Astrovault: Evolving the AMM Model Past Pre-Money Speculation with Sustainable Incentives and Independent Liquidity

Abstract

Astrovault is a hybrid Automated Market Maker (AMM) and Decentralized Autonomous Organization (DAO). Astrovault incorporates slippage-free 1:1 trades alongside the traditional AMM model to leverage staking derivatives as base pairs. Staking derivatives are used as primary liquidity, allowing liquidity hosted to be staked and earn rewards as revenue for the AXV DAO. This revenue is then dispersed as Protocol Owned Liquidity (POL) and rewards, which are essential for the endurance of attractive yield and provides eventual independence from reliance on external liquidity provision. The slippage-free pools allow easy conversion from the derivative to the native asset plus cheap multi-chain stable swaps.

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Contents

List of Tables

List of Figures

1 Motivation

"*Commerce on the Internet has come to rely almost exclusively on financial institutions serving as trusted third parties to process electronic payments. While the system works well enough for most transactions, it still suffers from the inherent weaknesses of the trust based model.*"[1] AMMs give control of digital asset management back to the people. Free trade and easy access are integral parts of web3, which allow for the ownership and digital transfer of assets.

Up until this point, AMMs have relied solely upon speculation to derive their value. They offer an integral service but don't adequately capture the value they provide through their token. The valuations for AMM governance tokens are arbitrarily based on Total Value Locked (TVL) and volume, but rarely do the tokens offer substantially more than governance power and theoretical value based on potential fees extracted from users. High valuations are required to sustain the high Annual Percentage Rate (APR) needed to retain liquidity providers, the mercenary capital on which they depend. In the case of a black swan event, the protocols unable to provide strong enough incentives to retain or incentivize user capital could be damaged beyond repair. The current models simply do not provide a transition from pre-revenue speculation to post-money sustainability.[2]

In 2019, Gartner, a prominent technological research and consulting firm positioned blockchain technology in the category *'trough of disillusionment'* of their well-respected Hype Cycle for Emerging Technologies. This is a clear indicator of decreased investor interest as experiments and implementations fail to deliver. These failed experiments were stepping stones towards an eventuality promised by Decentralized Finance (DeFi).

"*We are witnessing many developments in blockchain technology that will change the current pattern. By 2023, blockchain platforms will be scalable, interoperable, and will support smart contract portability and cross chain functionality.*"[3]

In 2021, Avivah Litan, distinguished analyst and research vice president at Gartner stated, "*Decentralized finance (DeFi) applications offer substantially greater financial rewards than traditional finance. Centralized firms like hedge funds already take advantage of this.*" and went on to elaborate, "*We project that by 2023, 35% of enterprise blockchain applications will integrate with decentralized applications and services. The rewards are simply too high to ignore, and are far greater than the costs.*"[4]

With enterprises already aware and starting to take advantage of the promises of decentralized finance, it is more crucial than ever to provide sustainable, interoperable, high-yield, low-risk options.

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[1] Nakamoto, Satoshi. "Bitcoin: A Peer-to-Peer Electronic Cash System." Bitcoin.org, 2008. https://bitcoin.org/bitcoin.pdf

[2] Callow, Dana A, and Michaetl Larsen. "Understanding Valuation: A Venture Investor's Perspective." Millennia Partners. Boston Millennia Partners, 2003. http://www.millenniapartners.com/_documents/whitepaper/whitepaperattachment6.pdf

[3] Gartner, Meghan, and Laurence Gartner. "Gartner 2019 Hype Cycle Shows Most Blockchain Technologies Are Still Five to 10 Years Away from Transformational Impact." Gartner Newsroom Press Releases. Gartner Inc, October 8, 2019. https://www.gartner.com/en/newsroom/press-releases/2019-10-08-gartner-2019-hype-cycle-shows-most-blockchain-technologies-are-still-five-to-10-years-away-from-transformational-impact

[4] Litan, Avivah. "Hype Cycle for Blockchain 2021; More Action than Hype." Gartner Blog. Gartner Inc, July 14, 2021. https://blogs.gartner.com/avivah-litan/2021/07/14/hype-cycle-for-blockchain-2021-more-action-than-hype/

2 Astrovault

Astrovault is a novel adaptation of previous AMM models aligned to create sustainable token economics and designed to generate and capture continual value. *AXV* is built on Archway, an economically designed incentivized smart contract platform built on Cosmos Software Development Kit (SDK).[5] *ARCH* (the native governance token of Archway) and most other tokens in the Cosmos ecosystem run on a delegated-proof-of-stake inflationary model.[6] By utilizing the CosmWasm-20 (CW-20) standard to create these staking derivative solutions for various supported inflationary tokens, the majority of liquidity provided on Astrovault will exist in tokenized representations of staked assets that are earning interest and securing the various Layer-1 networks in the Cosmos ecosystem.[7] By capturing that interest directly, the DAO will generate steady revenue from its hosted liquidity, which will in turn be deployed as Protocol Owned Liquidity (or POL) and given to *AXV* stakers. POL and rewards create measurable value for the *AXV* token, which is given as rewards to liquidity providers. Increased value of the *AXV* token should incentivize mercenary capital to provide liquidity, which will again increase the revenue. As more POL is generated, mercenary capital becomes less of a dependency until it is no longer necessary and the protocol has achieved complete sustainability.

The *AXV* DAO will be more connected to its user base by being invested in the supported assets it aims to serve, and will be further incentivized to facilitate the success of those assets and the entire Cosmos ecosystem. In addition to economic sustainability, use of staking derivatives provides a vector for voting in the governance of all Layer-1 chains supported by the DAO, through the *AXV* token.

The core principles of Astrovault are:

[1] Create Sustainable Value
[2] Capture Value Sustainably
[3] Create a Catalyst for Liquidity on Archway
[4] Facilitate the Growth of the Cosmos Ecosystem

3 Nebula pools

Astrovault will have two types of AMM pools: Nebula and Plasma. Nebula pools will offer the typical $x \times y = k$ market maker mechanism.[8,9] Pairs on Nebula pools will be CosmWasm-20 (CW-20) tokens based on Layer-1 staking derivatives, Layer-2 tokens built on Archway, Inter-Blockchain Communication (IBC) enabled Layer-2 tokens, and bridged assets from external ecosystems.[10] All of the fees (0.20% of trade volume) from the Nebula pools go to buyback and burn the *AXV* token.

[5] Kwon, Jae, and Ethan Buchman. "Cosmos Whitepaper: A Network of Distributed Ledgers." Cosmos Network. Tendermint Inc., January 30, 2019. https://v1.cosmos.network/resources/whitepaper

[6] Authors, Unknown. "Archway Litepaper: An Introduction to Archway." Archway.io. Accessed August 19, 2022. https://archway.io/lightpaper.pdf

[7] maurolacy. "Github, CosmWasm/Cw-plus/Packages/cw20/ (CW20 Repository)." GitHub. Accessed August 18, 2022. https://github.com/CosmWasm/cw-plus/tree/main/packages/cw20

[8] Zhang, Yi, Xiaohong Chen, and Daejun Park. "Formal specification of constant product (xy=k) market maker model and implementation." White paper (2018). https://github.com/runtimeverification/verified-smart-contracts/blob/uniswap/uniswap/x-y-k.pdf

[9] Pourpouneh, Mohsen, Kurt Nielsen, and Omri Ross. "Automated Market Makers." IFRO Working Paper, No. 2020/08. University of Copenhagen, Department of Food and Resource Economics (IFRO), Copenhagen, July 2020. https://www.econstor.eu/bitstream/10419/222424/1/IFRO_WP_2020_08.pdf

[10] Authors, Unknown. "Cosmos IBC Official Documentation." IBC-Go. Accessed August 18, 2022. https://ibc.cosmos.network/main/ibc/overview.html

4 Plasma pools

Plasma pools offer consistent swaps at a 1:1 ratio between 2 or more assets with scaling fees instead of slippage. Having exponential fees prevents any side of the pool from being fully depleted while enabling cheaper and easier conversions that utilize more of the liquidity than the $x \times y = k$ model allows. All fees collected in the Plasma pools, both from trades and withdrawals, will remain in the Plasma pools as Protocol Owned Liquidity.

The formula for the trade fees is calculated as:

$$f_{\text{trade}} = 0.03\% + 0.025\% \times \left(\frac{P_{\text{in}}}{P_{\text{out}}}\right)^3$$

where f_{trade} is the Plasma trade fee
P_{in} is the ending pool percent of the sold token
P_{out} is the ending pool percent of the bought token

Example: Alice wants to trade 100 $xATOM$ for $ATOM$. The $ATOM$ Plasma pool has 2 denominations of 5,000 $xATOM$ and 10,000 $ATOM$.

$$P_{\text{in}} = \frac{5,100}{15,000} = 0.34 \quad \text{and} \quad P_{\text{out}} = \frac{9,900}{15,000} = 0.66$$

$$f_{\text{trade}} = 0.03\% + 0.025\% \times \left(\frac{0.34}{0.66}\right)^3 \approx 0.033\%$$

$$\therefore 0.033\% \times 100\ xATOM = 0.033\ ATOM \text{ in fees}$$

Table 1: Typical balancing and unbalancing fees for a 2-token pool

Pool Breakdown	Balancing	Unbalancing
50/50	0.055%	0.055%
45/55	0.044%	0.076%
40/60	0.037%	0.114%
35/65	0.034%	0.190%
30/70	0.032%	0.348%
25/75	0.031%	0.705%
20/80	0.030%	1.630%
15/85	0.030%	4.579%
10/90	0.030%	18.260%
5.93/94.07	0.030%	100%

In order for the Plasma pools to be sustainable they must avoid depletion and remain relatively balanced as often as possible. One balancing incentive is *GRVT8*, a primitive that rewards traders per their trading volume. The combination of adding *GRVT8* and keeping fees incredibly low creates unique profit opportunities and permanently incentivizes the balancing of these pools. If the user base fails to sufficiently balance these pools, this process could be automated indefinitely through the deployment of simple arbitrage bots. Bad actors could theoretically slow down or temporarily imbalance a pool, however, the expense would be economically inviable due to the exponential fee model. Further, the accrued fees collected represent revenue to the DAO and are retained in the pool as POL - replenishing the very liquidity the bad actor attempted to deplete..

In addition to the trade fees, two conditional withdrawal fees must exist. Plasma pools are single-sided depositories that grant liquidity providers partial ownership of the entire pool. To prevent users from depositing liquidity and withdrawing a specific asset as a means of avoiding the trade fee while slowly unbalancing a pool, there will be a 10-day soft-lockup period.

Unbonding liquidity can be done on any side of the pool, but removing it will have a fee of:

$$\max(\ 0\ ,\ 1\% - 0.1\% \times d\ )$$

where d is the number of days

This means that users can access their funds immediately, or can wait 10 days to withdraw their funds for free. It also means that users can perform fee-free swaps through these pools by depositing and withdrawing liquidity, but this would take 10 days to perform.

The other conditional unbalancing withdrawal fee is exponential and serves to protect the pool from depletion in the same manner as the scaling trade fees. The formula is as follows:

$$f_{\text{cuw}} = 0.023\% \times \left(\frac{\left(\frac{T_{\text{other}}}{N_{\text{denom}} - 1} \right)}{T_{\text{withdrawn}}} \right)^3 \iff f_{\text{cuw}} \geq 0.25\%$$

where f_{cuw} is the conditional unbalancing withdrawal fee
T_{other} is the ending pool percent of other tokens
N_{denom} is the number of different token denominations in the pool (2 or more)
$T_{\text{withdrawn}}$ is the ending pool percent of withdrawn token

Example: Alice wants to emergency withdraw 10k *USDC* from a Plasma Stable Pool. The pool is made up of the following five stablecoin denominations:

USDC	USDC(bsc)	USK	USDT	BUSD	Pool Total
2,000,000	4,000,000	7,000,000	6,000,000	4,000,000	23,000,000

First, the conditional unbalancing withdrawal fee is calculated:

$$T_{\text{other}} = \frac{23,000,000 - 2,000,000}{23,000,000 - 10,000} = \frac{21,000,000}{22,990,000} = 0.91344 \tag{1}$$

$$N_{\text{denom}} = 5 - 1 = 4 \tag{2}$$

$$T_{\text{withdrawn}} = \frac{2,000,000 - 10,000}{23,000,000 - 10,000} = \frac{1,990,000}{22,990,000} = 0.08656 \tag{3}$$

$$f_{\text{cuw}} = 0.023\% \times \left(\frac{0.22836}{0.08656}\right)^3 \iff f_{\text{cuw}} \geq 0.25\% \tag{4}$$

$$0.4223\% \geq 0.25\% \ = \text{TRUE} \tag{5}$$

A false condition would represent no fee.

$$0.4223\% \times 10,000 \ \textit{USDC} = 42.23 \ \textit{USDC} \text{ in fees}$$

Since emergency withdrawal days = 0

$$1\% - 0.1\% \times d = 1\%$$

The emergency withdrawal fee will then be in relation to the remaining (100% - 0.4223%) of the original requested withdrawal.

$$\text{Emergency withdrawal} = 9,957.77 \ \textit{USDC} \times 1\% \approx 99.58 \ \textit{USDC}$$

The combined withdrawal fee for this example would be:

$$42.23 \ \textit{USDC} + 99.58 \ \textit{USDC} = 141.81 \ \textit{USDC}, \text{ or } 1.4181\%$$

Table 2: A template for conditional unbalancing fees for a 2-token pool

Pool Breakdown	Balancing	Unbalancing
50/50	0%	0%
45/55	0%	0%
40/60	0%	0%
35/65	0%	0%
30/70	0%	0.292%
25/75	0%	0.621%
20/80	0%	1.472%
15/85	0%	4.185%
10/90	0%	16.767%
5.93/94.07	0%	100%

These fees allow users to withdraw funds whenever they want, in whatever denomination they prefer, while disincentivizing harm to the protocol. No user must experience withdrawal fees if they wait 10 days and withdraw the tokens in accordance with the needs of the pool. 100% of fees in Plasma pools will remain in the pool as POL.

5 GRVT8

5.1 Volume incentives

GRVT8 is a reward token given to traders in correlation with their trading volume. Designed as a subsidy to reduce trade fees and reward traders with *AXV*'s inflation, *GRVT8* plays an integral part in ensuring the longevity of the Plasma pools. Balancing the Plasma pools has trade fees as low as 0.03%, which will be lower than the *GRVT8* rewards, making trading that directly benefits the usability and sustainability of those pools profitable for the users.

The *GRVT8* contract will receive adjustable *AXV* allocation directly from inflation. *GRVT8* tokens will be minted upon each trade and are always redeemable for their proportion of total *AXV* held in the *GRVT8* contract. The *GRVT8* is burned (removed from total supply) upon *AXV* redemption.

The *GRVT8* claim ratio is $\dfrac{\text{Accumulated } AXV \text{ Tokens}}{\text{Total } GRVT8 \text{ Supply}}$

To properly understand the Astrovault trade fees as experienced by the user, the *GRVT8* Protocol must be factored in.

$$\text{Net Trade Fee } = \text{Trade Fee} - GRVT8$$

Let's revisit Alice's Plasma trade where she traded 100 *xATOM* for 100 *ATOM* which resulted in a trade fee of 0.033%, or 0.033 *ATOM*.

Let us suggest for this example:

- The *GRVT8* contract has currently accumulated 50,000 *AXV* tokens
- The current total supply is 10,000,000 *GRVT8*
- *GRVT8* is minted at a rate of 1 *GRVT8* per $1 of trade volume

Alice's trade would've minted a number of *GRVT8* tokens equal to:

$$G = 100 \times P$$

where G is the *GRVT8* minted
P is the price of *ATOM*

If *ATOM* is valued at $20, then Alice's trade has a volume of $2,000, her trade fee was $\$2,000 \times 0.00033 = \$0.66$, and 2,000 *GRVT8* will be minted and given to her. The updated total supply of *GRVT8* after this trade is 10,002,000, but the number of *AXV* in the contract hasn't changed (though in reality it's added to every block).

If Alice redeems her *AXV* at this time, she will receive:

$$2,000 \times \left(\frac{50,000}{10,002,000}\right) = 9.998 \ AXV$$

The *GRVT8* traded in will be burned from the supply, lowering the supply back to 10,000,000 *GRVT8*. The available *AXV* in the contract will lower from 50,000 to 49,990.002. Whether or not Alice fully recuperated her trade fees is dependent on the price of *AXV*.

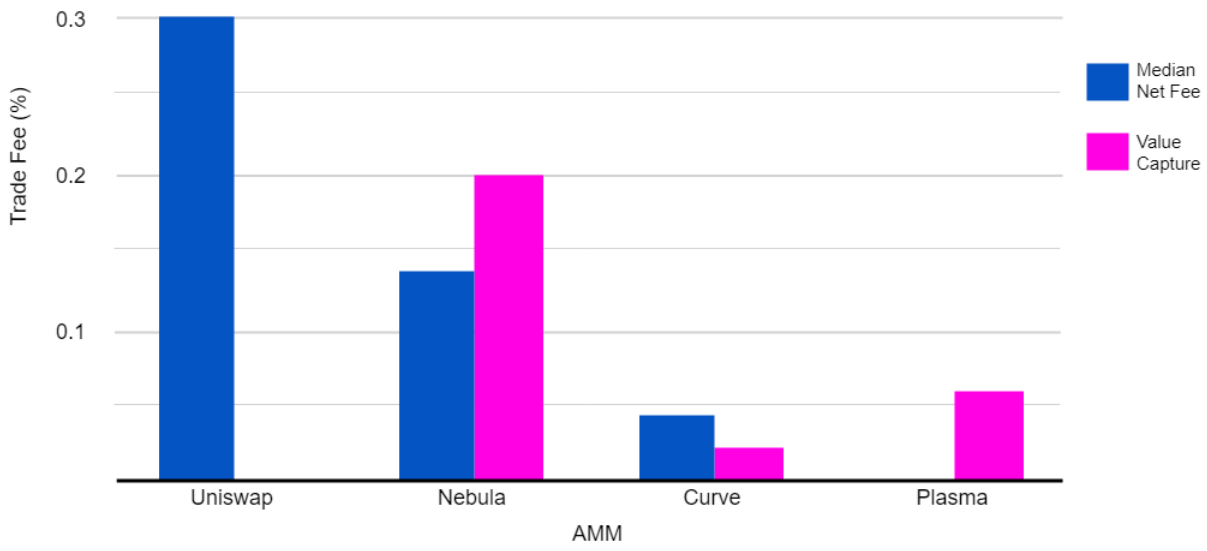
In order to properly incentivize balancing the pools, it's imperative that *GRVT8* maintains a redemption level above 0.03% of trade volume. Should it be above 0.055% of trade volume, it can be gamed across balanced Plasma pools until it is lowered to a low of nearly 0.055%. While the market controls the price of the *AXV* token, and the volume traded, the weight of the percentage of inflation directed towards the *GRVT8* contract can be adjusted to ensure the success and longevity of the protocol.

Assuming 0.055% of trade volume is recuperated by *GRVT8*, in Alice's trade *AXV* would have a price of \$0.12, and she would've received \$1.10 worth of *AXV* when she redeemed her *GRVT8*. Her net trade fee would be:

$$\text{Net Trade Fee } = \$0.66 - \$1.10 = -\$0.44$$

The negative trade fee means that Alice profited from her 1:1 slippage-free trade. As illustrated in the example, Plasma and Nebula will both offer lower net trading fees than current market standards.

Figure 1: Comparison of AMMs median net trade fee and captured value



The protocol sustainably captures the value directly by incorporating external revenue and generating Protocol Owned Liquidity, therefore, there is no dependency on trade fees to retain long-term liquidity provision. Through the use of *GRVT8*, the protocol will capture more from user fees than the users themselves will ever experience, and the Plasma pools can indefinitely be profitably balanced.

5.2 Organic bonding

The most common method of generating POL currently is bonding, where the protocol itself sells its tokens at a discount to purchasers for specifically desired tokens. While this does bring about the desired result of the protocol owning funds other than its own token, it brings about suboptimal flaws from a game theory perspective.

First, this presents the opportunity to perform dilatory arbitrage, which we will go into further in the derivative section. In essence, if Alice, an arbitrageur, can purchase a token at a 4% discount with USD, then when she gets that token she will sell it for USD at a 4% profit to perform the arbitrage again. This creates sell pressure on the token which lowers both the price and the amount of USD one would have to pay to purchase it at a discount.

Secondly, this urges the community toward a (3,3) mentality, which is an ill-informed game theory fad aimed to convince investors that holding and never selling would make everyone unfathomably rich. Urging people to buy/hold so that the valuation outpaces the value is an attempt to pay the current investors with the money paid from future investors, which is the definition of a "*Ponzi scheme*"[11]. A sustainable model wouldn't be broken by selling or volatility.

Organic bonding is done dynamically by trading in our Plasma pools when the volume incentives are higher than the trade fees. This would be arbitrage without predatory and speculative waiting periods, and profitability would be temporary and defined by the consistent codebase as opposed to cronyistic centralized preferences. Furthermore, the organic bonding model of Astrovault both assumes and accounts for the selling of the AXV token, and is justifiably only profitable until a price stabilization occurs. In essence, organic bonding is gaming AXV inflation by balancing our Plasma pools, providing a service and monetary value for risk-free profit.

[11] Chen, James. "Ponzi Scheme Definition." Investopedia, August 27, 2022. https://www.investopedia.com/terms/p/ponzischeme.asp

6 xDerivatives: External revenue and scalability

The xDerivatives are CW-20 tokens, fungible tokens based on the CosmWasm. They are the standard token specification across most Cosmos based smart contract platforms, including Archway. A user will initiate the derivative minting process by sending Layer-1 tokens to Archway via IBC. Once transferred to Archway, the tokens are automatically locked to their corresponding derivative contract. In exchange for the locked tokens, derivative tokens will be minted and sent to the user. On behalf of the DAO, the derivative

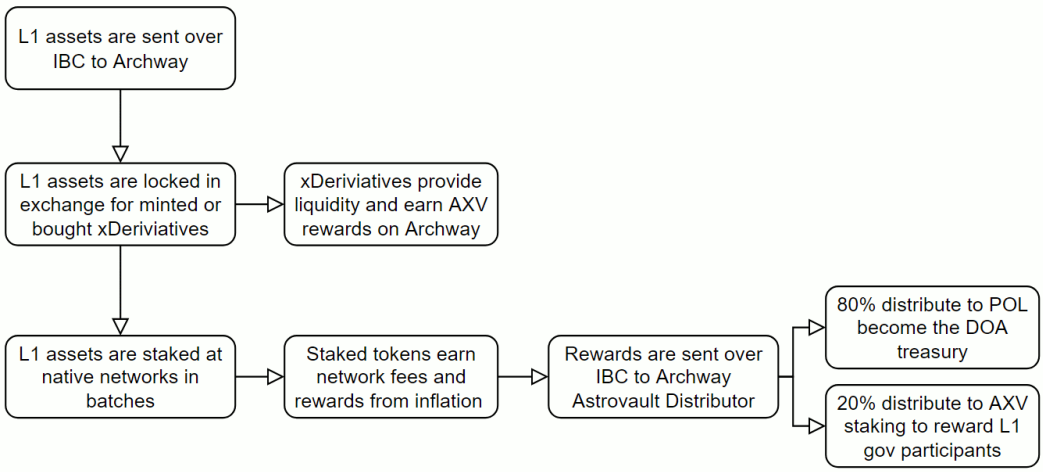


Figure 2: Process flow of incoming IBC assets

contracts on Archway will routinely send batches of locked tokens via IBC back to their native networks. These tokens are then staked, both to secure the underlying network and earn staking rewards for the AXV DAO. Rewards will be collected regularly, returned to Archway via IBC, and deployed in modular bulk distributors.

The Protocol Owned Liquidity will be deployed to the native asset side of the Plasma pool. This will allow for sustainable liquidity by which to liquidate the xDerivatives without needing to wait through an un-bonding period.

The Farm is a contract which distributes Layer-1 rewards to AXV stakers. Each supported xDerivative will have an accompanying farm in which users can stake their AXV to earn the corresponding Layer-1 token, while also having the opportunity to participate in the governance of that Layer-1.

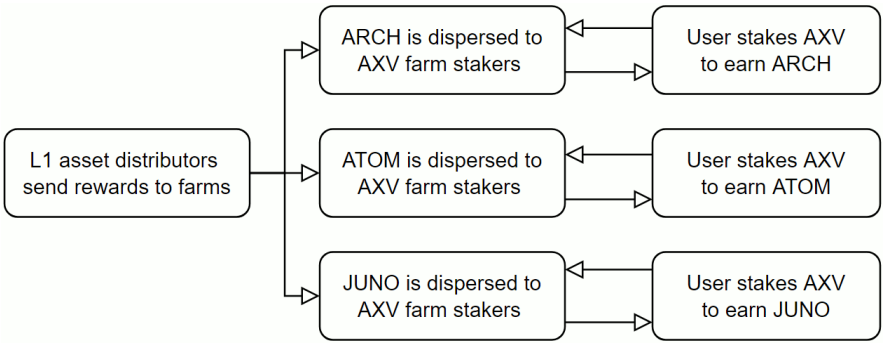


Figure 3: Process flow of deployed rewards from bulk distributors

6.1 Derivative scalability

6.1.1 The inefficiency of dilatory arbitrage in liquid staking solutions

A liquid staking solution, or staking derivative, is a token representing assets that are bound through Proof-Of-Stake consensus, and typically earning network fees and/or inflationary rewards.[12] Most current solutions are auto-compounding, meaning the staking rewards are added to the combined total of staked assets while not minting more of the representational token, ensuring that over time the representational asset is worth more than a 1:1 ratio of the staked asset.

For example, let's say:

- $dATOM$ is an auto-compounding staking derivative for the $ATOM$ token
- $ATOM$ staking APR is 20%

If Bob mints 100 $dATOM$, then his tokens represent 100 staked $ATOM$.

With staking rewards compounding, 20% APR compounds daily to 22.13% Annual Percentage Yield (APY). After one year, Bob's 100 $dATOM$ represents 122.13 staked $ATOM$.

Now if Bob wants to exit his position he may either sell the $dATOM$, or 'unbond' and wait through the 21-day unbonding period to recover his underlying 122.13 $ATOM$. Likewise, if a new user wants $dATOM$ they can either purchase it from Bob (or other holders) or mint at a 1.2213:1 ratio with their own $ATOM$.

Though Staking Derivatives are an easy route to earning revenue for an AMM, existing solutions are pragmatically illiquid. In order for a liquid staking solution to scale it must adequately solve two persistent problems:

1. Why mint the derivative when you can buy it?
2. How expensive is the arbitrage process?

The answer to the first question is usually an easy but dissatisfying response. You don't mint the derivative, buying it is cheaper. The price to purchase $dATOM$ should never be higher than the free cost of minting it, as users should opt for the cheaper entry. As the ceiling price of the $dATOM$ token is established by the ability to mint new tokens, what then is the floor price, or maximum liquidity premium?[13] This would be determined by the price at which users choose to purchase the asset in order to redeem the higher-valued underlying staked tokens, a process typically known as arbitrage. By definition though, arbitrage is the act of, "*... buying something in one place and selling it in another place at the same time, in order to make a profit from the difference in price in the two places.*"[14] This is a delta-neutral trading strategy, in that there is no risk of loss through the global price changes in the markets to the arbitrageur.[15] Since this synchronous, low-risk trading strategy is not possible for this scenario, we'll refer to the balancing trading strategy as 'Dilatory arbitrage'.

[12]King, Sunny, and Scott Nadal. "PPCoin: Peer-to-Peer Crypto-Currency with Proof-of-Stake." Self-published paper, August 19, 2012. https://bitcoin.peryaudo.org/vendor/peercoin-paper.pdf

[13]Thakur, Madhuri. Reviewed by Dheeraj Vaidya. 2022. "What is Liquidity Premium". Wall Street Mojo. https://www.wallstreetmojo.com/liquidity-premium/

[14]Oxford English Dictionary. 2nd ed. Oxford: Oxford University Press, 2004. https://dictionary.cambridge.org/us/dictionary/english/arbitrage

[15]Nadimpalli, Vijay. "Extended Optimal Arbitrage Strategies". Hudson and Thames. https://hudsonthames.org/extended-optimal-arbitrage-strategies/

Definitions and relations to aid understanding dilatory arbitrage:

$$\begin{aligned} \Delta D &= \text{Change in demand} && \text{and} && L = 1 + \text{Liquidity premium} \\ P_{ATOM} &= \text{Price of } ATOM && \text{and} && P_{dATOM} = \text{Price of } dATOM \\ S_{ATOMdXd} &= \text{Supply of staked } ATOM \text{ in} && \text{and} && S_{dATOM} = \text{Supply of } dATOM \\ & \quad \text{the } dATOM \text{ derivative contract} && \text{and} && t = \text{Time (in days)} \end{aligned}$$

Therefore, the following relations are true:

$$P_{ATOM} \leq \frac{P_{dATOM} \times S_{dATOM}}{S_{ATOMdXd}} \quad \text{and} \quad P_{ATOM} = \frac{L \times P_{dATOM} \times S_{dATOM}}{S_{ATOMdXd}}$$

$$L = \frac{P_{ATOM} \times S_{ATOMdXd}}{P_{dATOM} \times S_{dATOM}} \quad \text{and} \quad \begin{aligned} S_{ATOMdXd} &= S_{dATOM} \times APY \text{ ; since inflation is 20\%} \\ &= S_{dATOM} \times ((1 + 0.20/365)^t - 1) \end{aligned}$$

Let's run through an example of what optimal dilatory arbitrage looks like in this liquid staking scenario:

1. Carol buys *dATOM*
   - Cost = P_{dATOM} + 0.3% (trading fee) + slippage
2. Carol unbonds *dATOM*
   - Risk
     - Funds are not liquid
     - Holding a volatile asset that can depreciate over the unbonding period
   - Opportunity Cost
     - 21 days avg. unbonding period without rewards
       - Minimum: 20% APR 21 days=1.15% opportunity cost (compared to staking)
       - Maximum[16]: 100% APR 21 days=5.75% opportunity cost while liquid (compared to higher yield opportunities such as yield farming)[17]
3. Carol sells *ATOM* after 21 day unbonding period

The enumerated combined costs and risks affecting the profitability of this endeavor can be calculated as follows:

$$0.3\% + \text{slippage} + \text{opportunity cost} + 21 \text{ days of illiquidity} - \Delta P$$

Assuming no slippage, minimum opportunity cost, and no change in price, the absolute minimum liquidity premium for performing a potentially advantageous dilatory arbitrage on *dATOM* would be 1.45%, or:

$$L \geq 1.0145$$

[16]The actual maximum APR available in opportunity cost is potentially infinite and always different. 100% denotes an arbitrary but plausibly available opportunity with yield higher than staking rewards.

[17]Conway, Luke. "What is Yield Farming?: What You Need to Know". Blockworks. Published February 23, 2022. https://blockworks.co/what-is-yield-farming-what-you-need-to-know/

This sets a minimum expected threshold of *dATOM* being priced at 1.45% under the value of its underlying asset. But as slippage, much higher opportunity cost, and unnecessary risk of price depreciation and illiquidity are factored in, prices of 5 to 7% lower than the underlying assets represented may often be closer to the threshold of where the dilatory arbitrage is worthwhile. Any additional fees that may be arbitrarily added by the developers of these derivatives are added directly to the liquidity premium. Note that the higher the inflation of the Proof-of-Stake (PoS) asset, the higher the minimum liquidity premium will be.

Furthermore, this means that all of the dilatory arbitrage pressure exists to unbond *dATOM*, as opposed to minting more of it. While liquidity providing *dATOM* vs *ATOM* is guaranteed to accrue impermanent loss (as *dATOM* gains value compared to *ATOM* at the exact rate of compounded inflation: $S_{ATOMdXd} = S_{dATOM} \times 1.000548^t$), the constant threat and pressure of unminting the asset makes scaling the staking derivative virtually impossible, as growth requires the demand for the derivative asset to be growing exponentially in comparison to the demand for the native asset.

At scale:

dATOM is minted when $\Delta D_{dATOM} > \Delta D_{ATOM}$ while P_{dATOM} is at ceiling ($L = 1$)

dATOM is unminted when $\Delta D_{dATOM} < \Delta D_{ATOM}$ while P_{dATOM} is at floor ($L \geq 1.0145$)

$$P_{dATOM} = \frac{P_{ATOM} \times S_{ATOMdXd}}{S_{dATOM} \times L}$$

Ceiling: $L = 1$

Highest Floor: $L = 1.0145$

Lowest Floor: $L \approx 1.07$

In order for *dATOM* to be net positive minted year over year:

$$\Delta D_{dATOM} > 1.2213 \times \Delta D_{ATOM}$$

This progression would eventually lead to over 100% of staked tokens being in the derivative, which is an impossible outcome. Since this is verifiably unsustainable, the autocompounding derivative asset will be inevitably trading around its floor price.

6.1.2 The efficiency of the xDerivative liquid staking solution

Though auto-compounding derivatives are not scalable, non-compounding versions can be, and the *xDerivative* of Astrovault even more so. So let us revisit our previous persistent scaling problems with the new model:

1. Why mint the derivative when you can buy it?
2. How expensive is the arbitrage process?

The answer to the first question depends on our ability to mint a token cheaper than purchasing one. Historically, this would rely on the price of the derivative being higher than the price of the native asset, which is illogical. However, the goal can be achieved by fixing a 1:1 price between assets, but having our volume incentive (*GRVT8*) for trading be greater than the trading fee for purchasing assets. As a result, a negative liquidity premium encourages minting a derivative instead of purchasing it, which, in the problem case, would apply whenever an associated Plasma pool has more *ATOM* than *xATOM*. We will explore how expensive the arbitrage process is...

From the previous mathematical discussions on liquidity premiums:

$$
\begin{aligned}
P_{\text{in}} &= \text{Ending Plasma pool percent of sold token} \\
P_{\text{out}} &= \text{Ending Plasma pool percent of bought token} \\
\Delta D &= \text{Change in demand} \\
f_{\text{trade}} &= \text{Scaling Plasma trade fee} \\
G &= \textit{GRVT8 } \text{(Volume incentive)} \\
f_{\text{trade}} - G &= \text{Liquidity premium} \\
L &= 1 + (f_{\text{trade}} - G) \\
P_{ATOM} &= \text{Price of } ATOM \\
P_{xATOM} &= \text{Price of } xATOM \\
S_{ATOMdXx} &= \text{Supply of staked } ATOM \text{ in the } xATOM \text{ derivative contract} \\
S_{xATOM} &= \text{Supply of } xATOM \\
P_{ATOM} &= \frac{L \times P_{xATOM} \times S_{xATOM}}{S_{ATOMdXx}} \\
S_{ATOMdXx} &\stackrel{\text{def}}{=} S_{xATOM}(\text{xDerivatives}) \\
P_{ATOM} &\stackrel{\text{def}}{=} P_{xATOM}(\text{Plasma pool})
\end{aligned}
$$

Therefore, the following can be deduced:

1. $1 = L$

   $L = 1 + (f_{\text{trade}} - G)$
2. $f_{\text{trade}} = G$
3. $f_{\text{trade}} = 0.03\% + 0.025\% \times \left(\frac{P_{\text{in}}}{P_{\text{out}}}\right)^3$
4. When $G > f_{\text{trade}}$, the Liquidity premium is negative
5. $G \geq 0.055\%$ (see chapter 5, *GRVT8*)

6. Liquidity premium is negative $\iff 0.055 > 0.03\% + 0.025\% \times \left(\frac{P_{\text{in}}}{P_{\text{out}}}\right)^3$
7. $1 > \left(\frac{P_{\text{in}}}{P_{\text{out}}}\right)^3$
8. Liquidity premium is negative $\iff P_{\text{out}} > P_{\text{in}}$
9. When there's more *ATOM* than *xATOM* in the Plasma pool it is cheaper to mint *xATOM* than to purchase it.

Contrary to the potentially negative liquidity premium, it still can be the case that the liquidity premium is substantially positive when derivatives are liquidated in excess. In this scenario the dilatory arbitrage performed in the other model is still possible, but cheaper with the xDerivative model.

1. Dan buys *xATOM*
   - Cost = P_{xATOM} + 0.03% (f_{trade}) - 0.055% (G)
2. Dan unbonds *xATOM*
   - Risk
     - Funds are not liquid
     - Trapped in volatile asset which could depreciate over 21 day period
   - Opportunity Cost
     - 21 days without rewards
       - Minimum: 20% APR 21 days=1.15% opportunity cost
       - Maximum[18]: 100% APR 21 days=5.75% opportunity cost while liquid
3. Dan sells *ATOM* after 21 day unbond

The opportunity costs of the dilatory arbitrage are the same in this model as in the auto-compounding example case, but the direct costs are lower by 0.325% + slippage

Let's look into how often this arbitrage is actually necessary in this scalable model:

80% of the 20% inflation of the *ATOM* token earned by *xATOM* is added directly to the *ATOM* side of the Plasma pool.

In order for *xATOM* to be net positive minted year over year:

$$\Delta D_{xATOM} > 0.862 \times \Delta D_{ATOM} \quad \text{or} \quad 1.16 \times \Delta D_{xATOM} > \Delta D_{ATOM}$$

This figure assumes that all of the *xATOM* liquidity is in the Plasma pool, realistically this will be much lower as most liquidity will be deployed in Nebula pools.

[18]The actual maximum APR available in opportunity cost is potentially infinite and always different. 100% denotes an arbitrary but plausibly available opportunity with yield higher than staking rewards.

Let's assume instead that only 20% of the $xATOM$ liquidity of Astrovault was in the Plasma pool:

$$\Delta D_{xATOM} > 0.556 \times \Delta D_{ATOM} \quad \text{or} \quad 1.80 \times \Delta D_{xATOM} > \Delta D_{ATOM}$$

In other words, in order for dilatory arbitrage to become a factor, the demand for $ATOM$ would need to continually increase 1.8X compared to the demand for $xATOM$, and even then the pool would constantly be re-balancing itself. Instead, arbitrage will be working the other direction, with users (and the Plasma pool itself) removing liquidity in the form of $xATOM$ in order to profitably purchase $ATOM$ (when $G > f_{\text{trade}}$), minting more $xATOM$, and successfully scaling the derivative.

The AXV DAO could also vote to more quickly balance the pool by removing $xATOM$ from the Plasma pool and adding it to a Nebula pool, lowering the overall Plasma liquidity, but balancing the ratio in a manner that didn't require unbonding tokens and thus lowering staking revenue.

An assumption that a staking derivative would have consistently higher ΔD than the underlying asset is extremely counterintuitive. With what we know about liquidity premiums, a reasonable expectation would be that the ΔD of the derivative would on average be slightly lower than ΔD of the underlying asset. The xDerivatives will not only scale very efficiently under such conditions, but also escape unscathed under much harsher circumstances, while their auto-compounding alternatives require impossibly idealistic scenarios to even be adequately considered liquid.

7 AXV DAO: Money and power in the Cosmos

AXV will serve as the governance token for the Astrovault DAO. The DAO's governance system uniquely leverages the crosschain nature of Archway's smart contracts in a way that allows for provably accurate voting. Stakers in 'the Multiverse' (the farm that earns more *AXV* and other voluntarily contributed tokens from listing partners) get to participate in this governance. Users have 7-days to cast their vote and votes are tallied in accordance with the amount of *AXV* tokens staked at the end of the 7-day period.

xDerivatives create the opportunity for the *AXV* DAO to own governance power in the various Cosmos Layer-1 tokens that are supported. There will be subsections of the Astrovault governance model that allow *AXV* stakers to utilize the voting feature to direct the DAO's vote on the various native Layer-1 chains. These votes will have a shorter time period.

There are 3 types of proposals that can be governed by the DAO:

1. Spend Proposals
   (a) The DAO owns all Protocol Owned Liquidity and can spend it to fund various initiatives according to the will of the community.
   (b) The DAO can also add its POL to Nebula pools via governance.
      i. $1 Million worth of *xARCH* and $1 Million worth of *xATOM* be added to the *xARCH–xATOM* Nebula pool to raise liquidity in said pool by $2 Million, while potentially further balancing the Plasma pools for said tokens.
2. Layer-1 Proposals
   (a) All on-chain proposals of supported native chains will be voted on by the *AXV* DAO.
   (b) If a quorum isn't reached, the *AXV* DAO will vote to abstain from the proposal.
   (c) The *AXV* DAO will not create proposals on any of the supported chains.
3. Signaling Proposals
   (a) The DAO can use signaling proposals to better gauge sentiment on parameter changes, or to suggest actions desired of the core team
      i. Lower inflation
      ii. Change percentages of the bulk distributors
      iii. Change weights of the *AXV* rewards
   (b) The core team will take signaling proposals into strong consideration but reserve the right to act as they see fit in order to best ensure durational success for Astrovault.

8 Liquidity independence

By building a treasury of Protocol Owned Liquidity, there will eventually be a threshold at which the protocol is no longer dependent upon mercenary capital. If a signaling proposal is passed that reduces inflation to 0, and the core team agrees that this is best for the protocol, inflation can be fully redirected to the burn address. When this time comes, the derivatives from the substantial treasury of liquidity owned by the AXV DAO will still be earning revenue. This means that liquidity will continue to grow and be deployed in accordance with DAO Governance. AXV stakers will also still earn rewards from supported assets and there will still be codified buy-pressure for the now deflationary AXV token.

Previous AMM's have never decoupled from external liquidity provision, as any protocol owned liquidity has needed to come from largely unsustainable bond models or fee extraction.[19] This particular eventuality for a currently inflationary token provides a successful model for decoupling, includes sustainable growth, and removes the forced timeline that acts as an expiration date by which a product must reach independence. By creating a synergy between inflationary and deflationary pressure with consistent treasury growth and the promise of future independent functionality, Astrovault aims to be as flexible as it is profitable, with long-term sustainability at its core.

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[19]Capponi, Agostino, and Ruizhe Jia. "The Adoption of Blockchain-Based Decentralized Exchanges." arxiv.org. arxiv, July 22, 2021. https://arxiv.org/pdf/2103.08842v1

Glossary

AXV	The symbol of the Astrovault governance token. 1
GRVT8	The *Gravitate* trading incentive token. 6
Dilatory arbitrage	A buy and sell action of assets for profit at different locations that has significant delay between both actions. 10
Liquidity premium	The gap between price and value for an illiquid asset with known value. 10
Liquid staking	The act of delegating your tokens to a service that stakes for you without losing access to your funds. The funds remain in escrow, but aren't "locked" and inaccessible, as they would be with Proof-of-Stake (PoS). 10
Nebula pool	A traditional $x \times y = k$ AMM liquidity pool. 2
Plasma pool	A no-slippage pool with 2+ tokens, 1:1 swap ratios, and scaling fees. 3
Stablecoin	Assets with value that is pegged, or tied, to that of another currency, commodity or financial instrument. 4

Acronyms

AMM	Automated Market Maker. 1
APR	Annual Percentage Rate. 1
APY	Annual Percentage Yield. 10
DAO	Decentralized Autonomous Organization. 1
DeFi	Decentralized Finance. 1
IBC	Inter-Blockchain Communication. 2
POL	Protocol Owned Liquidity. 1
PoS	Proof-of-Stake. 18
SDK	Software Development Kit. 2
TVL	Total Value Locked. 1

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