# CRYPTO VOLATILITY INDEX v3

## Litepaper


### *Abstract*

In this paper, we describe CVI (The Crypto Volatility Index) v3 and its new features, including our new innovative liquidity vault: the **Theta Vault**, which allows a sustainable and scalable source of liquidity for the CVI volatility tokens on any secondary market and decentralized exchange.

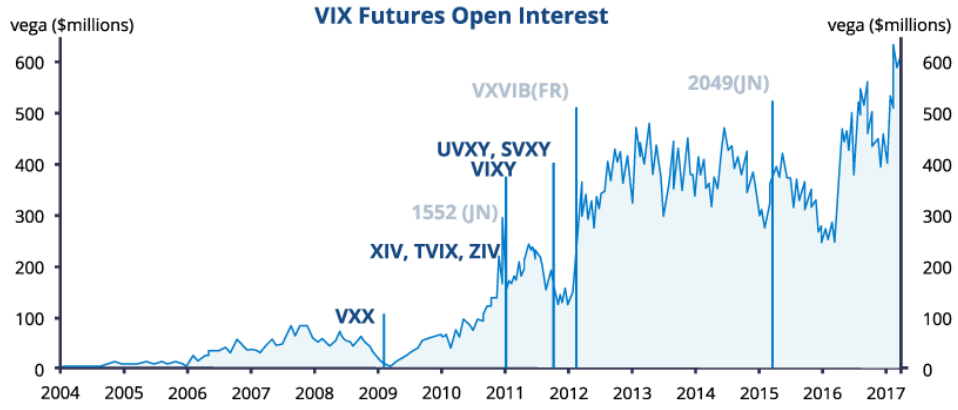
This major scalability improvement allows shipping one of the flagship products of the CVI ecosystem - the leveraged volatility tokens, which have been the early vision of the platform since its inception. In comparison with previous versions which were targeted toward early adopters, the new v3 is a complete and mature version of the ecosystem.


### *Introduction*

In the recent decade, volatility trading products based on the VIX of traditional finance have exploded in popularity. The ETPs such as UVXY & VXX, which have average daily volumes in billions of dollars, have attracted traders of all cadres  - from institutional investors, and day traders, to retail and funds who seek hedging on their portfolio.

The graph below shows the inception of the VIX ETPs over the timeline of the growth in trading of the VIX:

Exhibit 1: VIX ETPs have been a driving force behind the increase in VIX futures liquidity
VIX futures open interest in vega (VIX contract open interest x1000). Inception dates of 10 largest VIX ETPs by AUM. As of March 31, 2017.




*Source: Chicago Board Options Exchange, Goldman Sachs Global Investment Research*

As seen on the timeline, the launch of the above ETPs preceded the exponential growth in open interest for the VIX futures (VIX options open interest shows a similar pattern). This data validates the belief that they were a driving force behind the exponential growth which followed.

The increased volatility of crypto markets, along with the wide success of volatility trading products in traditional finance, suggests that equivalent products and indices are very much in need in the crypto markets as well. However, given the early days stage of the crypto derivatives markets, it is clear that adjustments should be made with careful judgment.

The vision of CVI since its inception has been to introduce to crypto markets not only an index, but a full-fledged eco-system of volatility trading products. Amongst its flagship products are the **Volatility tokens**, which allow taking a tokenized position in the form of an ERC20 token. Ideally, the price of such a token should have semantic meaning and support high capital efficiency for the underlying position.

## Design goals for a tokenized ERC20 range-bound volatility token

Below are the 4 design pillars upon which the volatility tokens are built as implemented in CVI v2 and v3:

| | *Design goal* | *CVI v2* | *CVI v3* |
|---|---|---|---|
| 1 | Full hedge and delta exposure to its respective index | V | V |
| 2 | Account for time decay, while keeping semantic meaning for the token price | V | V |
| 3 | Scalable source of liquidity for the volatility tokens | X | V |
| 4 | High capital efficiency for the volatility token's liquidity | X | V |

In 2021 the CVI shipped v2, alongside the CVOL ERC20 token, which is pegged to the CVI index. The token's innovative design enabled it to unlock two of the four design requirements stated above, while the new CVI v3 is designed to fulfill all of the original design goals. We will revisit each design requirement and illustrate how they were addressed in v3.

The different volatility tokens which implement these design goals:

| *Token* | *Introduced in version* | *Expected Trade range (Can deviate)* |
|---|---|---|
| CVOL | v2 | 0-200 (Targeted to maintain peg with the CVI via arbitrage) |
| UCVOL | v3 | 0-400 (Ultra CVOL - Targeted to maintain peg with x1.5 ≅ leveraged CVI via arbitrage) |

# Design goal #1:

## Full hedge and delta exposure to its respective index

A common usage of the VIX ETFs is for hedging and as such, it is a key requirement that the tokens are designed to work as a hedging tool. In order for the tokens to serve as a full hedge they must fulfill two requirements:

- ***Requirement 1:*** Fully backed by counterparty liquidity. This means that if CVI goes to its maximum value of 200, the tokens can be fully redeemed with no exceptions.

  In order to create an always-available source of counterparty liquidity which fulfills this goal, the CVI is built around an AMM. The AMM allows liquidity providers to deposit collateral, which is used as counterparty for the volatility tokens. As the volatility tokens represent a long position on the index, the AMM ensures that at all times there is enough counterparty liquidity to cover the scenario of CVI going to its maximum value of 200.

$$Liquidity(t) = (\frac{200}{CVI(t)} - 1) * CVOLTotalSupply(t)$$

***Formula 1***

***Formula 1: Needed liquidity at given time t***

*With 200 being the max CVI, and assuming CVOL is pegged to CVI value in USDC, the total protocol USDC CVOL worth is CVI(t) * CVOLTotalSupply(t). But it can potentially be worth 200 * CVOLTotalSupply(t), so the liquidity should fully cover the difference.*

The architecture of having volatility tokens on one side and an AMM which sells volatility on the other side allows the tokens to be used as full hedge, as there is always an available source of liquidity to cover profits from a rise in CVI.

- ***Requirement 2:*** Maintain exposure of 100% (or higher in case of leverage). A key aspect of this requirement is that as CVI goes up, there will not exist a mechanism which incentivizes closing the position, such as asymmetrical gains. For example, given that the CVI spiked from 80 to 120, excluding time decay, CVOL token holders would have a 50% profit, while given that it moved to 160, excluding time decay, CVOL token holders would have a profit of 100%.

$$P\&L(t) \cong \frac{CVI(t) - CVI(t_0)}{CVI(t_0)} * CVOLBuyAmount$$

*Formula 2*

### Formula 2: Estimated P&L of a single CVOL buy at $t_o$

*The P&L is proportional to the index change, excluding time decay, assuming CVOL is pegged to the index.*

$$P\&L(t) = \frac{CVOL(t) - CVOL(t_0)}{CVOL(t_0)} * CVOLBuyAmount - TimeDecayFees(t_0, t)$$

*Formula 3*

### Formula 3: Exact P&L of a single CVOL buy at $t_o$

*Assuming CVOL is pegged to the index, with TimeDecayFees being calculated intervally based on the CVI at each time interval. TimeDecayFees grow larger with time.*

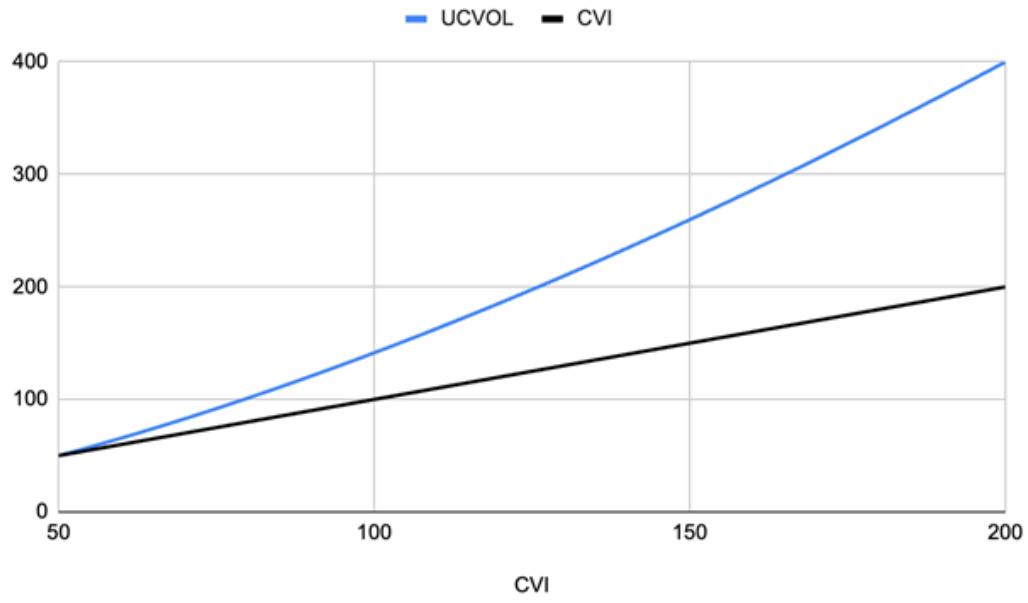
### Formula 4: Calculation of Ultra CVOL (Leveraged volatility token)

*We use the following formula to calculate Ultra CVOL:*

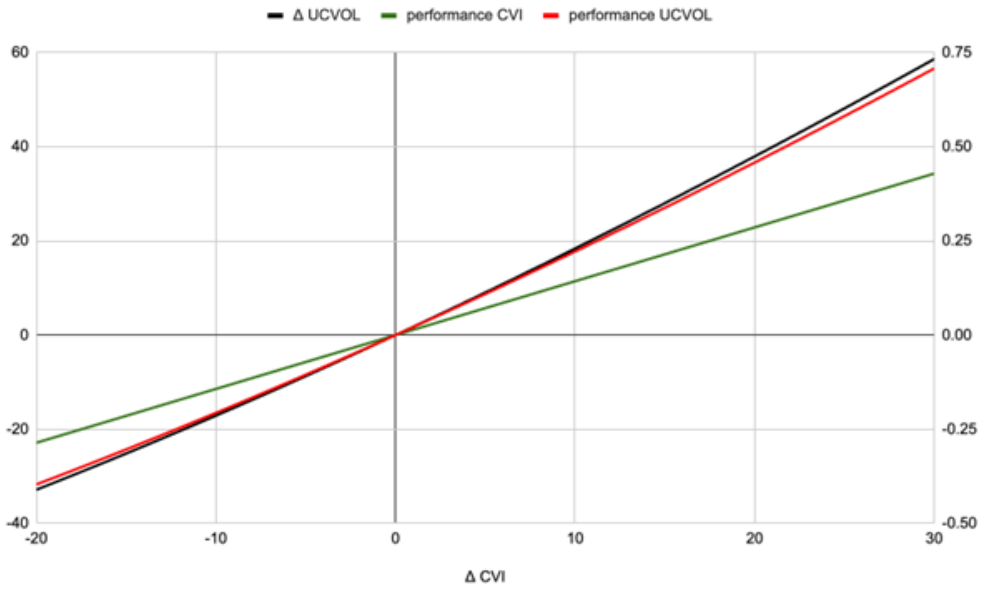
$$UCVOL(CVI) = \frac{CVI^P}{CVI_0^{(p-1)}}$$

*Formula 4*

*For 1.5X leveraged CVI, we use p=1.5, $CVI_0$ = 50.*



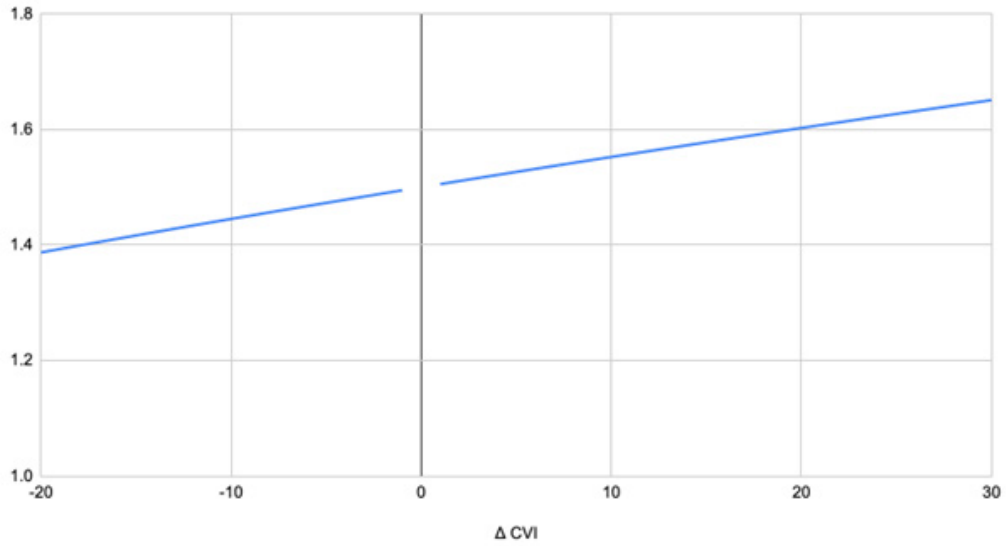
*This formula is time-invariant, as a result the daily performance of UCVOL is not exactly x1.5 leveraged CVI daily performance, but if Δ CVI is small, then Δ UCVOL ~ 1.5*Δ CVI.*
*The current CVI value for the following charts is 70.*




*Mathematically, the performance ratio for UCVOL and CVI is:*

$$\frac{\frac{\Delta UCVOL}{UCVOL}}{\frac{\Delta CVI}{CVI}} = p + \frac{p(p-1)}{2} * \frac{\Delta CVI}{CVI} + \ldots$$ *(for p = 2, it is simply* $2 + \frac{\Delta CVI}{CVI}$ *)*

*Performance ratio*



# Design goal #2:

## Account for time decay, while keeping semantic meaning

As the CVI is range bound [0,200] and is mean reverting, we can observe that any token which is pegged to it would have to incur a mechanism for time decay.

Without such a mechanism, it would be possible to mint/swap into the token at values below mean and hold it indefinitely until profit.

To account for time decay, the volatility tokens are built as a unified long position on the index, which pays a funding fee over time. However, this has a repercussion that if the tokens were regular ERC20 tokens, then due to arbitrage between DEXs and the CVI AMM their price on DEXs would over time decline in value, preventing them from keeping peg with the CVI index, thus losing semantic meaning.

In order to address this issue, the volatility tokens implement the ElasticToken interface, pioneered by the Ampleforth project. The elasticity allows the tokens to be negatively rebased, thus holding them over periods of time results in having less tokens in the holder's wallet. This trait allows the tokens to keep their peg with the CVI index, while accounting for time decay.

The rebase mechanism runs fully decentralized with the usage of Chainlink keepers, which activate it every day at midnight UTC. It's important to note that the rebase action is purely semantic, there is no added benefit to selling/buying the tokens before or after the rebase occurs. Without the rebase, an arbitrage between the DEX and AMM would have caused the token price to depreciate in value, thus losing peg, while the rebase instead lowers the token supply which allows keeping the peg.

In the event there was no arbitrage between the DEX and the AMM, the result of the rebase operations would be a token price higher than its intrinsic price on the AMM. Overall, the peg is kept by the combination of allowing arbitrage to flow between the DEX and AMM, in combination with the daily rebases. The following table summarizes the effect of both arbitrage and the rebase operations:

| | Arbitrage only, no rebase | Rebase only, no arbitrage | Arbitrage + Rebase |
|---|---|---|---|
| Token **DEX price** vs Token Intrinsic **AMM price** | With the passage of time as the intrinsic value would go down, the token would decline in value, losing its peg with CVI | As the tokens are negatively rebased, their price on the DEX would have gone up beyond their intrinsic value, thus losing peg with the index | Both combined allow the token to keep its peg with the index, thus keeping semantic meaning while accounting for time decay |

# Design goal #3:

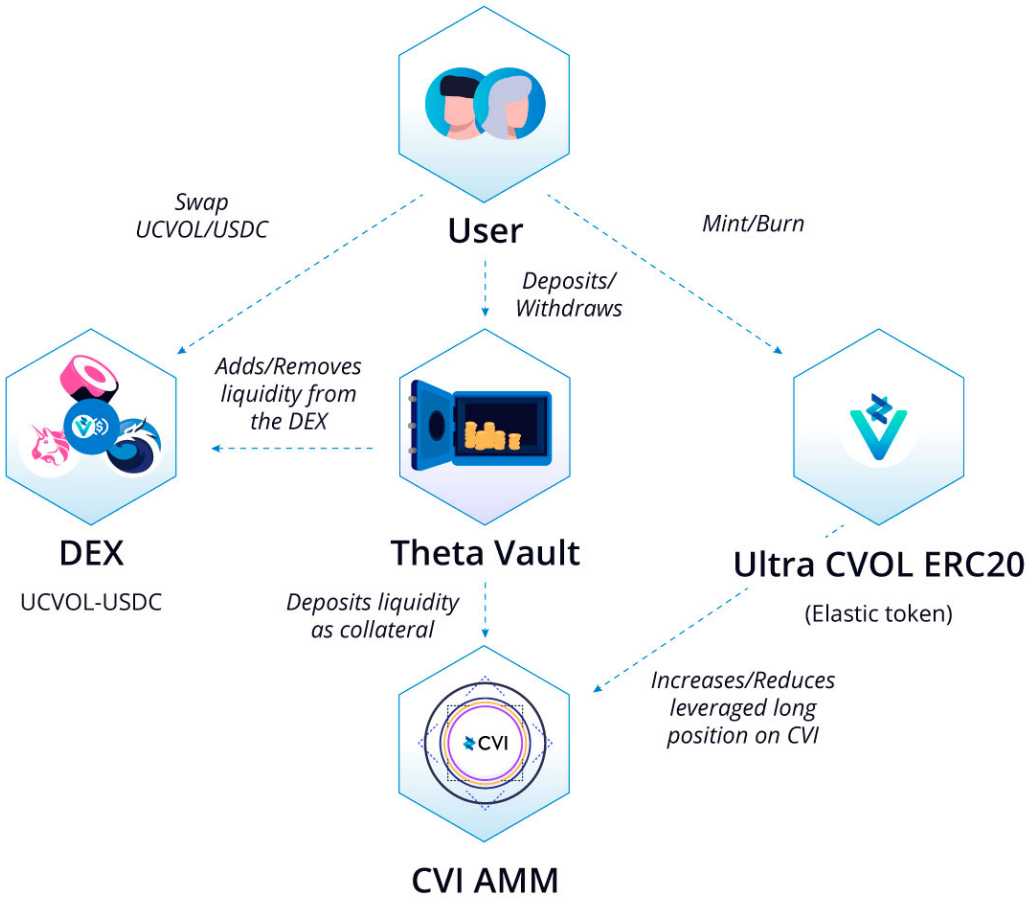
## Scalable source of liquidity for the volatility tokens

Theta is the change in an instrument's value with the passage of time, all other factors staying constant. As the volatility tokens charge time decay fees and are exposed to Theta, they are designed to be held only for limited amounts of time. However, in order for tokens to have a sustainable source of liquidity on DEXs, there has to be a mechanism which allows them to be paired in a liquidity pool without accounting for time decay. Without such a mechanism it would not make sense for a liquidity provider to add liquidity for such a pool for long periods of time.

Completing this design goal was the key element in CVI v3 with the introduction of the **Theta vault**, which was built on top of the CVI AMM.

The underlying architecture of the vault relies on the following key points:

- The vault is the only gateway for adding and removing liquidity from the CVI AMM
- It utilizes liquidity by depositing it as collateral to the CVI AMM vis-a-vis minting/burning volatility tokens and placing them on DEXs
- As the vault owns both the AMM liquidity and the DEX liquidity, it is the sole beneficiary of time decay fees, thus has no exposure to Theta for the DEX liquidity. This can allow the volatility tokens DEX liquidity to scale up.



### The users funnel under the new architecture includes the following actions:

1. Swap to/from volatility tokens on the DEX
2. Deposit/Withdraw liquidity to/from the Theta vault
3. Mint/Burn volatility tokens

### The mechanism for splitting the liquidity between the DEX and the AMM:

Splitting the amount being deposited into the theta vault correctly between DEX liquidity and CVI AMM liquidity should hold these requirements:

1. The CVI AMM liquidity must be P% higher than the liquidity needed as collateral backing them, in order to reserve liquidity for additional minting of CVOL tokens to be utilized by arbitrageurs (P to be a parameter, changeable based on market needs).
2. The vault may add liquidity to the DEX based on its spot price, only in situations where the intrinsic value of CVOL in the AMM is close enough to the CVOL price on the DEX, otherwise it opens up an arbitrage trade opportunity.

To satisfy all requirements, we create the following 3 variables linear equation system and utilize its solution. The variables are the amount to add as CVI AMM liquidity, and the amount to mint CVOL tokens along with the amount of USDC to add to the DEX liquidity.

$$(1)\ DepositAmount = a + b + c$$

$$(2)\ (a+b) * 100 == b * \frac{200}{CVI(t)} * (100 + P)$$

$$(3)\ \frac{b}{IntrinsicCVOLPrice} = \frac{c}{CVOLDEXPrice}$$

***Formula 5***

***Formula 5:*** *3-variable equation system for theta vault deposit amount split (a = CVI AMM liquidity, b = DEX CVOL mint amount, c = DEX USDC amount). Equation (1) is obvious, equation (2) specifies the relation between the liquidity and the CVOL mint amount, and equation (3) makes sure the CVOLs minted will be added to the DEX at spot price.*

With the mechanism above, the vault creates a sustainable source of liquidity for the volatility tokens on DEXs. Overall the volatility tokens allow traders a similar experience to the VIX leveraged ETFs, while the theta vault operates as a structured product: receiving DEX swap fees, mint/burn fees, time decay fees from volatility token owners and p&l from CVI index decrement as counterparty to the volatility tokens long position.

**Protocol fee under the new architecture:** The mint/burn fees of the volatility tokens are shared between the Theta vault and GOVI token holders.

## Design goal #4:

### High capital efficiency for the volatility token's liquidity

Concentrated liquidity DEXs, pioneered by Uniswap v3, allow traders to incur minimal slippage on trades while requiring considerably less liquidity than Uniswap v2 type DEXs. This however comes with several disadvantages, such as exposure to impermanent loss for liquidity providers, lack of support for rebase tokens and require active management of liquidity ranges. The unique architecture of the theta vault allows multiple vaults to be deployed simultaneously, each targeting a different DEX, and to specifically support a concentrated liquidity DEX. More details on this proprietary solution will be provided in the next iteration of the document. Overall, concentrated liquidity for the volatility tokens is a required step in order for them to be a viable hedging tool for large players and power users in DeFi.

## Summary

CVI v3, the upcoming iteration, encompasses the mature version of the ecosystem. The new iteration allows shipping one of its flagship products: the leveraged volatility tokens, which have been an integral part of the early vision to create a scalable, composable and capital efficient hedging and trading instrument to be used as part of any DeFi trader's toolset.