Saffron Fixed Income Vaults

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Abstract

The Decentralized Finance (DeFi) ecosystem is undergoing a Cambrian explosion of protocols formalizing decentralized versions of financial instruments based on the derivative market. More recently, we and others have been exploring protocols focused on providing instruments for risk management. In traditional finance (TradFi), a common instrument used to balance portfolio risk is a zero-coupon swap. Zero-coupon swaps are futures contracts matching a buyer and a seller of yield. The seller owns an asset or instrument accruing variable yield, and the buyer purchases rights to that yield in exchange for fixed compensation paid at the end of an agreed-upon term. Moreover, the buyer pays the seller upfront in a reverse zero-coupon swap. Here we introduce Saffron Fixed Income Vaults, where each vault implements a reverse zero-coupon swap within a smart contract system. Vaults are built by applying reverse zero-coupon swap contract terms to any underlying yield-generating platform. We demonstrate the viability of fixed yield by examining our vaults' performance against historic DeFi yields.

Introduction

Financial derivatives are contracts that derive most of their value from some underlying asset, reference rate, or index [1]. A particular set of derivatives is the interest rate derivative (IRD), which receives its value from the interest rate of an underlying benchmark product. A popular IRD is a zero-coupon swap (ZCS), a particular case of the more generic interest rate swap (IRS). Both instruments have a variable side and a fixed side. These sides are sometimes called the "legs" of the contract. In the case of IRS instruments, payments are made periodically, and the difference between the variable rate and the fixed rate is the only exchange between parties on each side. In contrast, in a ZCS, a single fixed payment is executed at the end of the contract in exchange for the entire interest earned by the variable leg [2]. The Saffron Fixed Income Vault is a reverse zero-coupon swap (RZCS), an alternative to a ZCS, where the fixed payment is paid upfront. In TradFi, these and other financial instruments that fit under the umbrella of IRS-related instruments comprise the largest global derivative market with an estimated notional value of $397.1 trillion US dollars in outstanding over-the-counter (OTC) contracts in the second yearly half of 2021 [3].

The size of the derivatives market is evidence that IRS-related financial instruments are actively traded and demanded by economic participants because they mitigate exposure to future uncertain circumstances. For example, it is impossible for a farmer to predict a crop's yield. With an IRS, the farmer can swap part of their uncertain crop yield futures for a fixed payment, thereby decreasing their financial dependence on outcomes determined by variable uncertainties like weather, disease, and consumer demand. Similarly, the unpredictability of yield-generating instruments in DeFi makes them some of the riskiest financial investments available. This new and volatile economy benefits from IRS-related instruments in two ways: 1) they mitigate risk for portfolios that rely heavily on these yield-generating instruments, and 2) they open up increased risk exposure opportunities to savvy users with an aggressive thesis to realize more profitable outcomes in favorable scenarios.

The Saffron Fixed Income Vault is formally a reverse zero-coupon swap. More specifically, it is an instrument that mediates the purchase of the future yield from a yield-bearing asset. Therefore, The Saffron Fixed Income Vault has two sides: 1) the fixed side, where the seller of future yield owns a yield-bearing asset, and 2) the variable side, which buys the future yield. As a consequence of this arrangement, the Saffron Fixed Income Vault is a fixed income instrument from the seller's perspective and a variable rate, leveraged yield-generating position from the buyer's perspective.

Several initiatives have implemented protocols resembling IRS-related instruments in DeFi, similar to Saffron Fixed Income Vaults. A pioneer is Yield protocol[4], an on-chain, decentralized, zero-coupon bond (ZCB). To issue a bond, the user needs to over-collateralize their position and mint the bond with a certain maturity date. They can sell their bond on an automated market maker and get the underlying token. The zero-coupon bond locks in a price upon maturity, which is effectively the same as offering a fixed rate. Lending, which is equivalent to buying a bond, is more straightforward. You buy the tokenized bond for a discounted rate and can exchange it at maturity for its face value. The difference between the discounted value and the face value dictates the return rate of the instrument, which is set after the bond's purchase.

Notional finance[5] and Yield Protocol use a similar approach for borrowing and lending. The main difference is that Notional uses a different mechanism to implement a market between the yield tokens, fCash in the Notional ecosystem, and the underlying currency.

Pendle finance[6] implements the idea of stripping the yield from yield-bearing tokens, separating the yield tokens and principal tokens, and allowing them to be freely traded in a custom automated market maker. In their documentation, they classify the principal token as equivalent to zero-coupon bonds and the yield token as coupon bonds. This mechanism is similar to the one used by Devl (formerly Element Finance)[7], Swivel Finance[8], APWine[9] and Sense[10].

BarnBridge’s version 2 protocol uses epoch systems that the BarnBridge DAO initially funds and the yield is distributed proportionally at the end of the contract to the users that deposit funds. The BarnBridge v2 protocol deploys the funds deposited by users and DAO-funded rewards into a yield-generating instrument like Aave. The yield generated in the current epoch rolls over to the next epoch as the yield is guaranteed as fixed income[11].

Tranche finance implements its own token to guarantee incentives for users to provide enough capital to honor the withdrawal of deposits seeking fixed rate returns when the market conditions are not favorable [12]. These protocols set the stage for the fixed income / fixed rate market in DeFi, Table 1.

Table 1: Market share as of April 14th 2023, among the top fixed income and related instruments in DeFi according to Defi Llama.

Name	Market share (%)
Pendle	60.21%
Notional	30.79%
Yield Protocol	2.92%
BarnBridge	2.34%
Delv (former Element)	1.84%
Sense	0.95%
Tranche Finance	0.58%
APWine	0.37%
Swivel Finance	0.01%

The Saffron Fixed Income Vault protocol does not require incentives from a DAO or token emissions like BarnBridge and Tanche finance. It does not require collateralization like Yield and Notional. Saffron Fixed Income Vaults are similar to Element, Swivel, and APwine in that they create a fixed return rate via a yield stripping mechanism. However, with these protocols, the user is required to participate in a market, and it is not guaranteed that they would be able to sell their tokens under extreme market conditions. Saffron's solution differs by implementing a reverse zero-coupon swap that guarantees up-front payment for fixed side users. In addition, it is the first protocol to support Uniswap V3 as the underlying instrument. Uniswap V3 is a market leader among the highest yield-generating protocols in DeFi, according to DeFi Llama[13].

In this paper, we introduce the Saffron Fixed Income Vault factory contract. First, we will focus on a conceptual description of the instrument, followed by its mathematical model, and discuss general concepts about reverse zero-coupon swaps. Then, we present the instrument as a risk management tool and further analyze the instrument's performance with historical data from a typical high-yield underlying Uniswap V3 pool. We also investigate strategies based on the term length of the contract and a step-by-step case study of how the vault works, focusing on what users can and cannot do during the contract's lifetime. Next, we discuss these results and place the instrument in the context of DeFi as a risk management tool. Finally, we discuss the incentives to establish different contract lengths for both sides of the vault, and we summarize all of the paper's information in the conclusion section.

Theory

The Saffron Fixed Income Vault is a reverse zero-coupon swap

Saffron's implementation of a fixed income instrument is a factory contract where users can build permissionless, decentralized, reverse zero-coupon swap (RZCS) contracts based on an underlying yield-producing platform. The RZCS has two sides: a fixed and a variable side. During vault creation, the user must set three out of four parameters and specify the underlying instrument of the contract. The parameters are: 1) the capital capacity of the fixed side of the contract, 2) the capital capacity of the variable side, also known as the fixed income amount to be received by the fixed side, 3) the annualized fixed rate of return and 4) the length of the contract in days. Setting any three variables will force the fourth one to be calculated. The specification required for the underlying instrument depends on the instrument itself. For example, if the underlying instrument of the vault is a Uniswap V3 pool, the user is required to set a price range for their position. Once the vault is created, it enters the assembly phase, Figure 1, where it begins to accept users' deposits. The funds are not locked during this phase until both fixed and variable sides are filled to capacity . The vault remains open indefinitely until these requirements are met. During this period, users can withdraw their funds at any time.

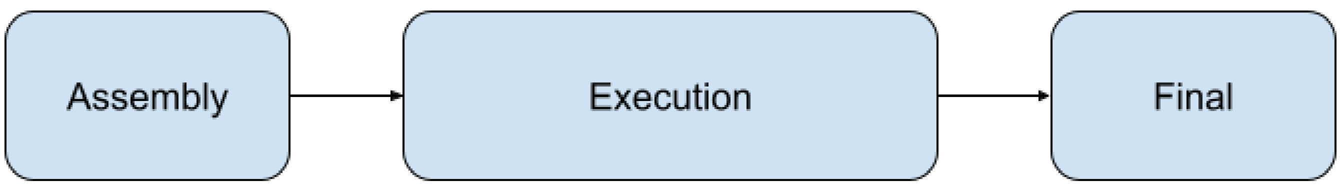

Figure 1: Sequence of contract phases.

Contract phases and deposit requirements

In the assembly phase, users that wish to join the fixed side must deposit assets that will be converted into a position of the underlying instrument as specified in the vault parameters. Similarly, users wishing to join the variable side will deposit assets accordingly. When both sides are filled the vault locks all funds and enters into the execution phase.

The execution phase starts with the contract issuing tokens representing the variable and fixed positions in the vault. These tokens are fungible bearer assets representing access to users' deposits. Next, the contract authorizes the fixed side depositors to withdraw the upfront premium, which is funded by variable side deposits. This action adds the "reverse" attribute to the ZCS because a normal ZCS pays the fixed side at the end of the contract. During the execution phase, yield is accumulated by the yield-bearing instrument locked in the vault. Users with capital deployed on the variable side can withdraw their portion of the yield at their discretion[1]. At the end of the term, the contract enters the final phase. In this phase, the contract unwraps the assets deployed to the underlying instrument and re-enables fixed side withdrawals.

Variable side continuous withdrawal

Users with positions in the variable side can swap their NFT to receive the fees accumulated in the contract. If the contract is in the execution phase, the user receives their yield and another NFT. They can use this NFT to collect the rest of the yield in the future. If the contract is at the final phase, the user only collects yield, and is not issued another NFT.

This feature is possible because the Saffron Fixed Income Vault protocol tracks all the fees earned by the contract, and each variable side user's NFT tracks all fees collected. Whenever a user withdraws their fees, the protocol uses the total fees accumulated to calculate the proportion of fees earned by the user, then subtracts this value from the fees already collected by the user to arrive at the final value for their withdrawal. Finally, the protocol adds the fees sent to the user to their already collected fees.

Returns and risks of the variable side.

The fixed side is paid upfront and therefore has a straightforward return rate. The same is not true for the variable side. We calculate the variable return as follows. Let C_F to be the total fixed capital, R_F the fixed rate defined in the Saffron Fixed Income Vault, and, per definition, $C_V = C_F R_F$ be the total variable capital capacity of the contract. Now, let U be the underlying instrument's return rate during the contract period. Thus, the total capital earned by the contract is $Y = C_F U$ and, consequently, the total variable side earnings is $V = Y - C_V$, since the principal of the variable side is used to pay the fixed side. Hence, the relative gain of the variable side can be calculated as:

$$
\begin{aligned}
R_V &= \frac{V}{C_V} \\
&= \frac{C_F U - C_V}{C_V} \\
&= \frac{C_F U}{C_V} - 1 \\
&= \frac{U}{R_F} - 1 \qquad (1)
\end{aligned}
$$

[1] This feature might not be available to the first releases of the Saffron Fixed Income Vault.

The equation above brings the essence of Saffron Fixed Income Vaults for the variable side of the contract. The ratio between the underlying instrument's performance and the fixed side's pre-defined return rate determines the potential for gain and loss, Figure 2.

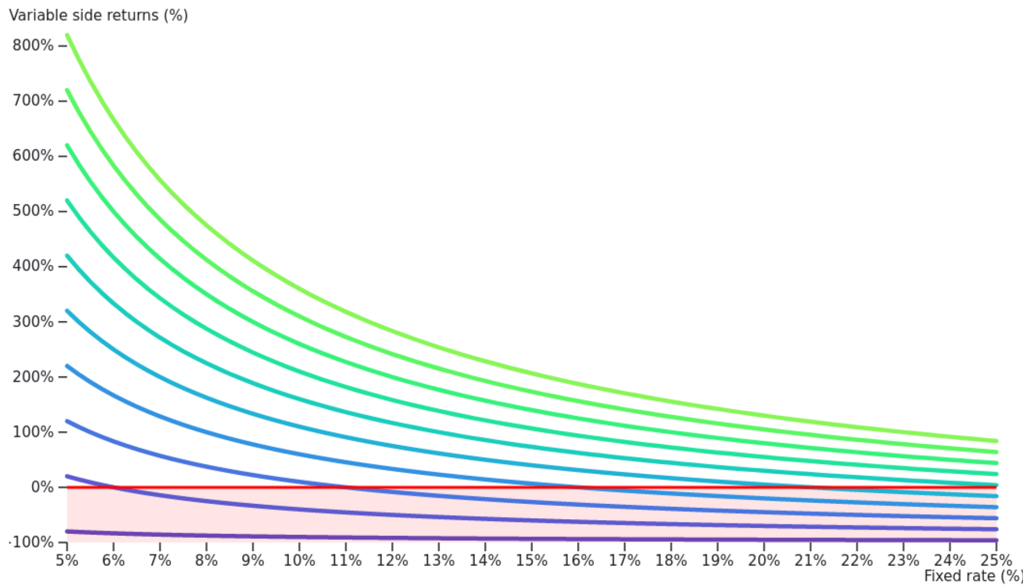

Figure 2: Performance of the variable side for a given fixed-rate at different levels of performance of the underlying instrument. The shaded area shows regions where the variable side is at a loss of capital.

The relationship between these variables is fundamental to understanding the Saffron Fixed Income Vault as a financial instrument. Users that take the variable side of the contract buy the risk of the underlying instrument’s performance and are rewarded with earnings from an instrument much larger than their initial capital investment. This is analogous to obtaining a leverage position that takes a premium in exchange for removing the risk of liquidation. The no-liquidation feature of Saffron means variable side users continue receiving earnings from their leveraged position in any market circumstances. Here, the user's leverage on the variable side user is inversely proportional to the return rate defined for the fixed side.

Length of the contract influence in the variable side strategy

The formula (1) calculates the rate of return for the variable side over the total contract duration and implicitly contains the length of the contract within it. To show how the length of the contract affects the variable side return, we will model the underlying instrument returns as a daily return rate u_i, where the index i is referent to the day into the contract. Consequently, the total yield generated by the underlying instrument:

$$Y = \sum_{i=0}^{T} C_F u_i = C_F \sum_{i=0}^{T} u_i \tag{2}$$

where T is the total term length of the contract in days. Thus, the variable return can be calculated as:

$$\begin{aligned} R_V &= \frac{V}{C_V} \\ &= \frac{Y - C_V}{C_V} \\ &= \frac{C_F}{C_V} \sum_{i=0}^{T} u_i - 1 \end{aligned} \tag{3}$$

where R_V is the variable side return rate. However, $R_F = C_V/C_F$ is the fixed return rate for the total period and thus $r_F = R_F/T \; = \; C_V/TC_F$ can be considered the rate of return per day. Then, we can substitute $r_F T \; = C_V/C_F$ in (3):

$$R_V = \frac{1}{r_F T} \sum_{i=0}^{T} u_i - 1 \tag{4}$$

Thus, the rate of return appears to be inversely proportional to the term length T. We can further manipulate equation (4) by rewriting the sum term as the average of the underlying instrument's daily return rates over the contract period. By definition of the average:

$$\begin{aligned} \overline{u} &= \frac{1}{T} \sum_{i=0}^{T} u_i \\ \sum_{i=0}^{T} u_i &= \overline{u} T \end{aligned} \tag{5}$$

where $\overline{u}$ is the average daily return rate of the underlying instrument. Applying eq. (5) on eq. (4) we recover an expression to describe the return of the variable side similar to equation (1):

$$R_V = \frac{\overline{u}}{r_F} - 1 \tag{6}$$

Thus, we show that the return rate of the variable side is independent of the term length of the contract even when modeled explicitly.

The shorter the contract, the sooner the variable side will realize its proportional gain, because the rate of return for the variable side is independent of the term length of the contract. We can show this explicitly when calculating the annualized return rate of the variable side: Because the R_V is the total return rate of the whole period, we can calculate the annualized rate of return (APR), a_V, as:

$$a_V = 365\frac{R_V}{T} = \frac{365}{T}\left(\frac{\overline{u}}{r_F} - 1\right) \tag{7}$$

a_V is inversely proportional with the length of the contract. Thus, the shorter the contract, given the same r_F and $\overline{u}$, the larger the variable side's annualized rate of return. Also, the shorter the contract, the smaller the capacity of the variable side of the contract. This allows a user with limited capital to own a larger share of the yield. This is central to understanding the incentives for both sides to determine a suitable contract length for them.

Vault fees

Saffron Fixed Income Vaults generate yield based on the performance of their underlying instrument and thus are paid solely by the variable side of the contract. The usual protocol fee is 12.5% of the earnings of the floating leg.

Results

Saffron Fixed Income Vaults as a risk management instrument.

One of the acceptable formal definitions of risk for a given financial instrument is a measurement of the uncertainty of return, which can be modeled to be proportional to the market's volatility. There are different types of risks related to financial instruments, but here we will focus on the uncertainty of the rate of return. For the sake of argument, we are not considering risks associated with protocol failure, network hacks, or any other external cause of loss of funds. However, we recognize that these are valid concerns for any DeFi application.

The DeFi market has been experiencing highly volatile scenarios since its development and therefore is considered high risk[14]. For example, with a Uniswap V3 pool as yield bearing instrument, a liquidity provider must consider two different risks related to the uncertainty of the market. First, the return of a liquidity pool is proportional to the trade volume. In addition, the liquidity provider must consider price variation between the assets in the pool, which ultimately dictates a general loss of capital, also known as impermanent loss.

Saffron Fixed Income Vaults eliminate the risk of low trade volume from the LP because the fixed side receives the entirety of its payment at the beginning of the contract. Thus, it can be used to diminish the overall risk of a DeFi portfolio by providing fixed return rates. Furthermore, the users of the fixed side do not need to worry about estimating the time value of the money at the end of the contract because they always receive that value upfront.

Simulation of return using historical data.

To demonstrate the performance of the fixed and variable sides of Saffron Fixed Income Vaults, we used historical performance data from Uniswap V3 pools registered according to The Graph[15]. Daily performance data is mainly composed of three important components: 1) trading volume, 2) total value locked (TVL), and 3) the price of tokens against a base currency. To estimate the fees earned by a liquidity provider position, we must collect the fee percentage from the total volume traded, divide it by the total value locked, and multiply it by the size of the position. It is noteworthy that this calculation is better suited to Uniswap V2 pools and only serves as a rough approximation for Uniswap V3 positions. The primary objective of this study is to demonstrate the outcome for users of Saffron Fixed Income Vaults with plausible scenarios in the recent past. This exercise does not attempt to claim any prediction power. The approach we take to estimate the gain of liquidity providers by looking at the recent past, although not exactly accurate, fulfills the intent of this exercise.

We acquired the data from June 1st, 2022, until December 1st, 2022, for the USDC-WETH 0.3% Uniswap V3 pool on the Ethereum network[2]. We used this data to simulate one vault lasting the entire 183-day duration. During this time, the return of the underlying instrument performed at (25.9 ± 23.3)% APR. For example, a Saffron Fixed Income Vault configured for 183 days on June 1st with a 20% fixed return rate APR would have resulted in a 26.7% APR for the variable side in this period. During this period, the price variation between USDC and ETH was 0.71. In a Uniswap position with a price range multiplier of 2, ranging between half and twice the price at the beginning of the contract, accrue a 5% impermanent loss. The fixed 20% APR return offsets the impermanent loss, and the total return on investment is 10.2% APR.

We can also calculate the performance of vaults with shorter lengths by using a running window of the contracts within our dataset. For Example, between June 1st and December 1st, we have 154 possible vaults of 30 days. This allows us to have a more statistical approach to these possible vaults. For instance, the average value for the return of the underlying instrument for all possible 30-day contracts during this period is 25.1 ± 8.9 % APR. Because the contract has a 20% fixed APR, the average return APR for the variable side is 117.5%. However, it is important to note that several of these contracts led to a loss of capital of up to 52% for the variable side, equivalent to approximately 632.7% annualized loss. In contrast, the most favorable contract leads to a real capital gain of 111.5% that, when annualized, becomes 1,356.2% APR. From the 154 scenarios, 55.2% had a positive return rate to the variable side.

[2] Pool address: 0x8ad599c3a0ff1de082011efddc58f1908eb6e6d8

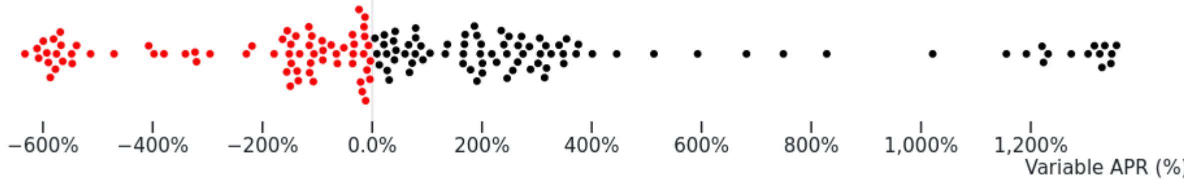

Figure 1: Spread of annualized return rates for the variable side in 154 vaults with 30 days length and 20% fixed APR rate using the USDC-WETH (0.3% fee) Uniswap V3 pool as the underlying instrument between June 1st and December 1st in 2022. Each dot represents the gain (black) and loss (red) of each of the 154 vaults.

On the fixed site, we can calculate the fixed rate of return distribution that would have guaranteed the 117.5 % APR for the variable side. The rates vary from 8.75% APR to 38.6% APR without accounting for impermanent loss, Figure 2A, and from 141.9% loss to 32.9% gain when we account for impermanent loss, Figure 2B. From these scenarios, 52.6% had a positive return rate to the fixed side even when we account for the impermanent loss in the period.

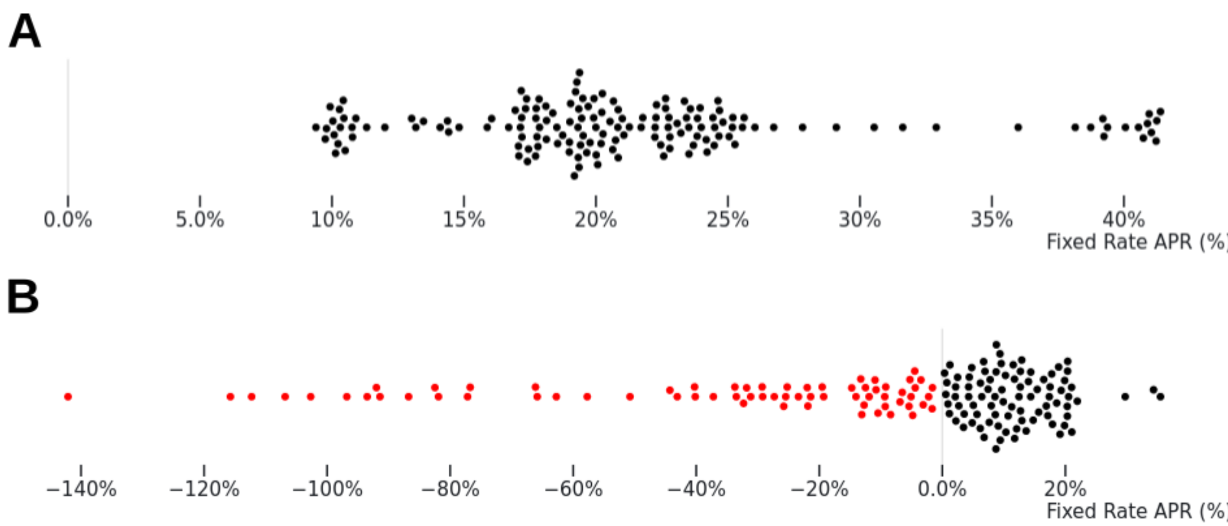

Figure 2: Spread of annualized return rates for the fixed side in 154 vaults with 30 days length that would give 111.5% variable side APR rate using in the USDC-WETH (0.3% fee) Uniswap V3 pool as the underlying instrument between Jun 1st and Dec 1st in 2022 not considering price variation between the assets (A) and taking price variation in consideration (B). Each dot represents the gain (black) or loss (red) return of all 154 scenarios.

To expand this research to other vault analyses, we built an application in ObservableHQ that is available at: https://observablehq.com/@rx3a97/saffron-fixed-income-vault.

Comparison of strategies regarding the length of contracts with reinvestment

Based on the historical data we collected, we simulated different strategies using the Saffron Fixed Income Vault. From the 154 vaults analyzed, we will choose a representative mid-range outcome. The 30-day contract that starts on September 1st has a performance of the underlying instrument around 24% APR, which leads to a 59.8% APR return rate for the variable side. Against a 50/50 hold portfolio, this fixed side gained 3.85% APR because the price variation factor k is 1.2, which leads to a loss of 1.3% of the capital deployed given a position with a range multiplier 2.

Here, however, we explore a comparative strategy. Instead of deploying one 30-day vault, we deploy 30 vaults in series: one per day, every day, for 30 days. For clarity, we ignore the deployment costs, which in real scenarios can be negligible if the capital invested is high enough. To better understand the differences between these strategies, we will suppose that a Saffron Fixed Income Vault starts with a fixed side capacity of $1,000,000.00 which, at the 20% APR return in 30 days, establish a return of 1.64%, and further sets the capacity for the variable side as $16,438.36. However, for 1-day-long vaults, the real return rate for the fixed side is 0.0548% (which equals 1.64% if repeated 30 times) so the daily premium from the variable side is only $547.95. This implies that the only difference between these two strategies for the fixed side is that in the 30-day contract, they receive a total of $16,438.36 upfront, whereas, in the daily strategy, they receive a fixed income of $547.95 every day for 30 days.

For the variable side, the major difference is if they have enough capital to deploy to the 30 days vault, i.e., $16,438.36, instead of a daily amount of $547.95 every day. This fact is central to the difference in performance for the variable side. Of course, a user willing to participate in the variable side does not need to cover the entire share of the contract alone because of the decentralized nature of the Saffron Fixed Income Vault. However, the contract splits the yield proportionally to the user's contribution to the total premium of the contract.

To further compare the strategies, let's first consider a user wishing to enter the variable side with only $547.95 available. They can still enter into the 30 day contract, but they would only have 1/30th of the entire capital needed for the variable side. During this time, the pool performed on average 23.98% APR leading to a total capital available to the variable side of $17,246.64 at the end of the 30 days, after protocol fees. The user who deployed $547.95 will receive $574.89, a $26.94 gain in 30 days, equivalent to a 4.92% return rate or 59.82% APR.

However, if they use the daily contract strategy, they still receive the same $574.89, but instead of waiting for 30 days, they get this amount in one day because now they own 100% of the shares of the variable side of the vault. Furthermore, supposing that the daily return of the pool every day does not deviate much from the average return, the variable side still realizes 4.92% of real return in 1 day instead of 30, which amounts to a 1,794.74% APR. In other words, since they receive $574.89 at the end of the day, they could reinvest $547.95 on the next day's contract (assuming such a contract exists) and keep the difference every day for 30 days. That amounts to a $1,356.23 total gain and $808.29 increase from their initial capital, the same 1,794.74% APR return as the 1-day vault mentioned previously.

The key here is the reinvestment aspect. In this strategy, the user's total investment in the contract is $16,438.36, the same as the lump sum they would have to pay for the 30-day contract. This capital is not readily available to the user on the first day, and it depends on the market performance to become a reality. However, the underlying instrument is not guaranteed to perform well daily.

Historical analysis of the reinvestment strategy in short contracts.

We could have modeled the performance of the underlying instrument as a random variable sampled from a normal distribution with a mean and standard deviation of the historical data for a specific Uniswap V3 pool. However, we favor using real daily performance data of the pool in order to capture a typical outcome of this strategy. For that, we used the 154 possible contracts within the previously described historical dataset. With the same parameters as in the previous section, the user in the variable side can reinvest up to $547.95, which is the size of the variable side of that vault. In this scenario, the user can reinvest up to $547.95 from their portfolio. We call this a 30 times 1-day contract series, 30x1. To simulate a minimum cost to enter the contract, we defined that the user cannot continue in the 30 times 1-day series of contracts if their portfolio value is below $5.00. We compare these results with the outcome of each of the possible 30-day-long contracts or one contract of 30 days, 1x30, already calculated, Figure 1.

From all the possible 30x1 scenarios analyzed, only 53.9% (83) were able to complete the end of the series of the contract. Of those completing the contract, 75% returned less than 13,914% APR, and 50% returned less than 6,363% APR, Figure 3.

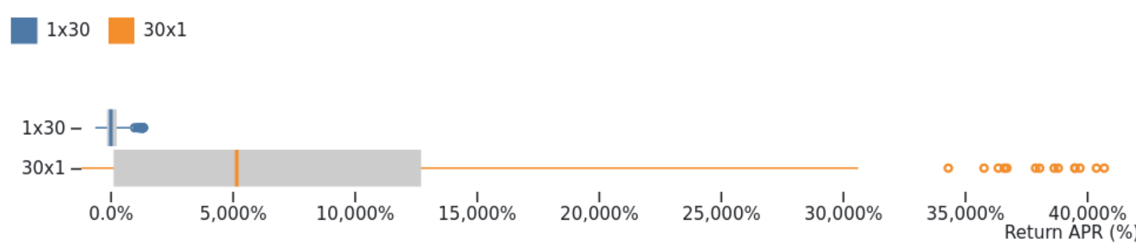

Figure 3: Distribution of returns for the variable side using two strategies: one contract of 30 days (blue) or 30 sequential contracts of 1 day with re-investment (orange). All aspects of the vault are the same in both scenarios: 20% fixed APR and $1,000,000.00 fixed side capacity.

Also, we see that 20 scenarios for the 30x1 strategy underperform the lowest 1x30 outcome, Figure 4. Thus, with the 71 incomplete scenarios, 59.1% of all scenarios underperformed the least favorable scenario for the variable side with the 1x30 strategy. Only 37.7% of (58) of the 30x1 strategy results outperformed the best result of the most favorable scenario for the variable side using the 1x30 strategy.

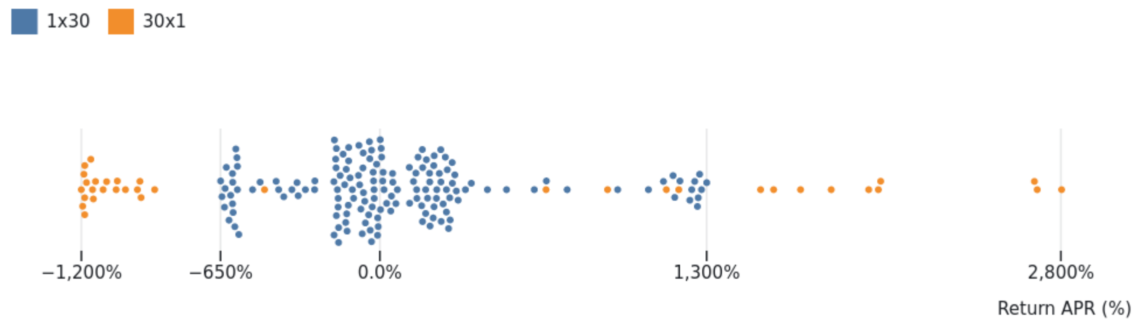

Figure 4: Possible returns for the variable side using two strategies focused on the returns below 2,800% APR: one contract of 30 days (blue) or 30 sequential contracts of 1 day with re-investment (orange). All aspects of the vault are the same in both scenarios: 20% fixed APR and $1,000,000.00 fixed side capacity.

This demonstrates the flexibility of the Saffron Fixed Income Vaults. More importantly, it shows how the users willing to use a high-risk financial instrument should seek the variable side of short-term contracts if available.

Discussion

We have demonstrated a DeFi protocol that implements a decentralized version of a reverse zero-coupon swap contract. This contract has two sides: the fixed side and the variable side. In short, the users of the fixed side trade the unknown future yield of their yield-bearing financial instrument during a certain time period in exchange for a fixed amount paid upfront. Importantly, this payment can be interpreted as fixed income or a fixed rate of return. Most DeFi instruments existing today rely on emissions of their own asset to honor the delivery of a fixed income in times of market volatility. Saffron Fixed Income Vaults introduce a fixed yield opportunity based on real economic activity in DeFi without emissions or other dilutive rewards programs.

In addition, here we make it clear that the contract described also has the opportunity for the variable side to purchase the future yield of a much larger position. Thus, one way to interpret the instrument from the variable side is that they enter a leveraged position without the usual risk of liquidation based on asset price. Saffron Fixed Income Vaults offer an attractive no-liquidation option for users speculating on the performance of Uniswap V3 pools.

These interpretations are examples that highlight the flexibility of RZCS contracts to manage investment portfolios. From a risk management perspective, Saffron Fixed Income Vaults offer a way to decrease overall portfolio risk by adding a low-risk investment option. It would be appropriate to consider the fixed side of the contract as having risk-free yield because its return is guaranteed. However, the total investment return is not guaranteed because of the possible loss of principal investment in the underlying instrument. For example, Uniswap V3 pools are prone to losses due to price variation between its tokens as the price traverses through the position's range.

At the same time, the variable side of the contract is a high-risk, high-return investment, as most leveraged positions are. To make a profit, the users on the variable side need the instrument's average rate of return to be higher than the rate of return promised to the fixed side; otherwise, they incur an actual loss of capital. In that sense, the users on the contract's variable side must consider several market factors and predict the rate of return of the underlying instrument during the length of the contract.

The length of the contract has serious implications for the users of Saffron Fixed Income Vaults. First, for the fixed side, the longer the contract, the larger the lump sum received up-front, with the same rate of return. However, the longer the contract, the larger the risk of devaluing the total portfolio due to impermanent loss. In addition, splitting a long-term vault into shorter contracts allows the fixed side more opportunities to adjust the fixed income rate in the case of a significant change in market conditions. These two aspects balance the motivations of the fixed side to consider an optimum term length for the contract.

The motivations for setting the contract length for the variable side are slightly different. We showed that with the same configuration of fixed return rate APR on a vault, the variable return rate APR is inversely proportional to the term length, equation 7, which encourages the variable side to prefer very short contracts. However, this is equivalent to concentrating the investment capital in the average outcome of multiple sequential bets into a single one. By shortening the length of the contract, the variable side is more exposed to bad market periods for the underlying instrument. With this strategy they could incur a substantial loss of capital early on without an opportunity to recover. In longer contracts, the variable side has less risk of severe loss of funds because the performance of the underlying instrument is aggregated over time.

We put this in evidence by analyzing two types of strategies to approach a Saffron Fixed Income Vault contract between fixed and variable sides. The default strategy is to make a single contract of multiple days, 1xt, and the alternative is to make a series of multiple contracts of one day, tx1. We showed that by analyzing these strategies using historical performance data of a popular Uniswap pool, the variable side rate of return has a dramatically different outcome. First, over 59.1% of the tx1 contract series underperformed, the lowest return of the 1xt possible returns. In contrast, only 37.7% outperformed the best 1xt return. Obviously, the higher the volatility of the underlying asset's performance, the higher the risk of capital loss, together with the possibility of a substantial return.

A hybrid strategy is for the variable side to avoid interruption of the process by blocking the necessary capital to enter in every single of the future contracts. This strategy leads, in general, to the same outcome as the 1xt strategy, with the difference of remaining in control of the blocked capital instead of releasing it to the fixed side at once.

Although we executed these studies looking at historical data from one Uniswap pool, they should be general. We only relied on historical data to show outcomes with values in typical ranges. We know that our methodology of using historical data to estimate future return of a Uniswap pool falls short of being entirely accurate. However, accuracy regarding the past return of a Uniswap pool hardly improves the purpose of these analyses, which is to show how the instrument would behave under typical market conditions. In DeFi, the word “typical” has a fuzzy definition. Thus, we think that even rough estimations in recent past data largely accomplish our purpose.

The complex economic pressures involved in determining an optimal contract length should be balanced. Table 4 summarizes these arguments in the case that only the term length is flexible. In other words, the table considers Saffron Vaults configured with the same fixed rate and underlying instrument.

Table 4: Arguments for different types of term lengths in the contract.

	Longer terms	Shorter terms
Fixed side	● Larger upfront payment	● Lower risk of significant impermanent loss
Variable side	● Lower impact of bad market period	● Higher APR

This work describes all the intended features of the Saffron Fixed Income Vault in the original conception of the protocol. However, some of these features might not be available in the first releases. For example, in the first released version, vaults can only be launched by authorized addresses. There is only one user on the fixed side of the contract. The variable side of the contract can only withdraw funds at the end of the contract. These limitations are intended to be temporary. In addition, the contract was built to work with Uniswap V3 as an underlying yield source, but could be expanded to other yield-bearing instruments in principle.

Conclusion

Here, we described the Saffron Fixed Income Vault, a decentralized implementation of a reverse zero-coupon swap. The protocol has two sides that exchange cash flow by swapping a fixed return rate for an unknown future yield of an underlying financial instrument. Users can take a position on the fixed side and receive their preset lump sum return at the beginning of the contract. They can also take the variable side of the contract by paying the fixed side return and receiving the yield of the underlying instrument deployed with the fixed side capital for a pre-determined period. Saffron Fixed Income Vaults are a tool for users to manage their portfolio's overall risk by entering either the low-risk fixed side or the high-risk variable side.

Although the first implementations of the protocol lack some features described here, they could be prioritized and implemented upon request via governance. In the future, upon observed demand, there could be an implementation of the protocol that handles other types of yield-generating underlying instruments in addition to Uniswap V3 pools.

Overall, here we show a solution for DeFi fixed income that does not rely on emissions to maintain the fixed rate of return despite market conditions. Because the protocol is a reverse zero-coupon swap, it maximizes capital efficiency by releasing the fixed income payment in a lump sum at the beginning of the contract. We anticipate the protocol being used as a sophisticated mechanism for risk management by users with DeFi portfolios.

Methods

Fetching historical dataset

We used a slightly modified script, available in the DeFi Llama github repository [URL] to query The Graph [15] and estimate the yield generated by USDC-WETH with a 0.3% fee Uniswap V3 pool on the Ethereum network (0x8ad599c3a0ff1de082011efddc58f1908eb6e6d8) from June 1st, 2022, until December 1st, 2022, as annualized yield per day. For that the script uses the following equation:

$$y = 365 \frac{f_{24h}}{P_{TVL}} 100 \tag{8}$$

where y is the yield in percent APR, f_{24h} is the fees accumulates from the trades in the past 24 hours and P_{TVL} is the total value locked by the pool. The fees were calculated from the trade volume of the day multiplied by the fee tier of the pool.

Calculations of Impermanent Loss

We use the following equation to calculate the impermanent loss (IL) of a position with range r and price variation k [16]:

$$IL = \frac{\sqrt{r}}{\sqrt{r}-1} \cdot \left(\frac{2\sqrt{k}}{k+1} - 1\right) \tag{9}$$

The range r is defined as a symmetrical interval between the initial price divided by r and multiplied by r. For example if the current price is 1 and r = 2, it means that the position on uniswap is defined as 0.5 and 2. This range defines where the liquidity provided by the position is spread uniformly. The price variation k is the the ratio between price of one of the tokens regarding the other when the position is closed and when the position is open. We did not consider asymmetrical positions in this paper.

Simulation of Saffron Fixed Income Vaults performance and calculations of study case

To make all the simulations we build a simplified library that mimics the Saffron Fixed Income Vault operation called Dashi. The library is written in typescript and is available [URL ObservableHQ or NPM?]. These tow sections were coded in ObservableHQ Notebooks and can also be accessed at
https://observablehq.com/collection/@rx3a97/saffron-fixed-income-vault-paper.

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