

Research on ASMR

Part 1. Efficient liquidity in dTAO: liquidity sizing, price discovery and settlement in subnet markets

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November 2026

CAN A SUBNET HAVE TOO MUCH LIQUIDITY?

Building on the Exploit Summit talk, Montreal, September 29, 2026.

RESEARCH SUMMARY

In the ten most liquid subnet pools, liquidity grew 196% since June 2025 while trading fell 61%. Over the same period the daily volatility of the subnet index, measured in TAO, fell 69%, and per day the index now moves less than the S&P 500 does in dollars. Subnet pools hold 1.97 million TAO, 61% of everything emitted since dTAO launched, and about 45% of it sits beyond the reach of any holder.

Why it matters. A subnet grows through a flywheel: revenue buys Alpha, a higher Alpha price pays its miners more, and better-paid miners add the capacity that earns more revenue. Excess liquidity mutes the second link. dTAO gives every subnet a liquid market from its first day, which solved the bootstrapping problem, but it has no feedback loop: liquidity enters the pools with emission, not with the trading they have to absorb, and no rule takes it back when trading fades. Left alone the pools keep deepening, and a 100,000 TAO buy that lifts Chutes by 123% today would lift it by 103% in two years.

The debate about what to do next is usually framed as a choice of curve: Uniswap v2 (constant product), Balancer, Uniswap v3, d2TAO or another. That framing runs two questions together:

- **Efficient liquidity.** How much depth does a subnet need to absorb its normal directional flow at an acceptable market impact?
- **Efficient settlement.** What should TAO reserves, Alpha claims, and prices represent when the pool reaches its economic boundary?

> THESIS. **Efficient liquidity is not maximum liquidity**. When protocol-owned reserves grow faster than trading demand, liquidity stops improving execution and starts suppressing price discovery. Bittensor should choose the market quality it wants and size liquidity to deliver it, rather than letting depth accumulate as a by-product of emission. Liquidity control addresses sizing while curve and settlement design address the boundary. Neither solves both.

This paper, Part 1 of two:

- **First**, measures the **effects of excess liquidity** and traces them to their origin, **Alpha injection**
- **Then**, separates **liquidity from settlement** and introduces an AMM pool based on **super-elliptic curves** with fixed 21 million boundaries
- **Finally**, introduces **ASMR (Alpha Subnet Market Reloaded)**, a liquidity control, and tests it in a **one-off transition** simulation that retires Alpha the protocol injected into the pools and lifts the subnet index 2.3 times. **Part 2** develops the continuous feedback loop

> HOW TO READ. **This research comes in two papers, released together. Part 1, this paper,** measures the problem and builds the tools: the diagnosis, the curve designs, the slippage benchmark and a one-off transition experiment. It stands on its own. **Part 2** develops the continuous feedback loop, simulates it over two years and sets out who could receive the liquidity it releases. Both papers are dense by design. **Readers can give them to their favorite AI agent.**

Acknowledgments. The author thanks Louis Guigo, Kiana Kheiri, Karl Osis and Greg Schvey for their review of earlier versions of this research and for the comments that improved it, and the Yuma team for its support. Any remaining error is the author's.

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1. LIQUIDITY SUPPLY VERSUS DEMAND IMBALANCE

1.1 Too liquid to break out or fail?

Chutes holds one of the largest pools in the network, 203K TAO in reserve. It has captured emission more successfully than almost any other subnet, yet its trading has faded. Liquidity kept arriving long after demand stopped growing, and the result is a market that grows ever more expensive to move, even for investors with a strong view on its value.

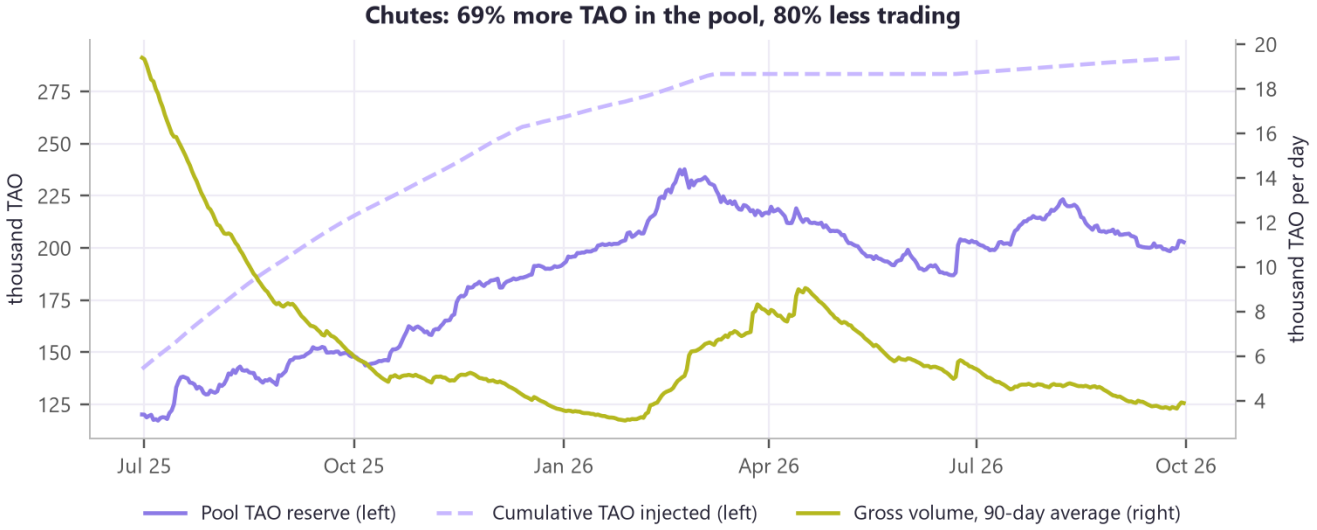


Figure 1. Chutes, June 30, 2025 to September 30, 2026. Pool TAO reserve and cumulative TAO injected (left axis) against 90-day exponentially weighted gross volume (right axis).

Four related effects stand out. Figures 1 to 3 and Table 1 carry the numbers:

- **Liquidity grew while trading did not.** Chutes' TAO reserve grew by 69% from June 2025 to September 2026, while daily gross volume, the sum of all buys and sells in TAO, fell by 80%. The reserve peaked at 238K TAO in February 2026 and has slipped 15% since, as holders sold. Liquidity, $\sqrt{(\tau\alpha)}$, did not fall: a sale moves TAO out and Alpha in along the curve, and only injection changes it. It was flat from March to June 2026, when Chutes received no injection, and has grown 3.8% since, to its high on September 30. No rule ties it to trading.
- **Most trading is offsetting.** By September, absolute market flow, the daily net of buys and sells once the protocol's own injections and chain buys are removed, was about 1.0K TAO per day against 3.9K of gross turnover. The pool carries a fraction of the inventory risk that headline volume suggests.
- **Slippage and volatility compressed together.** Chutes' market-flow-to-reserve ratio fell 62%, from 1.34% to 0.51%, while realized daily volatility fell 75%, from 5.73% to 1.41%. The pool has become much harder to move in either direction.
- **More of the reserve sits beyond any claim.** Locked TAO rose from about 54K to 96K over the same period. Reachable TAO grew too, but the locked part is TAO that even a complete sale of every staked Alpha cannot recover.

The link between depth and price impact is mechanical. For a fee-free constant-product pool, a TAO buy of size q against TAO reserve τ has average execution slippage s and moves the marginal price from p_0 to p_1:

$$s = \frac{q}{\tau} \quad and \quad \frac{p_1}{p_0} = \left(1 + \frac{q}{\tau}\right)^2$$

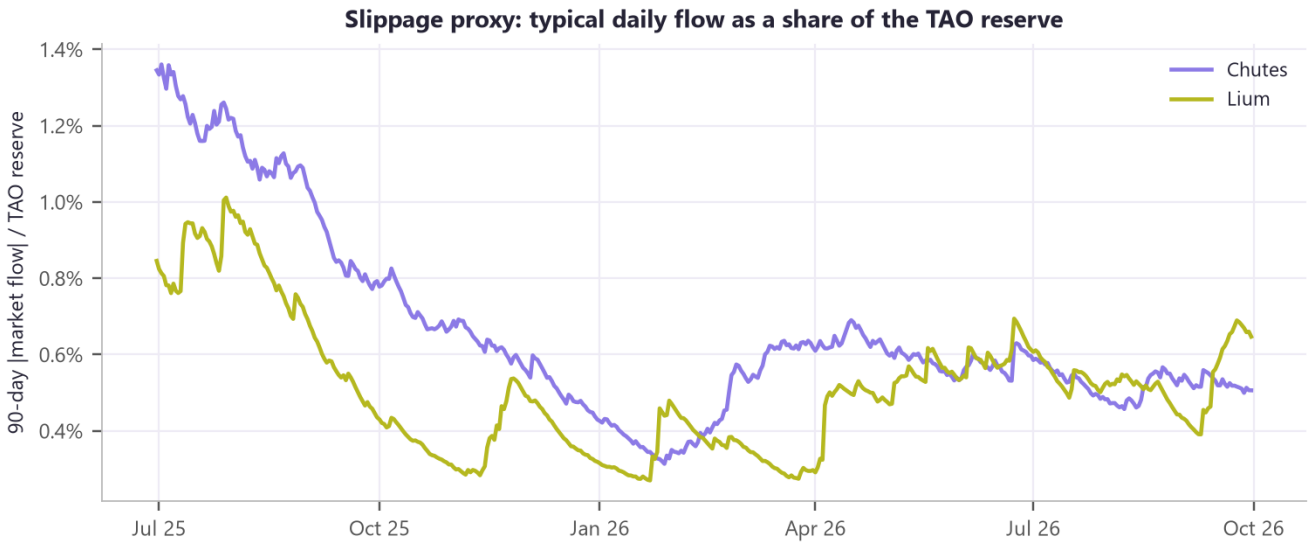


Figure 2. Slippage proxy, June 30, 2025 to September 30, 2026: 90-day exponentially weighted absolute market flow divided by the TAO reserve, Chutes and Lium.

Slippage is a local property of the curve around spot, and the locked balance is a global property of where the curve ends. Both come from the same reserves, but they answer different questions: how far one trade moves the price, and how much of the pool holders could ever take out.

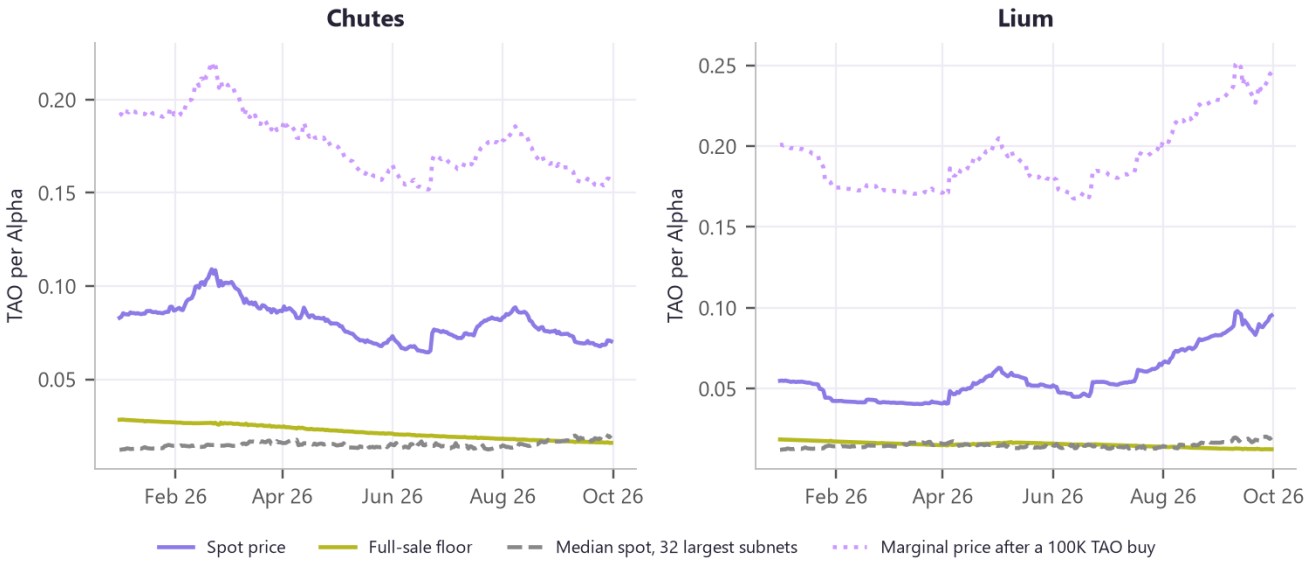


Figure 3. Chutes and Lium, January 1 to September 30, 2026. Spot price against the modeled full-sale floor and the median spot price of the 32 largest subnets by TAO market capitalization. The dotted line is the marginal price after a hypothetical 100K TAO buy.

Chutes and Lium now point to the same structural problem. Their TAO reserves increased by 69% and 220%, respectively, while market flow relative to reserve fell by 62% on Chutes and 24% on Lium. Realized daily volatility declined by 75% and 59%. Both markets are materially deeper and less responsive than they were in June 2025. A 100K TAO purchase would lift Chutes' marginal price to 2.23 times spot and Lium's to 2.58 times. In June 2025 the same purchase would have taken Lium to 8.61 times. Even an inflow of that scale produces only a low-single-digit price multiple. At an illustrative $300 per TAO, the trade represents $30 million.

Measure	Chutes Sep 30, 2026	Change since Jun 30, 2025	Lium Sep 30, 2026	Change since Jun 30, 2025
Pool TAO reserve	202,808	+68.8%	165,231	+219.5%
Gross volume, 90d EWM (TAO/day)	3,888	-80.0%	6,039	-8.4%
Absolute market flow, 90d EWM (TAO/day)	1,026	-36.5%	1,068	+144.4%
Market flow / reserve, TAO side	0.51%	-62.4%	0.65%	-23.5%
Market flow / reserve, worse side	0.51%	-62.4%	0.79%	-6.6%
Daily volatility, 90d EWM	1.41%	-75.5%	2.25%	-59.4%
Reachable TAO	106,407	+60.4%	105,447	+245.7%
Locked TAO	96,401	+79.1%	59,785	+181.9%
Spot price (TAO per Alpha)	0.070361	-58.1%	0.095360	+21.1%
Modeled floor / spot	22.59%	+2.5 pp	13.09%	-3.7 pp
Spot impact of a 100K TAO buy	122.93%	-112.8 pp	157.67%	-603.1 pp
Spot impact of a 1K TAO buy	0.99%	-0.7 pp	1.21%	-2.7 pp

Table 1. Chutes and Lium at September 30, 2026 against June 30, 2025. Market flow is the daily change in the TAO reserve net of protocol injection and chain buys. The slippage proxy is its 90-day average divided by the reserve, on the TAO side and on the worse of the two sides. Volatility is the 90-day exponentially weighted standard deviation of daily log returns. Changes are relative except where marked in percentage points. Before October 22, 2025 the data counted burned Alpha as staked, so the June 30, 2025 values of reachable TAO, locked TAO and floor / spot treat it as sellable.

The imbalance is more problematic on Chutes. Its 90-day gross trading volume fell 80% as reserve depth increased, and absolute market flow fell 36%. Lium's gross volume was broadly stable, down 8%, while absolute market flow increased 144% and spot price rose 21%. Lium has therefore attracted more directional demand as its pool deepened. Chutes has not. Yet both pools became less responsive, and Chutes' weaker demand makes its additional depth harder to justify.

> KEY INSIGHT. **Excess liquidity costs breakouts and breaks the flywheel.** A deeper curve makes a breakout more capital-intensive and cushions the repricing that external selling should cause. Some depth is useful where demand is rising, as on Lium. Chutes shows what happens when liquidity keeps growing after demand has faded: execution gets cheaper, but **price loses its ability to discipline the market or reward new conviction**. That matters beyond price. A subnet whose revenue buys back its Alpha needs that buying to show in the price, because **the Alpha price pays its miners and funds new capacity**. A muted price stalls that growth flywheel, and with it the real growth of the subnet. The protocol needs **a liquidity feedback loop that tracks actual trading need** and lets supplied depth contract when demand no longer supports it.

1.2 Alpha injection changes what the price means

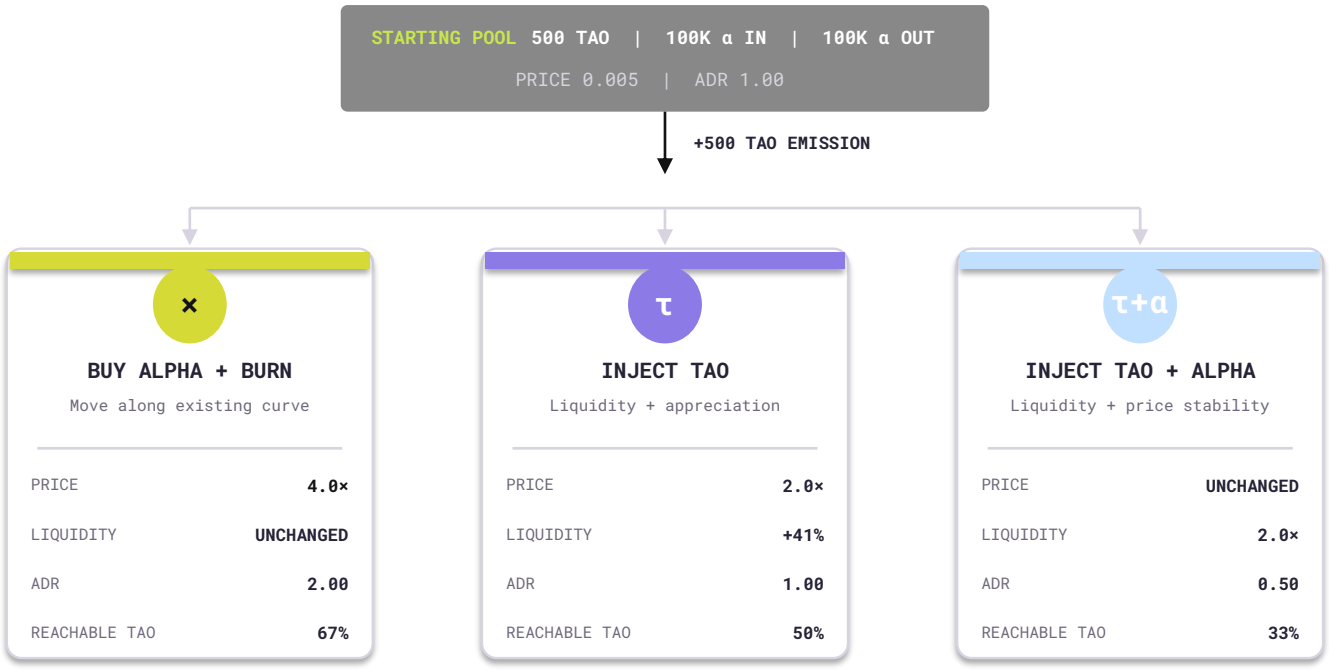
The imbalance observed on Chutes follows directly from how emissions enter the pool. TAO emissions create value for a subnet. Alpha injection or ejection determines whether that value appears in price or is absorbed as additional liquidity. The cost appears over time. Reserves deepen without a new investment decision, and the same unit of external demand carries less information into price.

To illustrate the underlying mechanism, this section explores the liquidity injections in a constant-product AMM pool, with TAO reserve τ and Alpha reserve α. Liquidity L measures the size of the invariant and is defined as the geometric mean of TAO and Alpha reserves. ADR measures external Alpha A relative to pool inventory α.

$$L = \sqrt{(\tau\alpha)} \quad ADR = \frac{A}{\alpha}$$

As an example, start with 500 TAO and 100,000 Alpha in the pool, plus 100,000 Alpha held externally. Price is 0.005 TAO and ADR is 1. The protocol allocates another 500 TAO.

The same 500 TAO can produce a 4x price, a 2x price, or no price move. The difference is whether TAO and/or Alpha are injected:



1,000 TAO in every ending pool. Alpha issuance changes price, depth and modeled accessibility.

Pool	Start	Buy + burn	Inject TAO	Inject both
TAO in pool	500	1,000	1,000	1,000
Alpha in pool	100,000	50,000	100,000	200,000
External Alpha	100,000	100,000	100,000	100,000
Spot (TAO / Alpha)	0.005	0.020	0.010	0.005
Liquidity	reference	unchanged	+41%	+100%
ADR	1.00	2.00	1.00	0.50
Reachable TAO	50%	67%	50%	33%
Floor price (TAO / Alpha)	0.001250	0.002222	0.002500	0.002222
Price floor / spot	25%	11%	25%	44%

Table 2. Allocation outcomes from the same starting pool. At the start a 10 TAO buy has 2% average slippage. External Alpha remains 100,000 in every path.

- **Signal suppression.** TAO-only injections double the price. Paired injection adds the same TAO with no price appreciation. Value enters the subnet, but the market price does not record it. Newly issued Alpha inside the pool also weakens the pricing power of existing Alpha holders, because investors can purchase Alpha that was never earned through investment, production, or economic activity.

- **Claim and boundary dilution.** Paired injection creates new Alpha against the reserve, with no external claimant. As it accumulates in the pool, external holders can reach less of the reserve: locked TAO rises from 250 to 667 and the price floor from 25% to 44% of spot. For a full sale of external Alpha, reachable TAO R, locked TAO B and the final price follow from constant product:

$$R = \frac{\tau A}{\alpha + A} \quad B = \frac{\tau \alpha}{\alpha + A} \quad p(full\ sale) = \frac{p}{(1 + ADR)^2}$$

The locked balance can also be written $\text{locked} = \tau\alpha/(\alpha + A) = L^2/(\alpha + A)$, with L the pool's liquidity. A swap changes neither term, so trading never moves it: only injection, issuance, burns and deregistrations do.

> KEY INSIGHT. **Alpha injection decides whether a subnet's emission shows up as price or as liquidity.** TAO emission adds value to the subnet's pool. Injected together with Alpha, that value is absorbed as depth and lower volatility instead of a higher price. The distinction between **Alpha that holders earned** and **Alpha that the protocol injected to keep the price stable** carries through the rest of the research: Section 3 and Part 2 only ever burn the injected part, and keep any mined Alpha they retire in a vault.

1.3 Consequences at the network level

Sections 1.1 and 1.2 showed the pattern on Chutes and its mechanism: paired injection turns value earned by a subnet into liquidity rather than price, and Alpha holders pay through weaker price discovery, diluted claims and a larger locked balance. This section tests the pattern across the network: the supply-demand imbalance, the growing role of chain buys, and the gap between headline issuance and the inflation holders can reach.

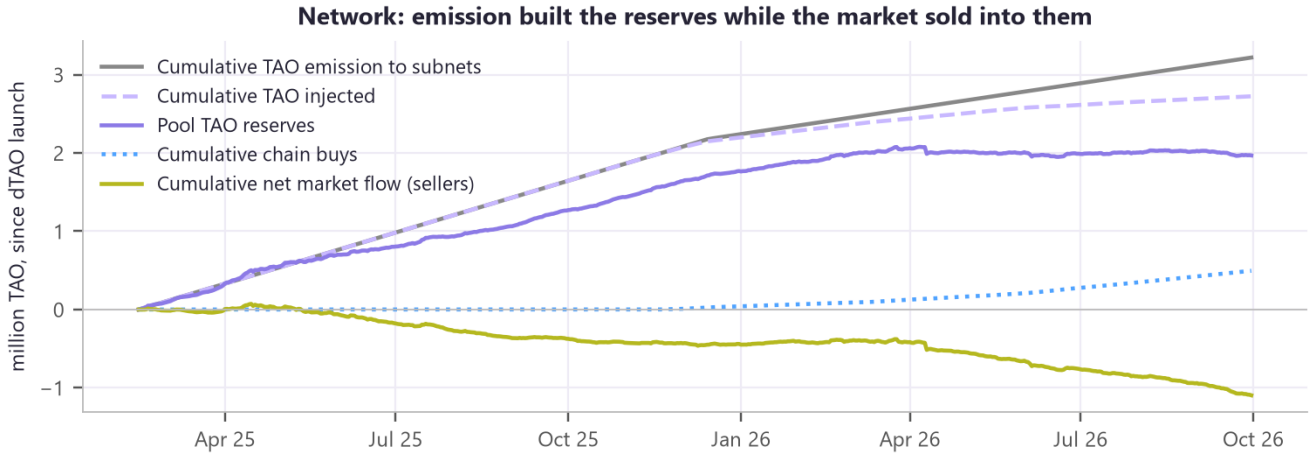


Figure 4. Network aggregates over the 128 non-root subnets, cumulative since dTAO launched (February 14, 2025, the first day of the data): TAO emission to subnets, TAO injected into the pools, chain buys, pool TAO reserves, and net market flow (negative means holders sold into the pools).

- **Most of what was emitted is still in the pools.** Since dTAO launched, subnets received 3.22 million TAO of emission, and all of it entered the pools: 2.72 million, 85%, as paired injection with Alpha, and 0.49 million as chain buys from November 2025. Holders sold a net 1.10 million TAO worth of Alpha into the pools, yet the pools still hold 1.97 million TAO, 61% of everything emitted. The balance, 154K TAO, mostly left with deregistered subnets.
- **Liquidity grew faster than trading.** From June 2025 to September 2026 pool reserves grew 145%, while gross volume fell from 224K to 150K TAO per day and absolute market flow rose only from 12K to 18K. In the ten most liquid pools, liquidity grew 196% while gross volume fell 61%. One of the ten, Affine, launched in June 2025. Without it the figures are +174% and −65%, and the net flow these pools absorb is about flat.
- **Price responsiveness declined across the network.** The capitalization-weighted slippage proxy fell from 1.58% to 1.05% on the TAO side, and daily YCX volatility from 2.07% to 0.64%. The two measures differ, but both point to deeper pools absorbing more demand before it reaches price.

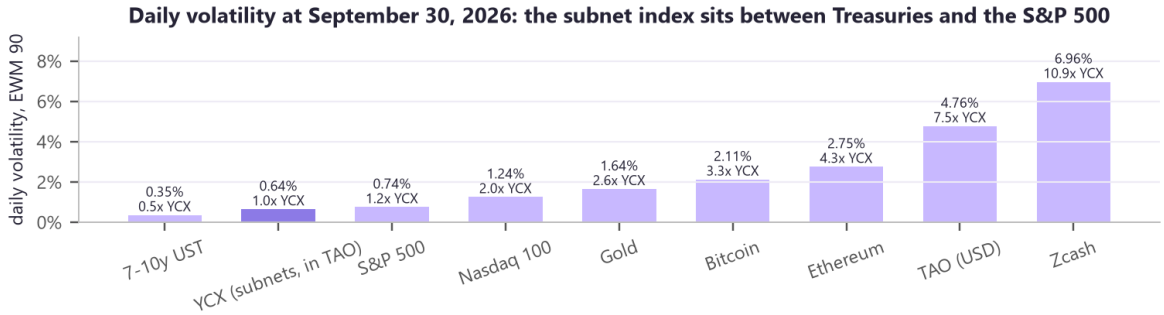


Figure 5. Daily realized volatility at September 30, 2026, 90-day exponentially weighted, per trading day and not annualized, with each asset's multiple of the subnet index (YCX). YCX is in TAO terms, so it measures subnet price discovery relative to TAO rather than risk in dollars. Per day it moves less than the S&P 500 and about 7.5 times less than TAO itself.

Alpha injection helped bootstrap dTAO liquidity, but it also diluted Alpha holders' claims and placed part of the TAO reserve beyond their collective reach. Headline issuance therefore overstated the inflation holders can actually receive. The figure below splits TAO and Alpha issuance into the locked

and reachable parts and shows how the split changed after the TAO halving of December 2025. Inflation rates divide by the live TAO supply read from the chain, not by a schedule.

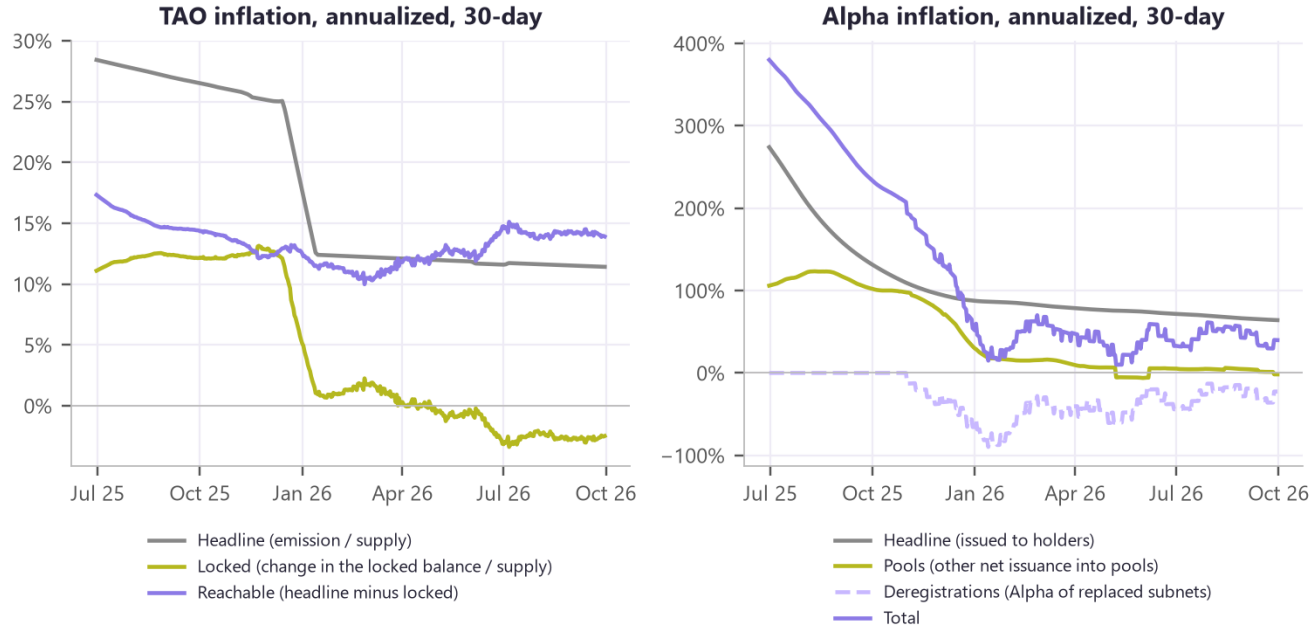


Figure 6. Inflation decomposition, June 2025 to September 2026, 30-day averages annualized. Left: TAO issuance split between the change in the locked balance and the reachable remainder, over the live TAO supply. Right: Alpha issued to holders, other net issuance into the pools, Alpha removed by deregistrations, and the total.

- **Headline inflation did not measure what holders received.** Through the second half of 2025 the protocol issued TAO at an annualized rate near 27%, but 12% of supply per year accumulated in balances no holder could reach, so effective inflation for subnet participants was closer to 14%. After the halving the locked balance is shrinking: headline inflation is 11% and reachable inflation 14%, not far from where it was before.
- **Alpha shows the same reversal.** The pools once took 40% of all the Alpha created. That share is now close to zero, because injection has shrunk and chain buys take Alpha out of the pools into a protocol balance.
- **Deregistrations remove far more.** When a subnet is replaced, its Alpha leaves the total. Deregistrations began in November 2025. At the September 2026 pace they remove 23% of supply per year, after a peak of 90% in January 2026, and with the slower injection total Alpha inflation came down from 250% in the second half of 2025 to 40%. Deregistrations also take TAO with them, the one flow that removes liquidity from the pools: the 48 resets since November 2025 emptied pools holding 172K TAO, most of them small.
- **Chain buys did not replace injection.** The share of each month's TAO emission injected as paired liquidity fell from 100% in October 2025 to 62% in May 2026, 36% in June and 31% in September. Most of the June fall came in the first week of the month, as more pools stopped receiving injection. On June 22, 2026 two rules changed: emission shares returned to prices, and a subnet's injected Alpha has since been capped at the root proportion of its Alpha emission, while the TAO that cannot be paired buys Alpha from the pool instead. Injection is smaller than it was, but it has not stopped, and the locked balance has only started to unwind.

> KEY INSIGHT. **The halving did not halve effective inflation.** Headline TAO inflation fell from 27% to 11%, yet **reachable inflation barely moved, from 14.4% to 13.9%**. Injection slowed faster than emission, and the locked balance declined on 59% of post-halving days. **New issuance now reaches holders, while part of the locked reserve slowly becomes reachable.** How fast that reserve should unwind, and how much liquidity the network needs, is the question Section 2 frames and Section 3 and Part 2 turn into a governance parameter.

2. LOCAL LIQUIDITY AND GLOBAL SETTLEMENT

2.1 Four curve designs chasing two separate objectives

Two objectives sit behind the same reserves. The local objective is price discovery: how much a unit of net flow moves the price, measured by slippage and realized volatility. The global objective is settlement: what the pool converges to once the external Alpha has been sold, measured by reachable TAO, residual TAO and the price floor.

Efficient liquidity is a market-making objective, while efficient settlement is a property-rights question. Treating them as one curve-selection problem makes it difficult to state what success would look like.

Dimension	Efficient liquidity	Efficient settlement
Question	How much depth should absorb normal flow?	Where does the full-sale path end?
Metrics	Slippage, market impact, utilization	Reachable TAO, residual TAO, price floor
Levers	Quantity and concentration of inventory	Curve boundary, claims, settlement rule
Trade-off	Execution cost versus price responsiveness	Reserve recovery versus boundary policy

Table 3. Liquidity versus settlement design.

Let α and τ denote the pool's Alpha and TAO reserves, A the externally held Alpha supply, and S = α + A the current total Alpha supply. Marginal price p is expressed in TAO per Alpha.

- **Constant product** provides continuous execution but keeps positive TAO after any finite Alpha sale. Its curve extends beyond the available supply rather than ending at it, so part of the reserve cannot be recovered even by a full sale of external Alpha.

$$\alpha\tau = k, \quad \tau_{end} = \frac{\alpha\tau}{\alpha + A} > 0$$

- **A Balancer pool** sets marginal price and directional sensitivity through reserve weights. Positive fixed weights still leave TAO after a finite sale and build in a liquidity asymmetry, while any adaptive rule adds a protocol parameter and a governance burden.

$$\alpha^{\omega_\alpha}\tau^{\omega_\tau} = K, \quad \omega_\alpha + \omega_\tau = 1, \quad \omega_\alpha, \omega_\tau > 0$$

- **Uniswap v3** concentrates depth within a selected range. At a range boundary a position becomes one-sided and provides no liquidity beyond it. The protocol, or users if they supply the liquidity, must choose ranges and decide whether to adjust them, and any adaptive rule again adds a parameter and a governance burden.

$$(\alpha + \frac{\ell}{\sqrt{p_b}})(\tau + \ell\sqrt{p_a}) = \ell^2, \quad p_a \le p \le p_b$$

- **d2TAO** targets a finite settlement boundary: in the specification examined here, TAO and marginal price reach zero when all Alpha held outside the pool is sold. If that boundary tracks current supply, issuance needs an explicit recalibration rule, and those protocol-driven updates change depth and spot price without a trade.

$$\tau = f\,k\left(\frac{1}{\alpha} + \frac{\alpha - S}{S^2} - \frac{1}{S}\right), \quad \tau_{end} = 0$$

The protocol is not an ordinary liquidity provider. It cannot step back when flow turns toxic, cannot price its own rebalancing and publishes its rule before it acts. Parameters that a competitive provider would set privately become public state that others can position around.

> KEY INSIGHT. **Constant product is not capital-efficient.** It keeps more TAO in reserve than local execution and full-sale recovery require, holding capital for Alpha beyond the available supply. **Balancer and Uniswap v3 need dynamic protocol management** of depth, range and asymmetry. **d2TAO solves the boundary**, but Alpha issuance would then move the price without any trade, a signal unrelated to trading.

2.2 The four designs on Chutes numbers

What do these differences mean for a real pool? Each design is placed on the Chutes reserves of September 30, 2026, with the same 3.18 million staked Alpha outside the pool. The settings are typical ones: Balancer at weights of 0.4 on Alpha and 0.6 on TAO, Uniswap v3 with a range four times either side of spot, and d2TAO with the factor that keeps today's reserves. All four start from the same point, and each price is measured against the design's own starting price, so the charts show only how each one moves away from it.

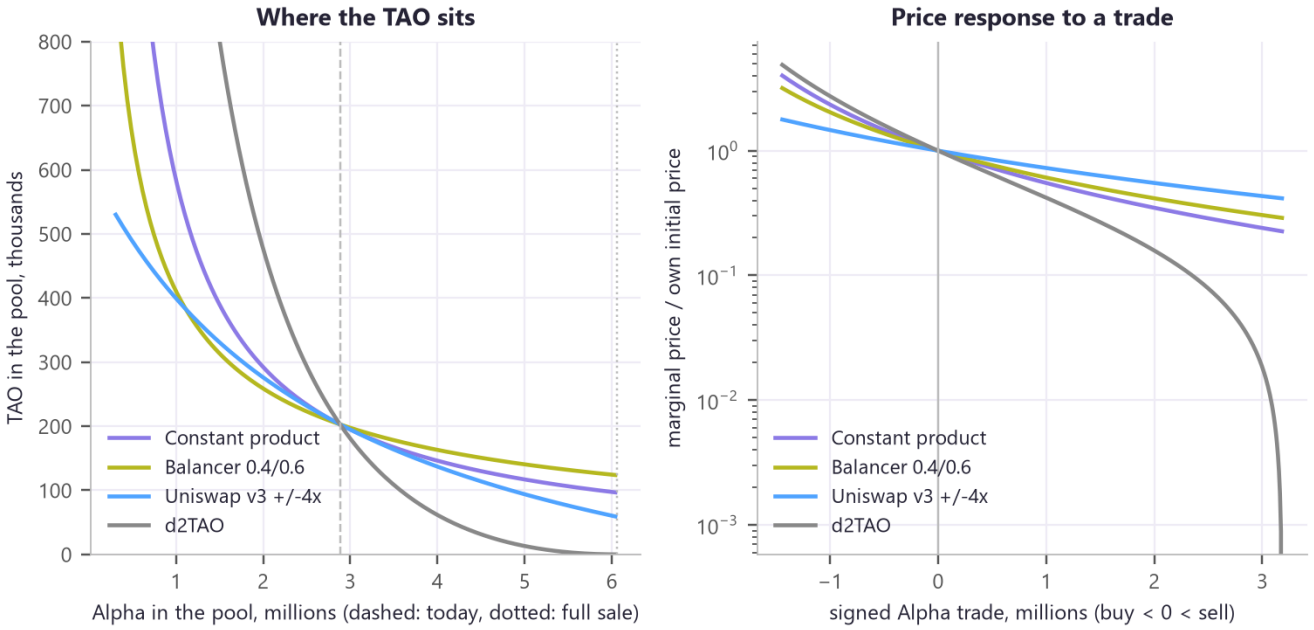


Figure 7. Left: where the TAO sits across the Alpha inventory range. Right: marginal price response to a signed Alpha trade, against each design's own initial price. All four pass through the same starting reserves.

Design	TAO extracted at full sale	Average execution discount	Terminal state
Constant product	52%	52%	TAO never reaches zero
Balancer, 0.4 / 0.6	39%	47%	TAO never reaches zero
Uniswap v3, +/- 4x	71%	36%	Depends on the chosen range
d2TAO	100%	68%	TAO and price reach zero

Table 4. Outcome when every Alpha outside the pool is sold, from the same starting reserves.

- **Balancer at a high TAO reserve weight extracts least and moves least.** It is the most protective of the pool and the least informative. A low TAO reserve weight does the opposite.
- **Uniswap v3 beats constant product on both counts over this range.** That is the capital-efficiency argument made concrete, at the cost of active and publicly visible range management.
- **d2TAO returns exactly 100% of the TAO reserve**, which is its point, at the deepest average discount.
- **None of them says how much capital the pool should hold.** That is what Section 3 takes on.

The comparison restates the trade-off of Section 1 in terms of the curve. A design that holds TAO back protects the pool and mutes the price, as Chutes' deep reserve does today: on constant product, 48% of the TAO is still in the pool after every outside Alpha has been sold. A design that hands more TAO back turns the same sale into a larger price move, which is what lets the market discipline a subnet. Each curve picks a point on that trade-off, and none of them changes how much TAO the pool holds to begin with.

> KEY INSIGHT. **A curve shapes how the price responds. It does not connect liquidity to demand.** All four designs start from the same reserve. **Switching curves changes how much of that TAO a full sale returns**, from 39% to 100%, and how sensitive the price is to a trade: d2TAO makes it more sensitive, not less. **But a curve is set once, and none of them adjusts the supply of liquidity when trading demand changes.**

2.3 Introducing super-elliptic AMM pools

Curves with a finite end are more capital-efficient than constant product: Uniswap v3 within its range and d2TAO at its settlement point stop holding TAO for Alpha that does not exist. Constant product has what they lack, one symmetric rule with no range to manage and no boundary to recalibrate. A super-elliptic curve, also called a power-sum curve, keeps both, and Bittensor's economics suit it, because TAO and every subnet's Alpha share the same 21 million cap. With both reserves in millions and both boundaries at 21 million, the invariant and the marginal price are:

$$\tau^R + \alpha^R = 21^R \text{ and } p = \left(\frac{\tau}{\alpha}\right)^{1-R}, \quad 0 < R < 1$$

A super-ellipse is not a regular ellipse. It is a power sum with an exponent R below one, against two for an ellipse, and R sets the curvature. Lower R curves more, so slippage and price response are larger, while R near one approaches constant sum and holds more depth mid-range. The ends do not move with R: 21 million Alpha and no TAO at one end, the reverse at the other. Every pool today sits inside those bounds, so one such curve passes through its reserves. For Chutes that curve has R = 0.22.

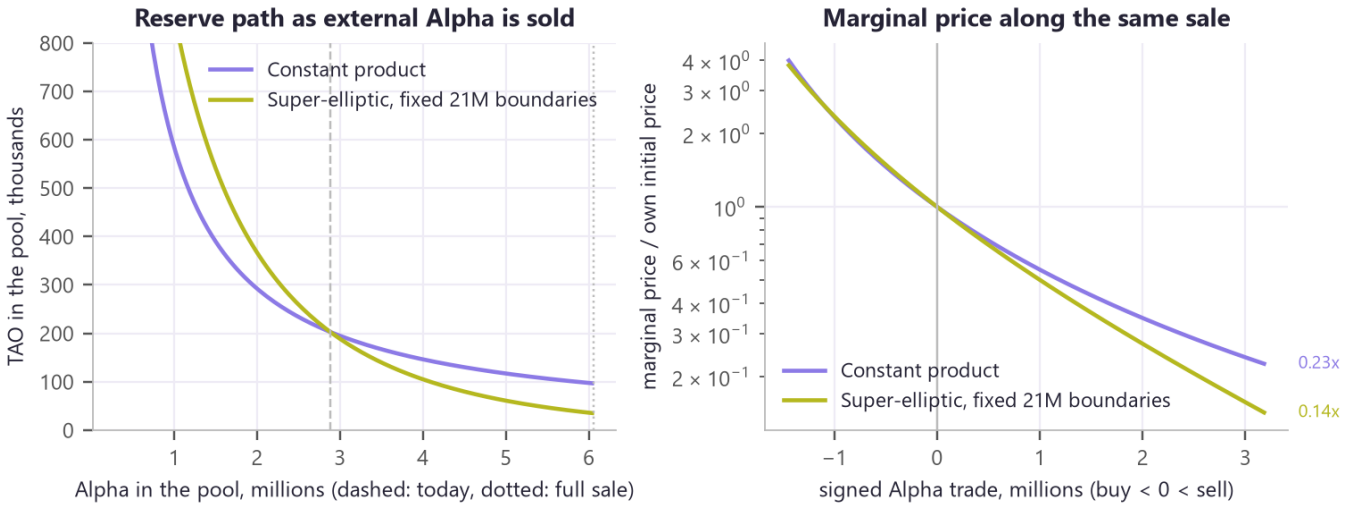


Figure 8. Constant product and a super-elliptic pool with fixed 21 million boundaries, both through the Chutes reserves at September 30, 2026. Left: TAO reserve as external Alpha is sold. Right: marginal price along the same sale, against each curve's own initial price, with the value at the full sale.

Benefits of the power sum

- **The strengths of constant product.** One symmetric rule and a single parameter, R, with no range to manage and no boundary to recalibrate.
- **The capital efficiency of a finite curve.** When the last external Alpha is sold, the power-sum pool has returned 83% of its TAO, against 52% for constant product, which still prices Alpha above zero. It keeps the rest for Alpha not yet issued.
- **Endpoints that stay put.** New issuance does not move the ends of the curve. Paired injection still changes R.

Trade-offs

- **The 21 million boundary is theoretical.** It will not be reached for a long time, so the curve holds depth for supply that is far away.
- **Migration is a trade-off.** The boundaries, the reserves and the price cannot all be kept. Keeping today's reserves marks the price up, 1.80x on Chutes. Keeping today's price means releasing part of the reserves, which is what the single-step migration of Section 3.3 does.
- **It is more complex than constant product.** Each pool carries its own exponent R, and price and depth depend on it, while the curve stays symmetric.

> KEY INSIGHT. **A power sum with an exponent below one and fixed 21 million boundaries keeps what works in constant product and adds a finite end.** It stays **symmetric and governed by one parameter**, gains **the capital efficiency of a finite curve**, returning 83% of the TAO at a full sale against 52%, and **its endpoints do not shift when new Alpha is issued**. Its exponent also gives a way to size a pool's depth at a given price, which Section 3.3 uses.

3. LIQUIDITY AS A MANAGED PROTOCOL RESOURCE

3.1 Slippage is the control variable

Section 1 showed that the largest pools hold far more liquidity than their trading needs, enough to keep a subnet from breaking out or failing, and that Alpha injection decides how much of the value of emissions ends up as depth rather than price. Section 2 showed that the shape of the curve does not fix that depth. The quantity of reserves does. To size that quantity, a pool needs a measure of whether it is over- or under-liquid, which is a ratio of supply to demand. Supply is the reserve. Demand is the trading the reserve has to absorb.

Gross volume is the wrong measure of that demand. Bots and arbitrageurs can trade large amounts back and forth within a day without ever needing depth to stay in the pool. What needs permanent liquidity is the directional imbalance, the net flow left once buys and sells offset. Typical net flow divided by the reserve is the slippage a typical day of trading pays, which is the slippage proxy. The price itself moves about twice as far. The protocol does not set price, volatility or volume, but it does set liquidity, so slippage is the variable it can control and volatility the outcome to monitor.

$$S_i = \max\left(\frac{F_{\mathrm{TAO},i}}{\tau_i}, \frac{F_{\mathrm{Alpha},i}}{\alpha_i}\right) \qquad \text{and} \qquad \text{benchmark} = \sum_i w_i S_i\,, \quad w_i \propto \sqrt{\tau_i \alpha_i}$$

Market flow is what traders did on the day: the change in the TAO reserve once protocol injection and chain buys are taken out. F is its absolute value, averaged over 90 days with exponential weights, and the Alpha side is the same flow at the pool price. τ and α are the TAO and Alpha reserves. The slippage proxy S of a pool is the worse of its two sides. The slippage benchmark averages the pools with liquidity weights w, proportional to the square root of the product of the two reserves, the same weights the experiment of Section 3.3 uses. It is the aggregate market impact a representative investor faces on typical flow.

On September 30, 2026 the slippage benchmark stands at 1.08%. The TAO side alone, weighted by TAO reserves, reads 0.94%. In a simulation a single side can miss part of the dynamic, because the two reserves do not always move together. Retiring Alpha on its own raises the price and thins the Alpha side while TAO-side slippage stays where it was, and chain buys add TAO while taking Alpha out. Taking the worse of the two sides makes the measure respond to whichever reserve gets thinner, which is why the simulations of Section 3.3 and Part 2 use it. The two sides differ only by how far the price has moved over the flow window, so the worse side reads **depth plus a premium for the price trend**. It is the conservative reading: after a rise it watches the Alpha side, the reserve that profit-taking draws on.

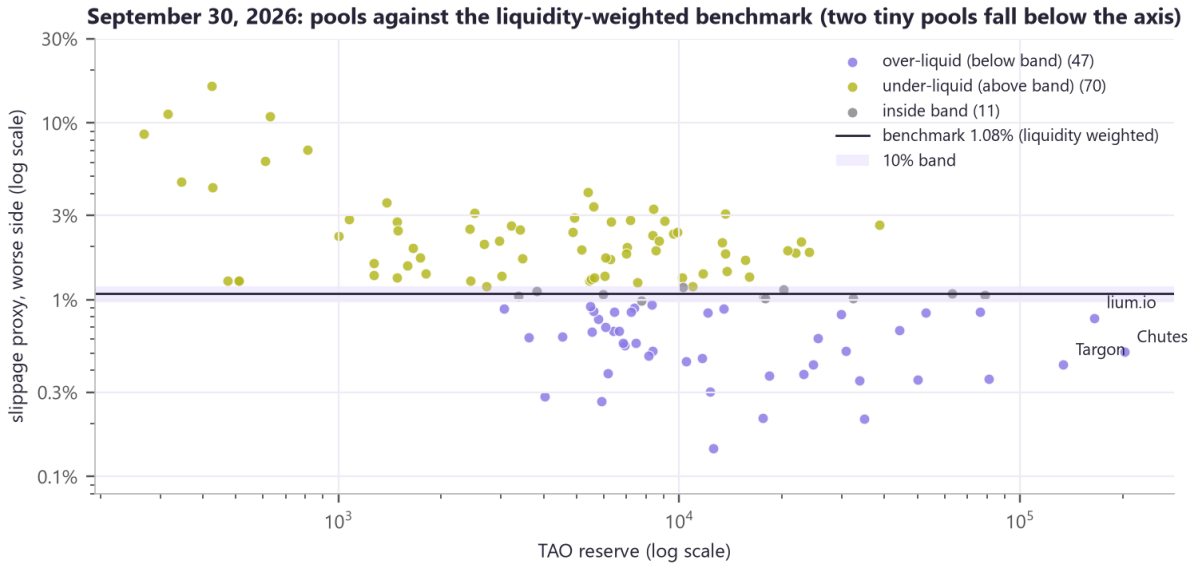


Figure 9. Every pool at September 30, 2026: slippage proxy (worse side) against TAO reserve, both on log scales, with the liquidity-weighted benchmark and the 10% band. Purple pools are over-liquid.

With a band of 10% around the benchmark, 47 pools holding 64% of all pool TAO sit below the band and are over-liquid by this standard, 70 pools holding 23% sit above it, and 11 sit inside. The large pools are the over-liquid ones.

Three practical questions decide whether the proxy can steer liquidity:

- **Does it measure the right thing?** The proxy captures price pressure, not the cost of a trade, but the two rank pools the same way. Utilization, gross volume over the reserve, has a rank correlation of 0.97 with the slippage proxy across pools, and no pool is over-liquid by slippage while being busy by utilization.
- **How fast does it react?** When daily flow triples, the 90-day reading takes 3 days to rise by 10%, the width of the band, and 5 days to rise by 20%. A 7-day reading does it in one day. Taking the worst of the 7, 30 and 90-day readings changes the verdict for 16 pools today and on 7.6% of subnet-days over the last year. The slow reading suits eligibility. A fast one suits the stop rule.
- **Can a subnet push its own reading?** Yes, but it takes months and carries risk. For Chutes, lifting its 90-day reading by one band width within 90 days takes about 250 TAO per day of trades timed around the daily snapshot, every day for three months, with each position exposed to the market until it is closed. Steady buying is far worse, because it adds to net flow only on days the market already buys: about 1,370 TAO per day, building a 123,000 TAO position that would lift the price 2.6 times. The fees, about 23 TAO over the three months, are not what protects the metric. The rule built on it does: pushing a reading up only stops a pool from giving up depth. The move that could pay is the opposite one, keeping flow off a pool so that it reads over-liquid, and Part 2 sets out the safeguards against it.

The sizing problem remains whatever the curve. Lowering k in a constant-product pool or lowering R in a super-elliptic pool steepens the price response in the same way: for each smaller k there is a lower R that starts from the same slope at today's reserves. The curve fixes the shape and the endpoints. Depth has to be chosen under either invariant, through k or through R. This is why we focus on how much liquidity sits in the pool rather than on the shape of the curve.

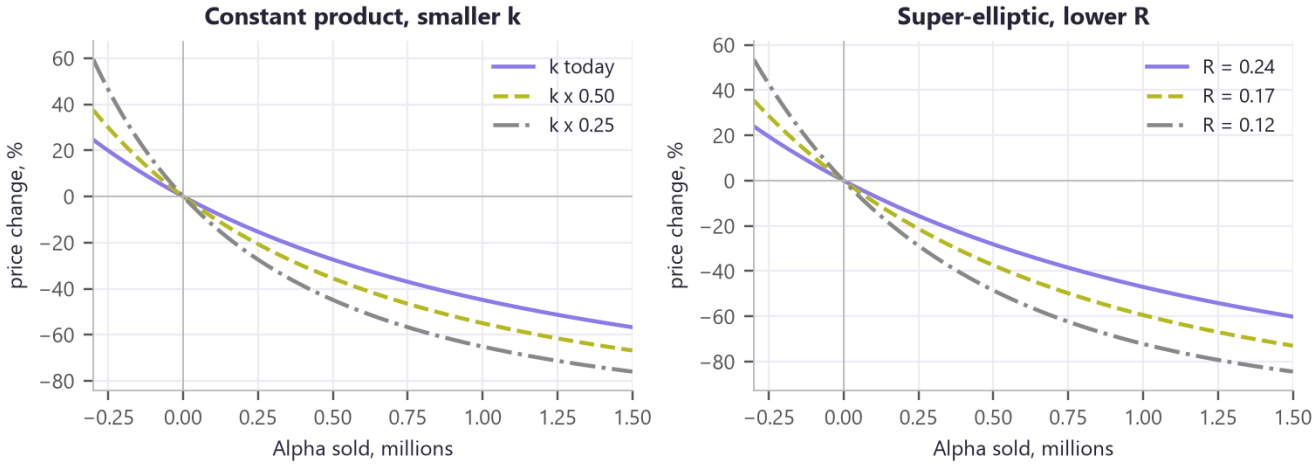


Figure 10. The same depth decision under two invariants, on the Chutes reserves. Left: constant product at successively smaller k, spot held constant. Right: a super-elliptic pool through the same point, Alpha boundary fixed at 21 million, with R lowered so that each curve starts from the same slope as the curve of the same style on the left. Lower R steepens the response as a smaller k does, so the quantity of reserves remains a separate decision from the curve.

3.2 What is efficient liquidity?

Is there an equilibrium level of liquidity to aim for? A break-even approach gives a way to answer. Start from a pool with no liquidity and ask how much a market maker would choose to supply, given the fees the chain pays, the volatility of the market and the yield the same TAO could earn by staking. The depth at which that provider is just indifferent is the liquidity a free market would supply on its own.

$$\frac{f\,V_i}{2\,\tau_i} - \frac{\sigma_i^2}{8} \geq r_0$$

The left side is what one unit of capital earns by providing liquidity. The first term is fee income: the swap fee f times the annual gross volume V, spread over the capital committed to the pool, 2τ, which counts the TAO reserve and the Alpha reserve at the pool price. On the same volume, a deeper pool earns less per unit of capital. The second term is the cost of being picked off. When the market moves, arbitrageurs trade against the pool at stale prices, and loss-versus-rebalancing puts that cost at $\sigma^2/8$ per year for a constant-product pool, with σ the 90-day realized volatility. The right side, r_0, is what

the same TAO earns by staking, without that risk. The staking yield changes over time, so 6% is used as a reference of the right order of magnitude, with no premium added.

Swap fee	Gross fee yield	LVR	Net return	vs 6% staking	Implied depth	Share of today	Implied benchmark slippage
5 bps (today)	0.77%	5.31%	-4.54%	-10.54%	134,105 TAO	7%	15.9%
30 bps	4.61%	5.31%	-0.70%	-6.70%	804,632 TAO	41%	2.6%
50 bps	7.69%	5.31%	2.38%	-3.62%	1,341,054 TAO	68%	1.6%
Break-even at current depth: 74 bps	11.31%	5.31%	6.00%	0.00%	1,972,071 TAO	100%	1.1%

Table 5. Private-provider economics across the 128-subnet universe at September 30, 2026. Annual gross volume is the trailing 365-day total, 60.7 million TAO, an order of magnitude rather than a forecast. Capital is marked at 2τ. Volatility is the TAO-weighted average of squared pool volatilities, 65% annualized. The last row solves for the fee that would sustain current depth. The implied benchmark slippage scales today's slippage benchmark, 1.08%, by the depth ratio.

The result does not rest on a risk premium, and adding one would only widen the gap. At today's 5 bps fee, the network's pools earn 0.8% per year in fees on the capital they hold and lose 5.3% to adverse selection, **a net loss of 4.5% per year where staking would have paid 6%**. At 30 bps the provider still loses 0.7%. At 50 bps fees finally cover adverse selection, but the return stays well below staking, and only a fee of 74 bps would make today's depth worth supplying. **A private market would supply roughly 134,000 TAO at today's fee, 7% of the 1.97 million actually deployed.**

$$\text{Subsidy} = 2\tau(r_0 + \ell) - f\,V$$

That gap is the subsidy: about 416,000 TAO per year at today's fee, or 32% of annual TAO issuance. Forgone staking yield is about 237K TAO of that cost and adverse selection paid to arbitrageurs about 209K, against 30K of fees. The figure is indicative: it holds volume fixed, although part of it, arbitrage above all, would leave with the depth. Its purpose is to show that **most of today's liquidity is a subsidy** at the current fee and volume, so the network is free to decide whether that value buys depth or price.

Subsidized liquidity is not a problem in itself. A new subnet has no flow until it has a market, so depth paid for by emissions is what lets trading start. The private-provider level is what the market would supply unaided. It is the least depth that could sustain itself, and not a level to aim for: at that depth typical slippage would be about 15 times higher, with a benchmark near 16%, and the market would barely function.

The right question is therefore not whether liquidity is subsidized. It is whether the subsidy is buying enough market quality, and whether anyone has ever specified how much.

Instead of targeting a depth, the community sets **the worst market impact it is prepared to accept**. Liquidity may be withdrawn from a pool only while its own impact stays inside that bound.

The provider economics give the bound an anchor. A 30 bps fee sustains 41% of today's depth and implies a benchmark of 2.6%. A 50 bps fee sustains 68% and implies 1.6%. A 2% cap on the benchmark sits between the two. It is the level Part 2 uses as the ceiling of its target, and it is a parameter for the community to set, not a result of this paper.

- **Excess.** A pool below the target releases liquidity. The target is the benchmark, capped at the ceiling.
- **Neutral.** A pool inside the band: no action.
- **Shortage.** A pool above the band releases nothing, and emissions rebuild its reserves.

The rule needs no forecast. No pool is pushed past the ceiling. Section 3.3 tests it in a simplified one-off transition, and Part 2 develops the continuous feedback loop.

> KEY INSIGHT. **Most of today's liquidity is a subsidy, so there is no market equilibrium to target.** Even at a 30 bps fee, private providers would supply only 41% of today's depth. That leaves a wide margin: part of the subsidy can be withdrawn and returned to holders as price support, inside a published ceiling on slippage or volatility.

3.3 Introducing ASMR: a one-off transition experiment

ASMR, Alpha Subnet Market Reloaded, is a liquidity control: a feedback loop that matches the supply of liquidity with the demand for it. This section tests the idea in a simplified experiment, a one-off transition that retires part of the Alpha the protocol injected into the pools. It was first presented at the Exploit Summit in Montreal on September 28 and 29, 2026, on the state of August 31, and is rerun here on the September 30, 2026 state of all 128 subnets. The experiment runs on a frozen state, with no emission, injection, chain buys or market response, which is why it comes to a stop. In practice the control has to run continuously, which is the subject of Part 2. The rule has five steps and runs one day at a time:

1. **Measure.** For each pool, the slippage proxy S is the 90-day average absolute market flow on each side, F_{TAO} and F_{Alpha}, divided by the matching reserve, on the worse of the two sides. Flows are held at their September 30 level.
2. **Benchmark.** The liquidity-weighted average of S across pools, recomputed every day on the current reserves.
3. **Retire.** Pools below the benchmark retire pool Alpha toward the quantity that would bring their S up to the benchmark. Only Alpha the protocol injected into the pool since its subnet was registered, its current episode, may be retired. This ownership guardrail is the rule that protects holders: Alpha they earned is never touched.
4. **Pace.** Each pool's price may rise by at most 50 basis points per day.
5. **Stop.** When nothing eligible is left to retire, or, in the version shown at the Exploit Summit, when the volatility proxy of the subnet index reaches 1% per day. On the September 30 state the guardrail binds first.

Retiring Alpha alone raises the price. The same action can be read in two steps: a price-neutral release of TAO and Alpha in proportion, followed by a swap of the released TAO back into the same pool. The two-step reading matters for Part 2, where the released TAO can go elsewhere. Here it stays in the pool, so holders of the repriced subnet receive the whole effect.

$$S_i = \max\left(\frac{F_{\text{TAO},i}}{\tau_i}, \frac{F_{\text{Alpha},i}}{\alpha_i}\right) \quad \text{and} \quad \text{benchmark} = \sum_i w_i S_i, \quad w_i \propto \sqrt{\tau_i \alpha_i} \quad \text{and} \quad \alpha_{\text{target},i} = \frac{F_{\text{Alpha},i}}{\text{benchmark}}$$

The last meaningful retirement takes place on day 417, and the run ends on day 447, after 30 days with almost none. **Most of it is done by day 250**: 96% of the Alpha is retired by then and the index already stands at 2.12 times its starting level. In total 98.3 million Alpha is retired out of 170.8 million the protocol injected, and 27 pools exhaust their guardrail and stay below the benchmark because nothing more may be taken from them. The subnet index (YCX) ends at 2.28 times its starting level, the mean pool at 2.00 times and Chutes at 3.81 times. The benchmark rises from 1.08% to 1.82% and the volatility proxy from 0.64% to 0.96% per day, still below the 1% boundary.

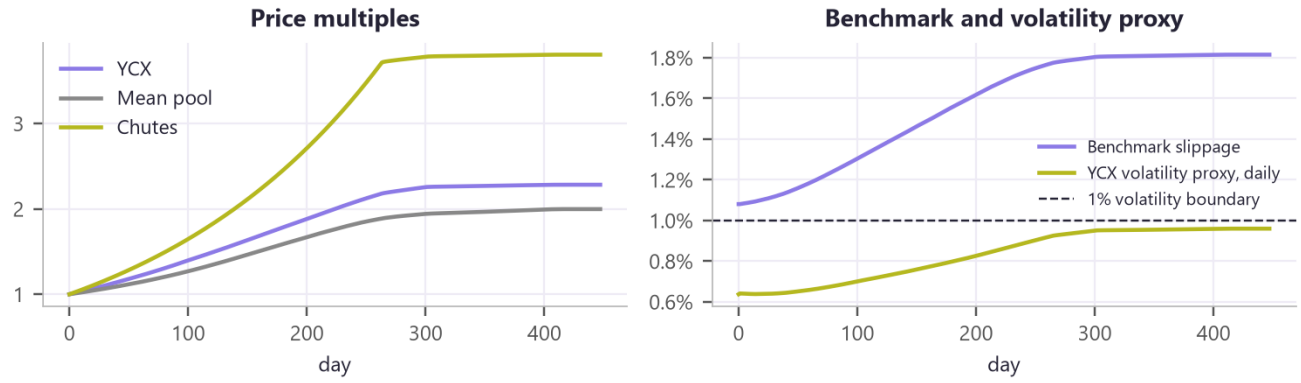


Figure 11. The one-off transition on the September 30, 2026 state. Left: price multiples of the subnet index, the mean pool and Chutes. Right: the liquidity-weighted benchmark and the volatility proxy against the 1% boundary.

	Before (Sep 30, 2026)	Day 250	After (day 447)
Pool TAO (all pools)	1,972,071	1,972,071	1,972,071
Pool Alpha, M	208.0M	113.7M	109.7M
Liquidity, sum of √(τα)	17,459,592	12,430,704	12,171,543
Locked TAO	888,442	549,242	531,409
Reachable share of pool TAO	54.9%	72.1%	73.1%
Benchmark slippage, liquidity weighted	1.08%	1.75%	1.82%
YCX volatility proxy, daily	0.64%	0.90%	0.96%
YCX level (start = 1)	1.00x	2.12x	2.28x
Mean subnet price multiple	1.00x	1.85x	2.00x
Chutes price multiple	1.00x	3.48x	3.81x
Pools at or below the benchmark	54	84	84
Pools at the ownership guardrail	0	20	27
Alpha retired, cumulative, M	0.0M	94.3M	98.3M

Table 6. The one-off transition: before, at day 250 and after. Pool TAO does not change because retired Alpha leaves the pools alone. Locked TAO falls because less of the reserve sits behind pool Alpha. At the end 84 pools sit at or below the benchmark: 27 are held below it by their guardrail, 4 have no injected Alpha to retire, and the other 53 have been brought up to it. The volatility proxy scales the September 30 index volatility with the capitalization-weighted aggregate slippage.

A single-step alternative

The alternative to a progressive transition is to **bring every over-liquid pool to the target in one step**. Two versions are computed on the September 30 state, with the Part 2 target: the benchmark capped at 2%, a 10% band, and 47 pools below the band. The first shrinks each pool along its constant-product curve, withdrawing TAO and Alpha in proportion. The second moves the pools onto the super-elliptic power-sum curve of Section 2.3, $\tau^R + \alpha^R = 21^R$, with reserves in millions and both boundaries fixed at 21 million. For each pool the migration picks the exponent R at which the new curve keeps the current marginal price and gives the local depth the target requires. Because the curve steepens away from spot, **that depth needs less TAO**, and the endpoints do not shift when new Alpha is issued. 32 of the 47 pools have such a point with less of both reserves. The other 15 keep the constant-product shrink.

Pull request 3210, open on the subtensor repository, takes a related path. It migrates every funded pool to a translated superellipse with the exponent fixed at two, keeping each pool's reserves, spot price and local sensitivity, so it reprices large trades but **releases no TAO**, and its endpoints shift with every injection. Here the exponent varies by pool so that depth can be set to the target, which releases TAO, and the endpoints stay at the 21 million boundaries, so **the settlement point is known in advance**.

	Constant-product shrink	Super-elliptic migration (fixed 21M boundaries)
Pools shrunk	47	47, of which 32 on the new curve
TAO released	596,944	781,442
Share of all pool TAO	30%	40%
Alpha released	52.4M	40.6M
Of which burned (injected Alpha)	49.7M	39.8M
Of which vaulted (beyond the guardrail)	2.6M	0.8M
Chutes TAO released	107,830	141,016
Chutes share of its TAO	53%	70%

Table 7. Single-step alternatives at the Part 2 target (benchmark 1.08%, band 10%). The constant-product version withdraws TAO and Alpha in proportion. The super-elliptic version moves each pool to a curve with the same marginal price and the same local depth, which needs less TAO because the curve is steeper away from spot.

For the same local market quality the super-elliptic migration releases 40% of pool TAO against 30%, and Chutes gives up 70% of its TAO against 53%. Both are static: they say where a pool would land, not how it gets there. Part 2 simulates the super-elliptic version.

> KEY INSIGHT. **Excess liquidity is a trade between depth and price.** The same injected Alpha that mutes price discovery also locks TAO behind it. Paced at 50 basis points per day, the transition runs 447 days, removes 98 million Alpha from the pools and lifts the index to 2.3x. It also frees about 357K TAO that holders can reach: locked TAO falls from 888K to 531K and the reachable share of pool TAO rises from 55% to 73%. A single-step move to the target would release 597K to 781K TAO at once, the super-elliptic curve releasing more for the same local depth.

CONCLUSION

dTAO makes three decisions at once and ties none of them to trading demand. How much a pool holds is whatever emission leaves behind. How that inventory turns into price is inherited from constant product. Where the pool lands when outside Alpha is sold is whatever the invariant implies.

Quantity is the problem today. In the ten most liquid pools, liquidity grew 196% since June 2025 while trading fell 61%, and across the network 61% of the TAO emitted since dTAO launched is still in the pools. The daily volatility of the subnet index fell 69%, to 0.64%. That is below the 0.74% of the S&P 500, and about level with it once each is annualized on its own trading days (12.2% and 11.8%), in a market where price allocates emission and decides which subnets survive.

A better curve does not fix it. Constant product, Balancer, Uniswap v3 and d2TAO hand back between 39% and 100% of reserves at the boundary and respond differently to a trade. But a curve is set once, and none of them adjusts liquidity when trading demand changes. A super-elliptic curve with fixed 21 million boundaries keeps the simplicity of constant product, adds a finite end, and gives a way to size depth at a given price.

Liquidity can be managed like any other protocol resource. Slippage on typical flow is the control variable and a private provider's economics anchor the ceiling. In a one-off transition experiment on the September 30 state, ASMR retires 98 million Alpha, lifts the index to 2.3x and Chutes to 3.8x, and cuts locked TAO by 40%.

Limits of a one-off transition. The experiment runs on a frozen state and comes to a stop. On a live chain emission arrives every day and injection rebuilds the depth that was removed, so a one-off adjustment does not hold. Part 2 develops the continuous feedback loop, simulates it over two years in a flat and in a falling market, and sets out who could receive the TAO it releases.

The same TAO can buy depth or price. Emission is value the subnets have mined, and it reaches Alpha holders as depth, as lower volatility or as price. Today the network buys depth it does not use, and a paced rule can return the difference as price. Taking liquidity out without returning that value would leave Alpha holders worse off. For a subnet that earns revenue and buys back its Alpha, **that is the difference between a price that carries its growth and a price that mutes it**. This research does not forecast prices and does not propose a change to the emission rule.

Next steps. Part 2 develops the rule into a continuous feedback loop that could run on a live chain, with the parameters and the choice of recipient it requires.

APPENDIX

A. Definitions and data

Data. Daily snapshots of every subnet pool from February 14, 2025 to September 30, 2026: reserves, outside Alpha, cumulative volume, injection, chain buys and emission, 128 non-root subnets alive on the end date. Prices are reserve-implied, TAO reserve over Alpha reserve. The live TAO supply is read from the chain at each snapshot block.

Market flow. The daily change in a pool's TAO reserve less protocol injection and chain buys. Its Alpha-side counterpart divides by the prior day's price. Days on which a subnet is deregistered and replaced are left out. Gross volume is the daily change in the cumulative volume column, clipped at zero where the column resets.

Slippage proxy. The exponentially weighted mean of absolute market flow (span 90 days, at least 30 observations) divided by the matching reserve, per side. The pool's S is the larger side. Pools with less than 30 days of history sit at the median relative flow of the universe.

Volatility. The exponentially weighted standard deviation of daily log returns, span 90, returns clipped at plus or minus ln 2, not annualized unless stated (annual is daily times the square root of 365).

Slippage benchmark. The liquidity-weighted mean of S over the universe, weights proportional to the square root of the product of a pool's TAO and Alpha reserves, recomputed daily on the prior state.

YCX. A capitalization-weighted price index of the subnets with more than one million total Alpha. Its volatility is the exponentially weighted standard deviation of its daily return, span 90: 0.64% per day at September 30, 2026. The volatility proxy of Section 3.3 scales that figure with aggregate slippage.

Reachable and locked TAO. A is the staked Alpha outside the pool. Burned Alpha, 24% of the Alpha recorded outside the pools on the end date, is not staked and cannot be sold: it is left out of A and ADR and kept in total Alpha. Protocol-owned Alpha, 14.0 million, may sit inside the staked count. Taking it out would raise locked TAO from 888K to 931K. For a fee-free constant-product pool with TAO reserve τ and Alpha reserve α, a full sale of A recovers the reachable TAO, leaves the rest locked, and moves the price from p to its value after the sale:

$$\text{reachable} = \frac{\tau A}{\alpha + A} \quad \text{and} \quad \text{locked} = \frac{\tau \alpha}{\alpha + A} \quad \text{and} \quad p_{\text{after}} = \frac{p}{\left(1 + \frac{A}{\alpha}\right)^2}$$

B. Super-elliptic local depth

Curve and price. A super-elliptic pool satisfies the curve below, with U and V the Alpha and TAO reserves as shares of their boundaries, and its marginal price follows:

$$U^R + V^R = 1, \quad U = \frac{\alpha}{\alpha_{\max}}, \quad V = \frac{\tau}{\tau_{\max}} \quad \text{and} \quad p = \frac{\tau_{\max}}{\alpha_{\max}} \left(\frac{V}{U}\right)^{1-R}$$

Local depth. Differentiating along the curve gives the price sensitivity to TAO, against $2/\tau$ for a constant-product pool, and so the constant-product-equivalent depth of the super-elliptic pool:

$$\frac{d \ln p}{d\tau} = \frac{1 - R}{p \alpha V^R} \quad \text{and} \quad \tau_{\text{eff}} = \frac{2 p \alpha V^R}{1 - R}$$

Migration. For each over-liquid pool the single-step migration of Section 3.3 finds the R that keeps the marginal price and gives the depth of the target. On Chutes R = 0.17, against 0.22 in Section 2.3, which keeps the reserves.

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