A Market Formation Model for PYE

Kosmos Ventures

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1 Overview

We present a discrete-time economic model of a staking marketplace in which validators issue time-locked staking contracts that decompose deposited principal into a *Principal Token (PT)* and a *Yield Token (YT)*. The model is designed to study adoption, liquidity formation, pricing, and profit distribution over a multi-year horizon.

Time is indexed at the epoch level for reward generation and at the monthly level for reporting and aggregation. The model supports endogenous agent behavior, stochastic reward environments, secondary market trading, and configurable fee-allocation policies.

2 Time and Horizon

Let epochs be indexed by $t \in \mathbb{N}$, and months by $m \in \{1, \ldots, 24\}$. Each month contains a fixed number of epochs E.

Define:

$$\mathcal{T}_m := \{t : t \text{ belongs to month } m\}$$

3 Agents

3.1 Validators

Let $\mathcal{V}$ denote the set of validators. Each validator $v \in \mathcal{V}$ issues one or more staking contracts ("Pye Accounts") indexed by $a \in \mathcal{A}_v$.

Each account a is characterized by:

- Principal $P_a > 0$
- Maturity epoch T_a
- Commission vector

$$\mathbf{c}_a = (c_a^{\text{inf}}, c_a^{\text{mev}}, c_a^{\text{fee}}), \quad c_a^i \in [0, 1]$$

3.2 Stakers

Let $\mathcal{S}$ denote the set of stakers. Each staker $i \in \mathcal{S}$ is characterized by:

- Risk aversion $\lambda_i \geq 0$
- Liquidity preference $\kappa_i \geq 0$

- Belief model for future reward streams

Stakers allocate capital across accounts and may trade PT and YT on secondary markets.

3.3 Market Makers (Optional)

Market makers provide liquidity in PT and YT markets and collect trading fees. Their behavior is abstracted unless microstructure is explicitly modeled.

4 Reward Environment

At each epoch t, the protocol generates per-unit-stake rewards from three sources:

$$\mathbf{r}_t = (r_t^{\text{inf}}, r_t^{\text{mev}}, r_t^{\text{fee}})$$

These processes are stochastic and may follow regime-switching dynamics. No parametric assumption is imposed beyond integrability.

5 Yield Accrual

For account a, the gross staking yield accrued during epoch $t < T_a$ is:

$$Y_{a,t}^{\text{gross}} = P_a \left(r_t^{\text{inf}} + r_t^{\text{mev}} + r_t^{\text{fee}} \right)$$

Validator revenue from commissions:

$$Y_{a,t}^{\text{val}} = P_a \left(c_a^{\text{inf}} r_t^{\text{inf}} + c_a^{\text{mev}} r_t^{\text{mev}} + c_a^{\text{fee}} r_t^{\text{fee}} \right)$$

Staker yield:

$$Y_{a,t}^{\text{stk}} = Y_{a,t}^{\text{gross}} - Y_{a,t}^{\text{val}}$$

6 Tokenization

Upon deposit of P_a:

- P_a units of PT are minted
- P_a units of YT are minted

PT entitles the holder to 1 unit of principal at maturity T_a. YT entitles the holder to all staking yield generated by the principal until T_a.

7 Secondary Markets

Let p_t^{PT} and p_t^{YT} denote market prices. Let q_t^{PT} and q_t^{YT} denote traded quantities during epoch t.

7.1 Trading Volume

Monthly notional trading volume:

$$\text{Volume}_m = \sum_{t \in \mathcal{T}_m} \left(p_t^{PT} q_t^{PT} + p_t^{YT} q_t^{YT} \right)$$

7.2 Trading Fees

Let $f \in (0, 1)$ be the ad-valorem trading fee rate. Monthly fees:

$$\text{Fees}_m = f \cdot \text{Volume}_m$$

8 Fee Allocation Policy

Trading fees are allocated according to a policy vector:

$$\boldsymbol{\pi} = (\pi_V, \pi_S, \pi_P), \quad \pi_V + \pi_S + \pi_P = 1$$

Monthly fee revenues:

$$\text{ValFee}_m = \pi_V \cdot \text{Fees}_m$$
$$\text{StkFee}_m = \pi_S \cdot \text{Fees}_m$$
$$\text{ProtFee}_m = \pi_P \cdot \text{Fees}_m$$

9 Profit Accounting

Define monthly totals:

$$\text{GrossYield}_m = \sum_{t \in \mathcal{T}_m} \sum_a Y_{a,t}^{\text{gross}}$$
$$\text{ValYield}_m = \sum_{t \in \mathcal{T}_m} \sum_a Y_{a,t}^{\text{val}}$$
$$\text{StkYield}_m = \text{GrossYield}_m - \text{ValYield}_m$$

Monthly profits:

$$\Pi_m^V = \text{ValYield}_m + \text{ValFee}_m - C_m^V$$
$$\Pi_m^S = \text{StkYield}_m + \text{StkFee}_m - C_m^S$$
$$\Pi_m^P = \text{ProtFee}_m - C_m^P$$

Total profit:

$$\Pi_m^{\text{Total}} = \Pi_m^V + \Pi_m^S + \Pi_m^P$$

10 Velocity

Define deposits D as average outstanding principal.

Define monthly velocity:

$$V := \frac{\text{Volume}_m}{D}$$

11 Deposits–Velocity Profit Matrix

For scenario inputs (D, V), cumulative 24-month trading volume:

$$\text{Volume}_{24} \approx 24 \cdot V \cdot D$$

Cumulative fees:

$$\text{Fees}_{24} = f \cdot 24VD$$

Let y_{24} denote cumulative staking yield factor over 24 months.
Total profit:

$$\Pi_{24}^{\text{Total}}(D, V) = Dy_{24} + f \cdot 24VD - C_{24}$$

Assuming average validator yield share $\alpha \in [0, 1]$:

$$\Pi_{24}^{V} = \alpha D y_{24} + \pi_V f \cdot 24VD$$

$$\Pi_{24}^{S} = (1 - \alpha) D y_{24} + \pi_S f \cdot 24VD$$

$$\Pi_{24}^{P} = \pi_P f \cdot 24VD$$

12 Reported Outputs

The simulator reports:

- Monthly trading volume $\{\text{Volume}_m\}_{m=1}^{24}$
- Monthly trading fees $\{\text{Fees}_m\}_{m=1}^{24}$
- Monthly profit distribution $(\Pi_m^V, \Pi_m^S, \Pi_m^P)$
- Deposits $\times$ Velocity profit matrix (total and split)

13 Experimental Results

13.1 Base Case Parameters

The following parameters define the base case simulation scenario:

13.2 Summary Statistics

Over the 24-month simulation horizon, the model produces the following aggregate results:

13.3 Monthly Profit Distribution

Table 3 presents monthly profit distribution for the first 12 months. Trading volume and fee revenue decline over time as accounts mature and deposits decrease.

13.4 Deposits–Velocity Profit Matrix

The profit matrix in Table 4 shows projected 24-month total profit Π_{24}^{Total} for various combinations of average deposits D and monthly velocity V.

Parameter	Value
Simulation horizon	24 months (720 epochs)
Epochs per month	30
Initial deposits	$10,000,000
Number of validators	5
Number of stakers	20
Trading fee rate f	0.30% (30 bps)
Fee allocation (π_V, π_S, π_P)	(0.40, 0.30, 0.30)
Base trading velocity	15% monthly
Validator cost (monthly)	$1,000
Protocol cost (monthly)	$5,000
Base inflation rate	4.5% annual
Base MEV rate	2.0% annual
Base protocol fee rate	1.0% annual

Table 1: Base case simulation parameters

Metric	Value
Average deposits $\bar{D}$	$7,083,333
Average monthly velocity $\bar{V}$	7.36%
Cumulative gross yield	$1,152,694
Cumulative trading volume	$13,129,104
Cumulative trading fees	$39,387
Cumulative validator profit $\sum \Pi^V$	$63,651
Cumulative staker profit $\sum \Pi^S$	$1,092,614
Cumulative protocol profit $\sum \Pi^P$	−$108,184
Cumulative total profit $\sum \Pi^{\text{Total}}$	$1,048,081
Yield factor y_{24}	16.27%
Average validator share α	6.24%

Table 2: Cumulative simulation results over 24 months

13.5 Key Observations

1. **Staker dominance:** Stakers capture the majority of total profit (104% of total, offsetting protocol losses), driven primarily by yield accrual rather than fee revenue.

2. **Protocol breakeven threshold:** At the base case parameters, the protocol operates at a loss (−$108K over 24 months). Profitability requires either:

   - Higher trading velocity ($V > 50\%$ monthly), or
   - Larger deposit base ($D >$ \$50M with current velocity), or
   - Increased protocol fee share π_P

3. **Velocity sensitivity:** The profit matrix demonstrates that velocity has a multiplicative effect on fee-derived profits. Doubling velocity from 100% to 200% increases total profit by approximately 30% at $100M deposits.

Month	**Volume**	**Fees**	Π^V	Π^S	Π^P
1	$759,212	$2,278	$3,509	$56,322	−$4,317
2	$694,878	$2,085	$4,209	$65,950	−$4,375
3	$697,352	$2,092	$3,724	$59,436	−$4,372
4	$769,811	$2,309	$4,110	$62,881	−$4,307
5	$774,505	$2,324	$3,916	$59,329	−$4,303
6	$804,798	$2,414	$4,120	$63,259	−$4,276
7	$766,434	$2,299	$3,772	$58,319	−$4,310
8	$667,123	$2,001	$3,483	$57,531	−$4,400
9	$789,954	$2,370	$3,897	$59,494	−$4,289
10	$693,086	$2,079	$3,954	$62,323	−$4,376
11	$711,411	$2,134	$3,787	$60,418	−$4,360
12	$707,804	$2,123	$3,914	$61,331	−$4,363

Table 3: Monthly trading volume, fees, and profit distribution (months 1–12)

Deposits	$V = 5\%$	$V = 10\%$	$V = 20\%$	$V = 50\%$	$V = 100\%$	$V = 200\%$
$1M	$22K	$26K	$33K	$55K	$91K	$163K
$5M	$688K	$706K	$742K	$850K	$1.03M	$1.39M
$10M	$1.52M	$1.56M	$1.63M	$1.84M	$2.20M	$2.92M
$25M	$4.01M	$4.10M	$4.28M	$4.82M	$5.72M	$7.52M
$50M	$8.17M	$8.35M	$8.71M	$9.79M	$11.59M	$15.19M
$100M	$16.49M	$16.85M	$17.57M	$19.73M	$23.33M	$30.53M

Table 4: Total profit matrix $\Pi_{24}^{\text{Total}}(D, V)$ over 24-month horizon

4. **Deposit decay effect:** Monthly profits decline as staking accounts mature (months 13–24 show reduced volume), highlighting the importance of continuous deposit inflows for sustained protocol revenue.

5. **Validator economics:** Validators earn modest but consistent profits ($63K cumulative) through commission income, with low sensitivity to trading activity.