The ItoVault System V1.0

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Abstract

The ItoVault system allows users to deposit collateral (e.g ETH) in order to generate Asset Tokens (e.g a token on the SPY would be called vSPY token) pegged to any well-behaved price process, like a diversified basket of real-world assets. The peg price comes from an oracle, with a fallback to a decentralized challenge system for the peg price. Margin requirements of each vault ensure collaterals are enough to cover the assets. Community members are rewarded for liquidation of undercollateralized assets. Dividends, short interest, and other economic benefits of holding the underlying asset are built into the token price (V1.0 already builds in dividends, and V2 will build in the remaining); holders need not roll over the tokens or lock tokens in order to receive these benefits.

About ItoVault

ItoVault is a project created in 2020 in Ethereum's defi ecosystem. V1.0 has already been released on November 16, 2020 under contract 0xF9E8, and V2 is anticipated for May 2021.

Overview of the ItoVault System

Popular digital assets such as Bitcoin and Ethereum are not diversified enough to be an optimal core asset for most people to hold, especially as a large fraction of their wealth in the very long term. Financial theory states that the optimal asset portfolio for passive holders would be a basket somewhat proportional to all world's assets. Since cryptocurrencies today represent a small fraction of world wealth, it would be beneficial for diversification for cryptocurrencies to be able to import the risk-reward characteristics of some of the largest asset baskets in the world.

The ItoVault system is a decentralized system that allows anyone to deposit collateral and generate Asset Tokens, tokens pegged in a decentralized way to various asset baskets that are recognized by both economists and financiers, both theoreticians and practitioners, as being strong long-term core positions. Prototypical Asset Tokens of the system include the SPY (liquid US stock index), the China stock index, the world stock index, the commodity index, the real estate index, gold index, and inflation-protected bond index.

It is important to note that the ItoVault system supports pegging of tokens to not just diversified baskets of traditional assets, but any price feed, given that the feed is sufficiently regularly behaved, modulo a carrying cost.[1] The ItoVault system can generate tokens that track individual stocks, levered cryptocurrencies, inverse cryptocurrencies, pre-IPO stock, startup market-caps, country GDPs, or even exotic price series like the cumulative sum of coin flips, cumulative rainfall in a state, or any exogenous Ito process.

Asset Tokens are pegged to an underlying asset through Collateralized Tokens Vaults (CTVs), similar to the CDPs of the Maker/DAI system.

[1] In particular, ItoVault is flexible enough to track any time series process that is 1) objectively reportable by oracles and 2) a martingale process in risk-neutral pricing space.

Asset Tokens frees access to these assets to anyone in the world on the defi ecosystem. For example, if a country X makes it onerous to buy the SPY ETF due to the large number of intermediaries or fees needed, a resident of country X could simply buy the vSPY token instead ("v" here is short for backed by a vault inside ItoVault). Likewise, the ItoVault system opens up assets to the large fraction of residents of even developed countries who are underbanked (e.g. cannot even open a checking account due to credit or other reasons).

An innovation of the ItoVault protocol is that the Asset Tokens are designed for no-action-needed, efficient holdings. No-action-needed means the Asset Token is designed to already capture all gains from dividend, interest, and short-loan interest through its price alone. The holder needs not lock up the coin in a savings rate mechanism, roll over the coin, or worry about any efficiency losses by not taking an action. Efficiency means that system fees are minimal: many other systems have either explicit fees or implicit fees paid by token holders to the system that is frictional. ItoVault is designed to have little to no system fees as it is mission oriented to serve the Asset Token users.

Implementation

Much of the implementation is based on the collateral-borrow pattern common in defi, like Synthetix, Compound, MKR. For example, understanding how the MCD operates will speed up understanding of the below.

CTVs Smart Contracts

Anyone who has collateral approved by ItoVault governance can use this collateral through the ItoVault platform to generate Asset Tokens by depositing them into the Collateralized Token Vault (CTVs). In V1.0 only ETH has been implemented as the collateral, ItoVault could extend by governance vote to WBTC, USDT, USDC, etc.

The CTV then lets the user issue (mint) the corresponding Asset Token (e.g. vSPY token) with a healthy margin; after issuance, the CTV effectively becomes net short the vSPY token.[2] The CTV collateral is effectively locked in until the underlying asset token is paid back, at which point the initial deposited value in the CTVs contract can be withdrawn.

Unlike the USDT and USDC system, and much like the Maker/DAI system, this system does not require the actual SPY ETF to be held by anyone in a centralized finance brokerage account.[3]

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[2] To be precise, when a user U causes their CTV to issue vSPY, that user U holds both the CTV (the CTV is short vSPY) **and** the vSPY at the same time. That user U is not yet net short vSPY. If and when user U decides to sell vSPY, then user U would be net short vSPY.

[3] However, actual SPY ETF held in a brokerage account *can* play a role in enforcing the peg of the vSPY token. In particular, if there is too much demand for the vSPY (say, due to a country censoring the SPY), the price of the vSPY will rise and (in V2) the interest rate adjustment on the vSPY will fall. An arbitrageur *could* then hold/long SPY ETF in a traditional finance

CTVs Interaction Process

Step 1: The CTV (MKR analogue is the CDP) user sends collateral (ETH) to the ItoVault system to create the CTV.

Step 2: The CTV user then sends a transaction to withdraw the amount of Asset Token (currently vSPY token) they want from the CTV. The CTV itself then becomes short vSPY. At this point, the CTV user owns both the vSPY (which they can sell) and the CTV. The CTV funds the Asset Token's rise (or benefits from its fall) until the Asset Token is returned (plus a system fee, which is currently zero, and subject to a hard cap). The CTVs lock users out of their collateral until the outstanding Asset Token is repaid. The CTV may issue a maximum of assets represented by the current asset price as reported by an oracle (see oracle system below), minus an initial margin factor designed with plenty of space for safety.

Step 3: When the CTV user wants to retrieve the collateral, the user must return the Asset Token back to the contract. In addition, in V2, the user needs to pay a small and limited system fee in the user's choice of either Ethereum or ItoVault Tokens (allows payment of fee at a discount). Currently in V1.0, this system fee is set at zero to reward early Asset Token users. After these system fees are returned to the CTV, the collateral is fully withdrawable by the CTV owner.

Capital Efficient Leverage through CounterVaults

The following feature is already implemented in V1.0. It is not necessary for creating vSPY, but natively allows short vSPY holders to leverage up that short, and long vSPY holders to leverage up that long.

For every <collateral, token> pair (for example <ETH, vSPY>), there exists an countervault (or counterCTV) <vSPY,ETH> that can be created.

The counterCTV allows a user to deposit vSPY and withdraw ETH. For example, a user can deposit $150 of vSPY, and then borrow $100 of ETH. If the value of ETH rises a lot compared to the value of vSPY, this counterCTV can be liquidated analogously to the standard CTV.

The source of ETH with this counterCTV would naturally be the original standard CTV that created vSPY in the first place.

In V1.0, the countervault <vSPY,ETH> margin parameters can be set separately from the standard vault <ETH, vSPY>. Since the interest rate adjustment on the normal vault is zero, the

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brokerage account, create a CTV to short the vSPY, and then gain from vSPY's price falling and (in V2) interest rate adjustment.

interest rate to borrow ETH from vSPY in the countervault is zero as well in V1.0. This is seen as a feature of owning vSPY and should increase vSPY value to users.

In the future, using a counterCTV to borrow ETH itself could command a separate interest rate (the counter interest rate). This counter interest rate would be credited to the counter CTV.

Composition of CTVs and counter CTVs allow leverage.

For example starting from ETH, if the below path is followed, you are able to short many multiples of vSPY (and collect the interest rate fee multiple times):
ETH->CTV->vSPY->Inverse CTV->ETH->CTV->vSPY etc

As another example, starting from vSPY (bought on Uniswap), if the below path is followed, you are able to lever up multiples of vSPY:
vSPY->Inverse CTV->ETH->CTV->vSPY etc

Much like fractional reserve banking, the above can be recursed infinitely.

Asset Token Value Index Carry Adjustments

An Asset Token is based on an underlying index, but should not be exactly equal to the underlying index: it should capture all the benefits and costs to carrying the index/stock, called Carry Costs. Carry Costs include ensuring Asset Token owners correctly benefit from dividends, interest income, value to the CTV in being able to short the index, and other so-called carry costs. The actual Asset Token Peg Price should instead be:

Asset Token Peg Price = Index Price * Cumulative Dividend Factor * Cumulative Interest Factor

If we define Cumulative Carry Factor := Cumulative Dividend Factor * Cumulative Interest Factor then this equates to:

Asset Token Peg Price = Index Price * Cumulative Carry Factor.

It is important to note that the Dividend Factor and Interest Factor does not represent any system fee on the CTV ecosystem: it is a **pure transfer** between the CTV that is short an Asset Token and the Asset Token itself.

V2 vs V1.0 difference: in V1.0, the Cumulative Interest Factor will not fluctuate but instead be set to 1. Supply and demand differences in the Asset Token will be mediated through the Asset Token market price instead. The Cumulative Dividend Factor however will be active and calculated in both V1.0 and V2,

Why are the Dividend Adjustment and Interest Rate Adjustment needed?

In this example, we'll use the SPY ETF as a generic example and vSPY as the corresponding token, but the discussion generalizes.

Having the vSPY token track the **raw** SPY is incorrect due to two reasons. Dividend adjustments and interest rate adjustments, together known as carry adjustments.

The Dividend Adjustment

Dividend rate adjustments reflect that if you were to purchase the SPY ETF, you would receive a dividend. Since we want holding vSPY to be similar to holding the SPY ETF, the vSPY token price should be adjusted by exactly the dividend amount. This also supports ItoVault's mission to offer fair-market low-system-fee Asset Tokens to the world.

Counterfactually, if the vSPY token were not adjusted, then the vSPY token would underperform the SPY ETF, making the vSPY token uncompetitive for holders. Further, CTV holders would be motivated by arbitrage to over-issue vSPY tokens, depressing the price of the vSPY tokens and adding a downward destabilizing force on the peg.

The dividend rate adjustment is computed via a Cumulative Dividend Factor (CDF) as the total percentage dividends paid out since an epoch (beginning date). For example, if the epoch is set to be January 1st, 2020, and the SPY pays no dividends until October 1st, 2020, at which point it pays a 10% dividend (the ex-date being October 1st), the CDF is 1.000 for all days before October 1st exclusive, and then 1.100 on October 1st and afterwards. If the SPY pays another 10% dividend on February 1st, 2021, then the CDF on February 1st, 2021 would rise to 1.210. The CDF can often be discontinuous, like above, since dividends often come on a small number of days per year. Appendix 2 provides a precise definition-by-example calculation of the CDF from January to October of 2020 on the SPY ETF assuming a 1/1/2020 epoch.

The currently outstanding vSPY token (0x3e1e) has an epoch date of November 16th 2020, and future Asset Token deployments will aim to follow the convention of the epoch being set to it's deployment time.

-The Interest Adjustment-

This section does not apply to V1.0.

The interest rate adjustment both (a) pegs the market price of the Asset Token to the peg price and (b) ensures economically efficient division of value between the CTVs who are short the

Asset Token, and Asset Token holders who are long the token.[4] (a) is the viewpoint of mechanical price clearing (b) is the viewpoint of the underlying value distribution.

For example, consider the case where vSPY rises in demand because a country in the world starts to disallow its residents from holding SPY directly.

Looking at it from the viewpoint of (a) above, vSPY market prices will be pushed above its peg price. This tells the ItoVault system to reduce the interest rate adjustment (i.e. reduce the expected gain from holding vSPY) -- incentivizing more users to create CTVs and issue vSPY, while dissuading vSPY holders. The final effect is to reduce vSPY market prices back toward the peg price, enforcing the peg.

From the viewpoint of (b) because vSPY is suddenly allowing citizens of the above country to bypass censorship, long holders of the vSPY on average are suddenly receiving higher value from the token. The interest rate adjustment decreasing passes some of the value to the people who issue vSPY: the CTV users that are short vSPY token.

Economic Reasons for Upward Pressure on Interest Adjustment

From the viewpoint of (b), the following is a partial list of factors that would cause relatively higher value to accrue to CTVs shorting vSPY, and relatively lower value to accrue to vSPY holders, thereby decreasing vSPY market prices below the peg price and causing the interest rate adjustment to rise:

- More people want to short vSPY. The increase in interest rate adjustment rewards long vSPY holders automatically much like a short sale fee rebate in stocks.
- CTV users want to lever up their collateral (ETH) holdings because they are bullish on ETH versus vSPY.
- A third-party fund enters the field, shorting vSPY and longing actual SPY ETFs to hedge their risk.
- The (riskless) interest rate rises in the fiat world or the crypto / USDT world.

Economic Reasons for Downward Pressure on Interest Adjustment

The following is a partial list of the opposite: factors that cause lower value to accrue to CTVs shorting vSPY, or relatively higher value accrue to vSPY holders, thereby increasing the vSPY market price above the peg price and causing the interest rate adjustment to fall:

- The opportunity cost of the ethereum collateral rises. (CTV users must lock up ETH to short vSPY, so this puts a higher cost on CTV users).

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[4] (a) and (b) are actually two sides of the same coin, analogous to the first fundamental theorem of welfare economics

- vSPY suddenly allows a foreign country's residents to access SPY which they were previously not able to directly hold.

Mechanical Implementation of Interest Rate Adjustment

The instantaneous interest rate adjustment is decreased if the asset token market price becomes significantly deviated below the peg price, and vice versa:

AssetToken Market Price - AssetToken Peg Price > 5%, decrease interest rates.
AssetToken Market Price - AssetToken Peg Price < -5%, increase interest rates.

The AssetToken Market price would be measured based on a transactions-based source, like the VWAP or TWAP Uniswap price. It could also be from a two-sided auction conducted by the ItoVault smart contract on a weekly basis.

The Cumulative Interest Factor is the multiplicative time integral of the instantaneous interest rate:

$$CIF(T) = exp(\int_0^T r(t)dt)$$

$CIF(T) = exp(\int_0^T r(t) dt)$, where r(t) is the instantaneous interest rate at any point in the past, and CIF(T) is today's Cumulative Interest factor.

In version 1 (MVP) of ItoVault, the Interest Rate will be set to zero. Under such a system, the vSPY price movements should still be tightly correlated with SPY, and the effective Interest Rate is implemented by the vSPY trading at a discount or premium to SPY. The system is still efficient -- the main artifact is that the optical vSPY price will not be the same as SPY.

The version 1 system highlights that the interest rate adjustment system is not strictly needed for the desirable properties of the ItoVault system. For simplicity, for version 2 of the ItoVault system, we have the following adjustment rules:

If Spread: = AssetToken Market Price - AssetToken Peg Price is:	Then:
Less than -10%	APY of r increases by 5% for the next week
Between -5% and -10%	APY of r increases by 1% for the next week
Between -5% and 5%	APY remains the same
Between 5% and 10%	APY of r decreases by 1% for the next week

Greater than 10%	APY of r decreases by 5% for the next week

Determination of Adjustment Factors

The Cumulative Dividend Factor is mechanically derived from data in the world, and thus would count as price data reported by the price oracle.

The Cumulative Interest Factor is determined by Market Price - Peg Price deviation. Currently it is set to zero. For flexibility, it is currently determined by governance, which should change rates in a way to enforce the pegs. At a future date, the interest rate could be derived directly from the above price data and adjusted automatically. Interest rate changes will generally be announced days before implementation to allow for fair time for CVTs and AssetToken holders to know what price to expect. When adjustments are determined by governance, adjustments are expected to happen no more often than monthly.

Other Notes

In service to the AssetToken holders, while the interest rate is still controlled by ItoVault governance, ItoVault governance aims (but does not guarantee) the following bounds:

- Interest rate factor between -0.5% and 2% monthly to minimize tracking error.
- The Cumulative Carry Factor to be above 1.00 to ensure it's a good competitive long run investment in the index.

-System Fee-

In V1.0, system fees are set to zero to encourage CTV and Asset Token use.

When the Asset Token of each CVT is redeemed, a system fee needs to be paid to the ItoVault system.

Currently, there is no system fee to encourage participation, so the items below would only apply to a future system.

Hard Upper Bound

The system fee has 1.9% APY as a hard upper bound. That is to say, the ItoVault system will not let anyone, even ItoVault governance, raise fees above this. This commitment is primarily due to the mission of ItoVault to create an efficient token of world assets with minimal fees. A

resulting practical benefit is to accelerate adoption of the AssetToken, as compared to systems in the past that have charged effectively double digit APYs for their analogy of system fees.

The actual system fee will be set by governance to be anywhere between 0% and the hard bound. Governance may lower, but not raise, the hard bound in the future.

Fees First Support a Buffer Pool

The highest absolute priority destination of the system fee is a buffer pool. The primary use of the buffer pool is to redeem AssetTokens in the off chance of undercollateralized CTVs. In such a case, governance will vote to use the buffer pool, and the ItoVault system will buy outstanding Asset Tokens, and use them to liquidate undercollateralized CTVs. The liquidation would occur with the most undercollateralized CTVs first. Such liquidations likely would occur at a loss (otherwise other users would liquidate them), which is why the buffer pool is needed.

After a sufficient buffer pool exists (generally 5% of the debt in existence), fees beyond this can be, if voted by governance, used to purchase back ItoVault tokens from current holders -- either directly or via the Uniswap pool.

System Fee 50% Discount if Paid in ivTokens

Stability fees may be paid either in ETH or ivToken, the native ItoVault governance token. Payment in ivTokens has a 50% discount. The 1.9% APY Hard Upper Bound is the limit if this system fee is paid in ivToken.

Price Stability Mechanisms

Price is maintained by a number of systems in an overlapping way that provides redundancy.

The primary mechanism of price stability is through the margin requirement together with the price oracle. In particular, ItoVault obtains prices of each collateral and asset regularly: on at least a weekly basis with V1.0, and at least daily starting V2 and becoming more frequent as the amount locked (TVL) under the ItoVault system increases. These prices, along with margin ratios, determine which CVTs may issue more Asset Tokens, and which CVTs need to absorb Asset Tokens in order to meet their margin requirements. As an asset price increases, CVTs need to buy back the AssetToken or put in more collateral, driving up the Asset Token Price. As an asset price decreases, CVTs may issue more Asset Tokens, driving down the Asset Token price. This issuance and absorption is the primary mechanism of price pegging, and alone should be sufficient to maintain the peg.

Secondary systems that maintain the peg include 1) self-reinforcing market beliefs, 2) global settlement, whereby if an issue is found with ItoVault, CVTs and Asset Tokens terminate at the last good price. These two system are already implemented in V1.0

Tertiary systems, yet unimplemented, include 1) allowing ItoVault governance to directly create some CVTs to issue Asset Tokens, or buy Asset Tokens to hold directly -- this enforces prices through open market operations. And 2) the interest rate factor.

Liquidation of Non Compliant Contracts:

Any CVT that goes below the maintenance margin requirement can be liquidated by any claimer (not just the CVT owner). The claimer simply supplies the AssetToken, and then can claim the corresponding collateral plus a Liquidation Penalty.

Margin Setting

This table gives the largest single-day drops in the price of ETH in USD. We see that out of approximately 1500 valid days, the four largest single-day drops are -42%, -27%, -23%, and -20% respectively. Setting the margin requirement so that the historical value-at-risk (VaR) is 0.0% on a daily basis is too aggressive when better mechanisms like intraday oracle updates and fast liquidations are sufficient to stabilize the system. The second or third largest daily drop seems like a more reasonable margin ratio. Our preliminary maintenance margin would then be 70% loan-to-value, and preliminary initial margin would then be 60% loan-to-value.

ItoVault Governance

ItoVault governance will be allowed to 1) add or remove new collateral types 2) add or remove new asset types 3) change maintenance and initial margin of CVTs per <collateral,asset> pair, 4) change the liquidation penalty 5) modify the interest rate on each asset 6) choose the oracles, 7) choose the global settler. In V2, there will be a more direct implementation than in V1.0.

Applications:

- Asset Tokens that closely track diversified asset baskets.
- Asset Tokens that track any reasonably well behaved price series (e.g. market cap of a pre-IPO company, cumulative rainfall in the Bordeaux region of France, binary option prices for a future event).
- Stablecoins: the system can be used to generate stablecoins with interest from raw Ethereum. The stablecoins generated can be applied to all decentralized stablecoin areas. In other words, the original Maker/DAI system can be implemented within ItoVault.
- Long Term holdings: AssetTokens allow users to be exposed to core positions recommended by economists by simply buying and holding a coin. The coin can be an efficient holder of the index, even on a very long term basis (decades). Without any need to roll the coin, or lock the coin up in any smart contracts, the coin automatically

accrues the value of dividends (through the dividend factor) and the value of CVT leverage and borrow rebate rates (through the interest factor).
- Inheritances: due to the long term stability of the coin, it can be used to generate trusts, inheritances, and dynastic wealth on-chain, permissionlessly.
- Exposure to a wide variety of baskets of assets: inflation protected indexes, commodity indexes, bond indexes, international stock indexes, and even indexes that don't currently exist in liquid format, like GDP indexes.

Risks and Mitigations:

Smart Contract Hack. Mitigation: V1.0 has been internally reviewed and thoroughly proofread for attacks and v2 will receive more formal review.

Collateral Downward Jump in Price. Mitigation: collateral required is based on historical 1-day downward jumps in price. The oracle updates on both a percent-move and time-basis. Anytime there is more than a 10% move, oracles are requested to update immediately with high gas limit to ensure the price propagates into the system. Further, V1.0 already implements an automatic noncompliant vault finding contract that lists every noncompliant vault immediately.

Oracles

The V1.0 oracle system consists of a primary whitelisted oracle, and a secondary defi oracle.

The primary whitelisted oracle is currently linked to an address that is a trusted account ("External Account" or EOA in Ethereum terms) run by the ItoVault foundation to feed in true price information. ItoVault governance has the ability to change this oracle authority to a smart contract that will collect price feeds from decentralized sources like Chainlink (analogous to Synthetix) or a set of high trust institutions (analogous to Maker).

The secondary oracle system, already implemented in V1.0, acts as a backup to the primary oracle. In case the primary oracle is not reporting (due to, say, censorship) the ItoVault system can operate in a *fully* decentralized way. Any account may issue a challenge to the oracle reporting by depositing ivToken (the native governance token for ItoVault), which begins a counterchallenge process whereby every new challenger must at least double the number of ivTokens at stake, until a final challenger remains unchallenged for 24 hours. At that point, the final challenger's price is adopted by the ItoVault system. All challengers that submitted price information equal to the final challenger get a pro-rata share of the amount staked by all the losers.

Note that the secondary oracle system is similar to the Augur challenge system except there is no built-in hard fork. The lack of hard fork ensures simplicity for V1.0. Also, the experience of the Augur system itself is that staking alone is sufficient to ensure correct reporting; after all, a

user who stakes a lot of ivToken is more likely to be serious, as they would lose the value of that ivToken if people stopped trusting the system.

Censorship Resistance: Residual Mode and Code Forking

In case of censorship, governance has built-in ability to turn on full defi mode, even in V1.0. In this mode, the primary whitelisted oracle is disabled, and so price updates will defer to the fully defi challenge mechanism above. The margin thresholds are also set to a permanent high ratio (e.g. 3:1) in order to assure stability of the Asset Tokens as the defi challenge oracle takes longer to resolve (e.g. a day or two) versus the whitelisted oracle mechanism (seconds to minutes). The governance mechanism also permanently self-eliminates its ability to change key parameters of the system (like margin requirements), meaning that the above changes cannot be undone by demand. We anticipate the above full-defi mode to become increasingly more robust with future iterations of ItoVault.

In the case of governance independence, the current CVTs and the Asset Tokens are still indefinitely useful. However, in case of governance independence or the governance compromise, supporters of this project and the mission are encouraged by the current ItoVault team to fork the code, establish a robust set of whitelist oracles in trusted, low censorship jurisdictions, and continue the project. Multiple forks are encouraged and adding new features are encouraged, including support for more collateral and assets.

Eventual Decentralization

Currently, governance is bootstrapped by the ItoVault foundation. However, ItoVault foundation's main goal is self-dissolution. Eventually, ItoVault will be managed by a DAO comprised of ivToken holders.

Appendix 1: Smart Contract Code / Address

You can find the Github repo here, and the Etherscan code verification here.

The smart contract address is 0xF9E8c18A855183246DBF19C8b249921fa64bD33c 0xF9E8c18A855183246DBF19C8b249921fa64bD33c . While we refer to this V1.0 contract as 0xf9e8 in trusted contexts, please do not take the first few address digits as proof of official address -- bookmark the address and bookmark the official site www.itovault.com .

The vSPY token is at 0x3e1e15AFD5d50b090aDcC88160dD84a48EA1B80E and is referred to in trusted contexts as 0x3e1e.

Appendix 2: Calculation chart for Cumulative Dividend Factor

SPY ETF exact calculation from January 1st 2020 to October 1st 2020.

Date	Open	Close	Dividend Paid Period After	Dividend as Fraction of Previous Close	Cumulative Dividend Factor
1/1/2020	323.54	321.73	0	0	1
2/1/2020	323.35	296.26	0	0	1
3/1/2020	298.21	257.75	1.406	0.005454898	1.005454898
4/1/2020	247.98	290.48	0	0	1.005454898
5/1/2020	285.31	304.32	0	0	1.005454898
6/1/2020	303.62	308.36	1.366	0.004429887	1.00990895
7/1/2020	309.57	326.52	0	0	1.00990895
8/1/2020	328.32	349.31	0	0	1.00990895
9/1/2020	350.21	334.89	1.339	0.003998328	1.013946897
10/1/2020	337.69	343.78	0	0	1.013946897

Columns 1 through 4 above are raw data, e.g. can be retrieved from Yahoo Finance, CRSP, Bloomberg, etc. Column 5 is calculated in Excel notation like E2:=D2/C2. Column 5 is calculated in Excel notation like F4:=F3*(1+E4). Columns 5 and 6 are truncated decimals.

Appendix 3: Capital Efficiency of Soft Peg

Given that arbitrageurs may play a large role in ensuring that any AssetToken is pegged correctly to the underlying index price, how can ItoVault users be most capital efficient?

First, you can and should utilize the vault-countervault system in order to maximize long and short leverage in the system. Conversely, using both vaults and countervaults allows much less ETH to need to be locked up for 1 positive or 1 negative unit of exposure to vSPY.

Second, in the future, the frequency of price oracle updates could increase, allowing the margin limits to decrease. In the limit, the frequency of updates could happen, say, every minute, allowing margin requirements to be single digit percentages (the limit of historical minutely jumps in the price process).

Appendix 4: Discussion on MVP (V1.0) Versus Full Version (V2)

The current release (0xf9e8) is a minimal viable product (MVP), also known as V1.0 and historically as V0.1. This is in contrast to the Full Version, which is also known as V2. The main goal of this MVP is to:

- Validate demand for the next iteration (full-blown) product.
- Have a token (vSPY) that will generally be soft-pegged to an underlying fund (SPY ETF).
- Soft peg will be enforced by basic vault mechanisms (oracle prices, decentralized vaults, margin requirements, decentralized liquidation and vaultkeeping).
- Reach customers and potential future customers.
- Have customers use vSPY, the vaults, or put up value (ETH) in a fully refundable way to vote for future features.
- Have a MVP vSPY that will be maintained by the foundation until at least January 2022.

The MVP does not aim for:

- >99.9% security audit/guarantee.
- Governance token distribution.
- Late-stage decentralization (full DAO)
- Implementation of system fees and interest rate adjustments.

Throughout the discussion above, sections which have title names surrounded by dashes, like:
-Subject-
Are considered to be sections where the implementation between V1.0 and V2 will be substantially different. Some notes have been put in italics which distinguish between the features as already implemented versus ones on the roadmap.