}$$

Priority fees are never burned; they go entirely to the block proposer as a tip for transaction ordering.

Proposition 3 (Deflationary Threshold)**.** *The network becomes net deflationary when the average block utilization exceeds $\bar{G} > G^* \cdot R_t/(\phi_{\min} \cdot \text{BaseFee}_t \cdot N_b)$, where N_b is the number of blocks per epoch.*

4.3 Multi-Chain Fee Aggregation

Each appchain k contributes to the primary network burn through a appchain fee tax τ_k:

$$B_t^{\text{total}} = B_t^{\text{primary}} + \sum_{k \in \mathcal{K}} \tau_k \cdot F_k^t \tag{11}$$

where F_k^t is the total fee revenue on appchain k in epoch t. The tax rate τ_k depends on the appchain's economic relationship with the primary network (see Section 6).

4.4 Fee Burn Stabilization

To prevent excessive deflation that could harm network usability, we introduce a floor on circulating supply:

$$B_t^{\text{effective}} = \min\left(B_t^{\text{total}}, \max\left(0, S_t - S_{\text{floor}}\right)\right) \tag{12}$$

where $S_{\text{floor}} = 0.5 \cdot S_0 = 250{,}000{,}000$ LUX. Once circulating supply reaches the floor, burning ceases and all fees are redistributed to validators.

5 Game-Theoretic Analysis

5.1 Validator Participation Game

We model validator participation as a staking game $\Gamma = (\mathcal{N}, \mathcal{S}, \mathcal{U})$ where:

- $\mathcal{N} = \{1, \ldots, n\}$ is the set of potential validators
- $\mathcal{S}_i = \{0, s_i^{\min}, \ldots, s_i^{\max}\}$ is the strategy space (stake amount)
- $\mathcal{U}_i(s_i, s_{-i})$ is the utility function for validator i

The utility for validator i is:

$$\mathcal{U}_i(s_i, s_{-i}) = \underbrace{r_{i,t}}_{\text{staking reward}} + \underbrace{p_i \cdot \text{tip}_t}_{\text{priority fees}} - \underbrace{c_i^{\text{hw}}}_{\text{hardware cost}} - \underbrace{s_i \cdot r_{\text{opp}}}_{\text{opportunity cost}} \tag{13}$$

where p_i is the probability of being selected as block proposer and r_{opp} is the alternative rate of return.

Theorem 4 (Nash Equilibrium Existence)**.** *The staking game Γ has a unique Nash equilibrium in pure strategies where each rational validator stakes $s_i^* = s_i^{\max}$ if $\mathcal{U}_i(s_i^{\max}, s_{-i}^*) > 0$ and $s_i^* = 0$ otherwise.*

Proof. The utility function $\mathcal{U}_i$ is concave in s_i because the reward function $r_{i,t}$ is concave in s_i (proportional allocation with diminishing marginal returns) while costs are linear. For each validator, the best response is unique: stake the maximum amount if net utility is positive, zero otherwise. The threshold for participation is:

$$s_i^{\min} \cdot \left(\frac{R_t \cdot u_i}{W} - r_{\text{opp}} \right) \geq c_i^{\text{hw}} \tag{14}$$

This defines a partition of $\mathcal{N}$ into active and inactive validators that constitutes the unique Nash equilibrium. □

5.2 Slashing as Deterrence

Validators who deviate from the protocol face slashing penalties. We define three severity levels:

Table 2: Slashing conditions and penalty structure.

Violation	Severity	Penalty (%)	Cooldown
Extended downtime (> 48h)	Minor	0.1	7 days
Double signing (equivocation)	Major	5.0	30 days
Coordinated attack (≥ 3 validators)	Critical	33.0	Permanent

Lemma 5 (Slashing Incentive Compatibility)**.** *Under the slashing penalties in Table 2, a rational validator's expected utility from honest behavior exceeds the expected utility from any Byzantine strategy, provided the validator controls less than $1/3$ of total stake.*

Proof. Let π_{attack} be the maximum profit from a successful Byzantine attack and p_{detect} the detection probability. The expected utility from attacking is $\mathcal{U}_{\text{attack}} = \pi_{\text{attack}} \cdot (1 - p_{\text{detect}}) - \text{slash} \cdot s_i \cdot p_{\text{detect}}$. For double signing, $p_{\text{detect}} = 1$ (cryptographically provable), so $\mathcal{U}_{\text{attack}} = -0.05 \cdot s_i < 0$. For coordinated attacks requiring $> 1/3$ stake, the penalty of 33% exceeds any extractable value under our fee structure. □

5.3 Sybil Resistance

The minimum stake requirement $s^{\min} = 2{,}000$ LUX and the proportional reward structure ensure that splitting stake across multiple validator identities provides no advantage:

Proposition 6 (Sybil Neutrality)**.** *For any validator with stake s, the total reward from running one validator with stake s equals the total reward from running k validators each with stake s/k, minus $k-1$ additional hardware costs.*

6 Appchain Economic Coupling

6.1 Appchain Registration and Fees

Creating a appchain on Lux Network requires a one-time creation fee F_{create} and ongoing validator staking. The creation fee is denominated in LUX and burned:

$$F_{\text{create}} = F_{\text{base}} \cdot (1 + \delta \cdot |\mathcal{K}|) \tag{15}$$

where $F_{\text{base}} = 1{,}000$ LUX and $\delta = 0.001$ provides mild congestion pricing as the number of appchains $|\mathcal{K}|$ grows.

6.2 Cross-Appchain Value Flow

Each appchain contributes to the primary network economy through multiple channels:

(1) **Validator staking**: Appchain validators must stake LUX on the primary network.

(2) **Fee tax**: A fraction $\tau_k \in [0.01, 0.05]$ of appchain fees flows to the primary network burn.

(3) **Warp messaging fees**: Cross-appchain messages pay LUX fees on the primary network.

(4) **Appchain token backing**: Appchains may optionally back their native tokens with LUX reserves.

Definition 2 (Economic Coupling Coefficient)**.** *The economic coupling coefficient for appchain k is:*

$$\kappa_k = \frac{\tau_k \cdot F_k + Stake_k + WarpFees_k}{TotalEconomicActivity_k} \tag{16}$$

measuring the fraction of appchain economic activity that accrues to the primary network.

6.3 Optimal Tax Rate

Theorem 7 (Revenue-Maximizing Tax Rate)**.** *The appchain fee tax rate τ_k^* that maximizes total primary network revenue, accounting for the elasticity of appchain transaction demand, is:*

$$\tau_k^* = \frac{1}{1 + \epsilon_k} \tag{17}$$

where $\epsilon_k > 0$ is the price elasticity of demand for transactions on appchain k.

Proof. Primary network revenue from appchain k is $\mathcal{R}_k(\tau_k) = \tau_k \cdot F_k(\tau_k)$ where $F_k(\tau_k) = F_k^0 \cdot (1 + \tau_k)^{-\epsilon_k}$ models demand elasticity. Taking the first-order condition:

$$\frac{\partial \mathcal{R}_k}{\partial \tau_k} = F_k - \tau_k \cdot \epsilon_k \cdot \frac{F_k}{1 + \tau_k} = 0 \tag{18}$$

Solving yields $\tau_k^* = 1/(1 + \epsilon_k)$. For typical blockchain transaction elasticities $\epsilon_k \in [0.5, 2.0]$, this gives $\tau_k^* \in [0.33, 0.67]$. In practice, we cap $\tau_k \leq 0.05$ to encourage appchain adoption, accepting suboptimal revenue extraction. □

7 Simulation Results

7.1 Simulation Setup

We simulate the Lux token economy over 500 epochs (approximately 10 years) under the following assumptions:

Table 3: Simulation parameters.

Parameter	Value	Description
S_0	500M LUX	Genesis supply
R_0	5M LUX/epoch	Initial reward
α	0.97	Reward decay factor
σ^*	0.67	Target staking ratio
Transaction growth	15%/year	Compound growth rate
Initial TPS	50	Transactions per second
Avg gas per tx	50,000	Gas units
Validators	1,000	Initial validator count
Appchains	$10 \to 200$	Growing over simulation

7.2 Supply Trajectory

Algorithm 2 Token Supply Simulation

Require: Parameters from Table 3

$S \leftarrow S_0$; $\sigma \leftarrow 0.40$; BaseFee $\leftarrow$ 25 gwei
for $t = 0$ to T **do**
  $R_t \leftarrow R_0 \cdot \alpha^t \cdot f(\sigma)$
  $\text{TPS}_t \leftarrow 50 \cdot 1.15^{t/52}$
  $G_t \leftarrow \text{TPS}_t \cdot 50000 \cdot 12$ ▷ Gas per block (12s blocks)
  Update BaseFee via Equation (8)
  $\phi_t \leftarrow \phi_{\min} + (\phi_{\max} - \phi_{\min}) \cdot \min(1, G_t/G_{\text{cap}})$
  $B_t \leftarrow \phi_t \cdot \text{BaseFee} \cdot G_t \cdot N_b$
  $V_t \leftarrow$ scheduled vesting
  $S \leftarrow S + R_t + V_t - B_t$
  Update σ based on yield vs opportunity cost
end for

The simulation reveals three distinct phases:

1. **Inflationary phase** (epochs 0–80): Vesting releases and rewards exceed burns. Peak supply reaches approximately 680M LUX.

2. **Equilibrium phase** (epochs 80–200): Burns catch up to emissions as transaction volume grows. Supply oscillates around 620M LUX.

3. **Deflationary phase** (epochs 200+): Burns consistently exceed rewards as the exponential decay of R_t continues while transaction volume grows. Supply decreases toward the long-run target.

7.3 Staking Yield Analysis

Table 4: Projected annualized staking yields by epoch range.

Epoch Range	Staking Ratio	Gross Yield	Net Yield (post-inflation)
0–50	$0.45 \to 0.60$	12.5%	8.2%
50–100	$0.60 \to 0.67$	8.3%	5.1%
100–200	0.67	5.8%	4.9%
200–500	0.67	3.2%	4.1%

Notably, the net yield in the deflationary phase (epochs 200+) exceeds the gross yield because deflation increases the purchasing power of staked tokens. This creates a positive feedback loop that sustains validator participation even as nominal rewards decline.

7.4 Sensitivity Analysis

We analyze sensitivity to transaction volume growth rate g:

Table 5: Supply at epoch 500 under varying transaction growth rates.

Growth Rate g	Supply at $t = 500$	Net Emission	Phase at $t = 500$
5%	640M	+0.3%	Mild inflation
10%	580M	−0.8%	Mild deflation
15% (base)	510M	−1.5%	Deflation
20%	430M	−2.2%	Strong deflation

The model is robust: even under pessimistic growth (5%), supply remains bounded. Under realistic growth (10–15%), the network achieves sustainable deflation.

8 Comparison with Existing Systems

Table 6: Tokenomic comparison across major blockchain platforms.

Feature	Lux	Ethereum	Cosmos	Polkadot
Supply model	Bounded with deflation	Unbounded with EIP-1559 burn	Inflationary	Inflationary
Target staking	67% (adaptive)	No target	67% (fixed)	50% (adaptive)
Fee mechanism	Multi-tier burn	EIP-1559	Fixed min fee	Weight-based
Appchain economics	Coupled with tax	L2 independent	IBC hub model	Parachain auctions
Capital efficiency	High (liquid staking)	Medium	Medium	Low (2-year lockup)
Yield variance	Low	Medium	High	Medium

8.1 Key Differentiators

Versus Ethereum. Ethereum's EIP-1559 burns 100% of base fees but has no supply cap and relies on PoS issuance to compensate validators. Lux's adaptive burn rate (50–90%) provides

more predictable validator revenue while still achieving deflation under sufficient utilization.

Versus Cosmos. Cosmos ATOM uses a variable inflation rate (7–20%) targeting 67% bonded ratio. This creates perpetual dilution for non-staking holders. Lux achieves the same staking target with bounded supply through the fee-burning mechanism.

Versus Polkadot. Polkadot's parachain auction model requires locking DOT for 2-year lease periods, creating extreme capital inefficiency. Lux appchains require only validator staking (minimum 2,000 LUX) with no lockup beyond the standard unbonding period.

9 Inflation Schedule Details

9.1 Epoch-Level Emission Table

The following table provides a detailed view of the emission schedule over the first 10 years:

Table 7: Detailed emission schedule by year.

Year	R_t (M LUX/yr)	Vesting (M LUX)	Est. Burn (M LUX)	Net (M LUX)
1	5.00	43.75	2.50	+46.25
2	4.85	43.75	5.00	+43.60
3	4.70	43.75	10.00	+38.45
4	4.56	43.75	15.00	+33.31
5	4.43	0	20.00	−15.57
6	4.29	0	25.00	−20.71
7	4.16	0	30.00	−25.84
8	4.04	0	35.00	−30.96
9	3.92	0	40.00	−36.08
10	3.80	0	45.00	−41.20

Note the inflection point at year 5 when vesting completes: the network transitions from net inflationary to net deflationary, assuming moderate transaction growth (15% annually).

9.2 Reward Half-Life

The reward emission has a half-life of:

$$t_{1/2} = \frac{\ln 2}{\ln(1/\alpha)} = \frac{0.693}{0.0305} \approx 22.7 \text{ years} \tag{19}$$

After 23 years, rewards are approximately 50% of initial; after 46 years, approximately 25%. This slow decay ensures continued validator incentivization for decades while maintaining long-term deflationary trajectory.

9.3 Treasury Management

The Foundation Reserve and Ecosystem Fund are managed under strict governance rules:

Algorithm 3 Treasury Disbursement Protocol

Require: Disbursement request (amount, purpose, recipient)

1: **require** DAO approval with $\geq 66\%$ vote
2: **require** amount $\leq 0.5\%$ of remaining treasury per quarter
3: **require** 7-day timelock after approval
4: Disburse from appropriate allocation
5: Publish transaction details publicly

The quarterly cap of 0.5% ensures treasury longevity: even with maximum disbursement every quarter, the treasury lasts at least 50 years.

9.4 Deflationary Acceleration Scenario

Under a high-growth scenario (25% annual transaction growth), the deflationary acceleration is significant:

Proposition 8 (Aggressive Deflation Bound)**.** *If transaction volume grows at $g = 25\%$ annually and the average gas price remains constant, the circulating supply reaches S_{floor} at approximately epoch 350 (year 7). At this point, fee burning ceases and all fees are redistributed to validators, creating a new equilibrium where:*

$$\textit{Validator Revenue} = R_t + F_t^{total} \quad (\textit{all fees, no burn}) \tag{20}$$

This increases validator yields and may attract additional staking, further tightening circulating supply.

9.5 Cross-Chain Token Flow Accounting

When LUX is bridged to external chains (Ethereum, Cosmos), the bridge-locked tokens affect circulating supply calculations:

Definition 3 (Effective Circulating Supply)**.**

$$S_t^{eff} = S_t - \textit{Staked}_t - \textit{BridgeLocked}_t - \textit{TreasuryLocked}_t \tag{21}$$

The effective circulating supply excludes tokens that are economically inactive (staked, bridge-locked, or treasury-controlled).

This metric provides a more accurate view of available market liquidity than raw circulating supply.

10 Related Work

Tokenomic design has been studied extensively in the blockchain literature. Catalini and Gans [6] provide foundational analysis of token-mediated markets. Cong et al. [7] formalize the interaction between token prices and platform adoption. Sockin and Xiong [8] analyze decentralized platform tokens as both currencies and securities.

Fee mechanism design was advanced significantly by Roughgarden's analysis of EIP-1559 [3], which proved incentive compatibility of the base fee adjustment. Chung and Shi [9] extended this to multi-dimensional fee markets relevant to multi-chain architectures like Lux.

Staking economics have been analyzed by Fanti et al. [10], who study compounding in Proof-of-Stake systems, and by Neuder et al. [11], who examine the interaction between staking yields and DeFi opportunities. Our adaptive reward function builds on these foundations while addressing multi-chain dynamics.

11 Conclusion

We have presented a comprehensive tokenomic framework for Lux Network that addresses the unique challenges of multi-chain consensus platforms. The key contributions are:

1. A bounded supply model with three distinct phases (inflation, equilibrium, deflation) that adapts to network utilization.
2. An adaptive staking reward function that provably converges to the target staking ratio under rational validator assumptions.
3. A multi-tier fee-burning mechanism that creates deflationary pressure proportional to cross-chain economic activity.
4. Game-theoretic proofs of incentive compatibility under Byzantine adversaries controlling less than one-third of stake.
5. Appchain economic coupling that aligns incentives between sovereign chains and the primary network.

Simulation results demonstrate that the model achieves net deflation within 200 epochs under realistic growth assumptions while maintaining stable validator yields and bounded supply variance. The framework is robust to a wide range of transaction growth scenarios and outperforms existing tokenomic models on capital efficiency and yield predictability.

11.1 Robustness Under Adversarial Conditions

We further analyze the tokenomic model's robustness under adversarial scenarios that go beyond the rational validator assumptions of Section 5.

Definition 4 (Adversarial Fee Manipulation)**.** *An adversary controlling fraction $\alpha < 1/3$ of stake attempts to manipulate the fee-burning mechanism by submitting high-gas transactions to artificially inflate B_t and accelerate deflation.*

Proposition 9 (Bounded Fee Manipulation)**.** *The adversary's cost of manipulation exceeds its benefit. Submitting transactions with total gas G_{adv} costs the adversary at least $BaseFee_t \cdot G_{adv}$ in fees, of which only ϕ_t fraction is burned. The adversary's net cost (fees paid minus proportional benefit from deflation) is:*

$$Cost_{adv} = BaseFee_t \cdot G_{adv} \cdot (1 - \alpha \cdot \phi_t) > 0 \tag{22}$$

since $\alpha < 1/3$ and $\phi_t \leq 0.9$, giving $\alpha \cdot \phi_t < 0.3 < 1$.

Algorithm 4 Adaptive Base Fee Under Manipulation Detection

Require: Block gas usage G_t, historical average $\bar{G}$
deviation $\leftarrow |G_t - \bar{G}|/\bar{G}$
if deviation > 3.0 **then** ▷ Statistical outlier
    Dampen base fee adjustment: use $\min(1/8, 1/16) \cdot (G_t - G^*)/G^*$
end if
Update $\bar{G} \leftarrow 0.99 \cdot \bar{G} + 0.01 \cdot G_t$ ▷ Exponential moving average

11.2 Governance-Controlled Parameters

Several tokenomic parameters are subject to governance adjustment via on-chain voting:

Table 8: Governance-adjustable tokenomic parameters.

Parameter	Symbol	Current	Range
Target staking ratio	σ^*	0.67	$[0.50, 0.80]$
Burn rate floor	$\phi_{\min}$	0.50	$[0.30, 0.70]$
Burn rate ceiling	$\phi_{\max}$	0.90	$[0.70, 1.00]$
Commission floor	$c^{\min}$	0.05	$[0.01, 0.10]$
Commission ceiling	$c^{\max}$	0.25	$[0.10, 0.50]$
Appchain fee tax range	τ_k	$[0.01, 0.05]$	$[0.00, 0.10]$
Reward decay factor	α	0.97	$[0.95, 0.99]$

All governance changes are subject to a 7-day timelock and require supermajority (66%) approval from staked token holders.

11.3 Emergency Mechanisms

In extreme scenarios (e.g., sustained network attack, critical protocol bug), the governance system includes emergency powers:

1. **Fee floor**: Governance can set a minimum base fee to prevent zero-fee spam during low-utilization periods.
2. **Reward acceleration**: If the staking ratio drops below $\sigma^{\text{critical}} = 0.40$, rewards temporarily increase by factor $2 \times f(\sigma_t)$ to attract emergency staking.
3. **Burn pause**: Governance can temporarily set $\phi = 0$ if deflation becomes too aggressive (supply approaching S_{floor} too rapidly).

11.4 Long-Term Equilibrium Analysis

We derive the long-term equilibrium supply S^* analytically:

Theorem 10 (Steady-State Supply)**.** *In the long run ($t \to \infty$), the circulating supply converges to:*

$$S^* = \frac{R_\infty}{\phi_{avg} \cdot \bar{F}_{avg} / S^*} \tag{23}$$

where $R_\infty = \lim_{t\to\infty} R_t$ is the asymptotic reward rate (approaching zero for $\alpha < 1$), ϕ_{avg} is the average burn rate, and $\bar{F}_{avg}$ is the average fee per unit supply.

As $R_t \to 0$, the equilibrium supply depends entirely on the ratio of fee burn to any residual emissions. In practice, governance-controlled minimum emissions may prevent R_t from reaching zero, maintaining a small positive reward to incentivize validation even in a fully deflationary regime.

Remark 1 (Comparison to Bitcoin's Fixed Supply)**.** *Bitcoin's fixed 21M supply creates a known endpoint but leaves validator (miner) incentivization entirely to transaction fees, which have proven volatile [19]. Lux's approach is more nuanced: bounded but dynamic supply with guaranteed validator rewards through the staking mechanism, augmented by fee revenue. This hybrid model provides more stable validator economics.*

11.5 Sensitivity Analysis

We analyze the sensitivity of key economic metrics to parameter perturbations. Let $\theta = (\sigma^*, \alpha, \phi, \tau)$ denote the parameter vector (target staking ratio, decay exponent, burn fraction, appchain tax rate). The Jacobian of the steady-state supply S^* with respect to θ is:

$$J_{S^*} = \begin{pmatrix} \frac{\partial S^*}{\partial \sigma^*} & \frac{\partial S^*}{\partial \alpha} & \frac{\partial S^*}{\partial \phi} & \frac{\partial S^*}{\partial \tau} \end{pmatrix} \tag{24}$$

Table 9: Sensitivity of steady-state supply to ±10% parameter perturbation.

Parameter	-10% **Change**	**Baseline**	$+10\%$ **Change**
Target staking σ^*	-3.2% supply	0	$+2.8\%$ supply
Decay exponent α	$+5.1\%$ supply	0	-4.7% supply
Burn fraction ϕ	$+1.8\%$ supply	0	-1.6% supply
Appchain tax τ	$+0.4\%$ supply	0	-0.3% supply

The decay exponent α exhibits the strongest influence: increasing α accelerates emission reduction, compressing long-run supply. The staking target σ^* has moderate impact through its effect on reward rates. The burn fraction and appchain tax show weaker sensitivity because they operate on fee flow rather than emission schedule.

11.6 Multi-Asset Fee Markets

While LUX serves as the primary gas token on the C-Chain, appchains may denominate fees in alternative tokens. The protocol requires periodic settlement to the primary network:

Definition 5 (Fee Settlement Obligation)**.** *Each appchain j with native gas token $G_j \neq LUX$ must settle its primary network tax obligation $\tau \cdot F_j$ in LUX within a settlement window of $W = 1440$ blocks (≈ 2 hours). The conversion rate is determined by the time-weighted average price (TWAP) from a designated oracle:*

$$Tax_j^{(t)} = \tau \cdot F_j^{(t)} \cdot TWAP(G_j/LUX, W) \tag{25}$$

Failure to settle within the window triggers a graduated penalty: 1% surcharge per missed window, capped at 10%. Persistent non-settlement (exceeding 10 consecutive windows) triggers a governance vote on appchain suspension. This mechanism ensures the primary network captures value from all appchain activity regardless of fee denomination.

11.7 Future Work

Several directions merit further investigation: (i) dynamic adjustment of the staking target σ^* based on security requirements, (ii) integration with liquid staking derivatives and their effect on effective staking ratio measurement, (iii) formal verification of the fee-burning mechanism under adversarial transaction patterns, (iv) cross-chain MEV implications for appchain fee tax design, and (v) mechanism design for optimal multi-asset fee settlement under volatile exchange rates.

11.8 Validator Revenue Decomposition

For transparency and predictability, validator revenue is decomposed into four distinct streams:

Table 10: Validator revenue streams and their characteristics.

Revenue Stream	**Source**	**Variability**	**Growth Driver**
Staking rewards	Protocol emission	Low (predictable)	Staking ratio deviation
Base fee share	Unburned base fees	Medium	Transaction volume
Priority tips	User tips	High (MEV-dependent)	DEX/DeFi activity
Appchain tax share	Appchain fee tax	Medium	Appchain ecosystem growth

The relative contribution of each stream evolves over time: in early epochs, staking rewards dominate ($\sim$80% of total); as transaction volume grows and emissions decay, fee-based revenue becomes the primary source. At steady state (epoch ≥ 300), the projected mix is approximately 25% staking rewards, 30% base fee share, 20% priority tips, and 25% appchain tax share.

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