Ratio Finance: De-Risking DeFi

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Abstract

In this paper, we introduce a decentralized protocol that establishes overcollateralized collateral debt positions with algorithmically set reserve ratios based on the underlying risk of the collateral.

We created Ratio Finance to democratize the risk assessment of various forms of yield-bearing collateral available on digital ledgers. Forms of collateral such as **Liquidity Provider tokens** (LP) are, in fact, complex financial instruments that can be made liquid by understanding their underlying value. By creating a **Collateralized Debt Position** (CDP), known on Ratio Finance as USDr, a user can take out a debt position against their illiquid, locked-up collateral, while at the same time the collateral continues to earn yield. The risk of the locked-up collateral is displayed in a forward-facing manner by Ratio Finance, a first in DeFi. The mintable amount of USDr from each respective vault containing the locked-up collateral is determined by the underlying asset's **Ratio Risk Rating** (RRR) in real-time, another industry first.

Contents

1 Introduction

Since 2020, Decentralized Finance (DeFi) has exploded in growth with continuous innovation. Among DeFi natives, one of the main methods to generate passive income is yield farming which consists of passively earning yield by transferring tokens to a range of yield generating protocols.

Other familiar sources of yield in DeFi are lending protocols, which allow users to earn significant income in a trustless manner. According to DefiLlama [1], there is more than $216.51 billion USD in Total Value Locked (TVL) across DeFi platforms, (as of March 24, 2022), with the most significant weight coming from lending protocols. In this space, MakerDAO [2], Compound [3], and AAVE [4] are the *go to* protocols for investors, collectively accounting for $40.3 billion in TVL.

The rewards generated by the users on these platforms do not come without risks. The yield earned has proven inefficient in many market crashes over the past couple of years. To improve yield efficiency some lending protocols attempt to quantify risk on issuing debt using highly volatile assets as collateral. The crux of the problem is that none of these protocols have been able to fundamentally understand and communicate this asset class's risk and the nuances associated with it. Ratio's key differentiator is bringing the fundamentals of traditional credit risk assessment, combined with other qualitative variables, to account for the nuances of this new asset class.

Ratio Finance is a collateralized debt position protocol on a mission to unlock the liquidity of Solana assets and mitigate downside risk for liquidity providers. On our platform, users can lock collateral in Ratio Vaults, mint USDr stablecoin tokens, and subsequently use these tokens in the Solana ecosystem. Users of the platform will be profiting from the quantitative and qualitative risk assessment built into our protocol.

2 The Ratio Protocol

Before further elaboration of Ratio's protocol, we list the common terminology throughout this paper.

Lenders Market participants with a surplus of resources that supply assets to a smart contract.

Borrowers: Market participants who, in exchange for liquidity, pledge a security deposit, known as collateral.

Collateral: In order to borrow newly minted USDr, a liquid debt position soft pegged to US dollar (i.e., 1 USDr to 1 USD), a user pledges an amount of LP tokens, which become locked in a smart contract.

Collateralization Ratio: The Collateralization Ratio is the ratio between the total value of collateral and debt. It is a dynamically calculated risk factor for each LP asset.

Over-collaterization: Since lending and borrowing on Ratio lacks compulsory means on defaults, on occasionally volatile collateralized assets, the amount of USDr that users can borrow is less than the sum collateralized, resulting in an *over-collateralized* loan.

LP Tokens: Liquidity Provider tokens (LP tokens) are tokens issued to liquidity providers on a decentralized exchange. These tokens represent the share of the liquidity pool that the liquidity provider owns.

Ratio Vault: The individual collateralized debt positions are called Ratio Vaults. After opening a vault with some collateral, users borrow (mint) USDr stablecoin tokens such that the dollar value of the locked collateral exceeds the dollar value of the issued stablecoins.

2.1 Risk Quantification

Ratio is a collateralized debt position protocol. The protocol lends against LPs and allows users to mint USDr stablecoin tokens to their personal Solana wallet. However, LP tokens themselves are a type of cryptoasset and, as such, have unique risks and properties. Since Ratio accepts LP tokens as collateral, it is crucial to capture the underlying risks related to these assets.

2.1.1 LP Risk Quantification

A liquidity pool is a pool of crypto assets or tokens locked in a smart contract which is used to facilitate trades on decentralized exchanges (DEXs) or automated market makers (AMMs). While many exchanges follow the limit order book design, an alternative exchange design is to collect funds within a liquidity pool utilizing Constant Function Market Makers (CFMM). The goal of liquidity pools is to facilitate trading, allowing capital providers to earn yield. Individuals, treasuries, and institutions acquire LP positions for various reasons, but in the end, they are providing liquidity to the market.

Since the assets on the pool are inherently volatile, most AMMs like Uniswap [5] and Raydium [6] follow a mechanism in which, for an arbitrary asset pair, the product is constant during trades, i.e.,

$$x \cdot y = k \,. \tag{1}$$

In this way, the depth of the market is defined by the pair xy, where x represents the amount of asset X and y the amount of asset Y in the liquidity pool[1]. Moreover, the invariant k in Eq. (1) can be generalized to assets with weights, as shown by Balancer Protocol [7]. A more modern approach is the utilization of the Stableswap efficient mechanism [8] which provides low slippage and low fees when trading stablecoins (such as USDC, DAI, USDT, etc).

By creating LPs on decentralized exchanges, users are, in effect, creating a derivative product that is intended to generate a positive flow of value in an attempt to compensate for the liquidity they provide. Consequently, credit risk exposure is created because lenders and borrowers are susceptible to the actions of other market participants [10, 11]. Thus, we can think of the pair as a derivative where one participant offsets their risk with another investor.

Moreover, recent developments in DeFi have allowed the creation of multi-asset LPs [7, 8, 9]. For example, Solana's low transaction fees and fast-growing ecosystem have attracted investors to projects like Mercurial Finance [12] and Saber Labs [13] where multi-asset stablecoin LPs are available.

Following [14], it is possible to model the LP pair using the two-asset portfolio model, where the underlying

[1]For a deeper discussion of this topic we strongly recommend reading reference [10]

risks of the portfolio can be measured in terms of the realized variance. While most people do not acquire LP to make multi-asset portfolios, by taking this approach, Ratio assesses the risks of the LP tokens more clearly. Since LP liquidation is a default on the acquired loan [15, 16], Ratio uses the LP token asset correlation to measure the probability of default.

Multi-asset portfolio variance

In the following section, the risks of acquiring LPs are assessed from the vantage point of combining multiple correlated risky assets in a portfolio. First, to understand the risk-return trade-off of the portfolio, it is essential to note:

1. **Risks in individual asset returns have two components:** systematic risks, which are common to most assets, and non-systematic risks, which are specific to individual assets.
2. **Systematic risks and non-systematic risks are different:** non-systematic risks are diversifiable, whereas systematic risks are non-diversifiable.
3. **Forming portfolios can help mitigate most non-systematic risks.**

An LP token can be considered a multi-asset portfolio and is characterized by the value invested in each asset. Let V_i be the dollar amount invested in asset i; thus, the portfolio's total value is $V = \sum V_i$. We define the weight of assets on the portfolio as $w_i = V_i/V$, such that for the multi-asset portfolio,

$$\sum_{i=1}^{N} w_i = 1\,. \tag{2}$$

Employing this definition, the expected return of the portfolio is a weighted average of the individual returns:

$$\bar{r}_p = \bar{r}_1 w_1 + \bar{r}_2 w_2 + \cdots + \bar{r}_N w_N\,. \tag{3}$$

The reader should note that weights are non-stationary and might shift over time due to the activity of the pool, i.e., $w_i = w_i(t)$, hence systematic and non-systematic risks are not thoroughly relieved.

Furthermore, since LP tokens consist of highly volatile assets, the realized return of the portfolio is not always $\bar{r}_p$. It is composed of two parts, the expected return $\bar{r}_p$, and the unexpected return $\tilde{r}_p$, defined as:

$$\tilde{r}_p = \bar{r}_p + \sum_{i=1}^{N} (\tilde{r}_i - \bar{r}_i) w_i\,. \tag{4}$$

Finally, the underlying volatility of the portfolio can be described in terms of the expected value of the realized returns, which is called the portfolio realized variance, $\sigma = \mathbf{E}[\tilde{r}_p]$, and is defined as:

$$\sigma(\{w_i, \sigma_i; t\}) = w_i \Sigma_{ij} w_j = w_i^2 \sigma_i^2 + 2\rho_{ij} w_i w_j \sigma_i \sigma_j\,, \tag{5}$$

Σ_{ij} is the covariance matrix of the realized returns, σ_i the standard deviation of asset i, and ρ_{ij} the correlation coefficient between assets i and j.

2.1.2 Impermanent Loss

Impermanent loss (IL) is a term used to describe liquidity providers experience due to price divergence. In short, impermanent loss happens when the prices of the assets in the pool change after being deposited in the liquidity pool. This loss disappears if the prices return to the same value as when they were added. Therefore, the loss is only realized when the liquidity provider withdraws their liquidity from a pool.

By definition [17], impermanent loss describes the ratio of change in dollar value concerning notional value when acquiring an LP position,

$$IL = \frac{\text{Pool Value in USD}}{\text{Notional Value USD}} - 1\,. \tag{6}$$

As described in Balancer's whitepaper [7], the dollar value and notional value of assets in the pool can be written in terms of the variation in the USD price of the asset i, ΔP_i, and their corresponding weights w_i. Employing this, Balancer Protocol arrives at a significant result:

$$IL = \frac{\prod_i \Delta P_i^{w_i}}{\sum_i w_i \cdot \Delta P_i} - 1\,. \tag{7}$$

This definition implies $IL \leq 0$, i.e., there is always some impermanent loss with any relative change in token prices.

From this discussion, it is evident that IL plays a vital role in quantifying the inherent risks of LP pools. Moreover, while liquidity providers can use stablecoins, yields, and rewards to help lessen the impact of impermanent loss [18], it is clear that LP risks increase if liquidity pools have uneven ratios of assets.

2.1.3 LP Token Pricing

After providing liquidity to a pool, the user receives an LP token, which represents a share of the pool, and is paid some dividends (or yield) proportional to the amount of tokens held. It is worth noting that LP tokens are not assets that can be traded in the open market, thus pricing an LP token is a challenging task.

The market value of LP tokens is usually calculated by adding the total liquidity in the pool and dividing by the number of LP tokens issued, i.e., the price of an LP token is the ratio of the total value locked (TVL) and the total LP token supply.

$$P_{LP} = \frac{\text{Total Value Locked}}{\text{LP Token Supply}}\,. \tag{8}$$

Since TVL is the sum of the value of the reserve assets then Eq. (8) can be rewritten as follows

$$P_{LP} = \frac{\sum_i r_i p_i}{r_{LP}}\,, \tag{9}$$

where r_i and p_i are the reserve amount and the spot price of token i, respectively, and r_{LP} is total LP token circulating supply. It should be noted that Eq. (9) works efficiently when the total liquidity in the pool is balanced, i.e, when $w_1 = w_2 = \cdots = w_N$; however, the underlying reserves and prices of an LP token are vulnerable to manipulations, e.g. Warp Finance's exploit in December 2020 [19]; so by using Eq. (9) Ratio would be vulnerable to flash loan attacks.

Alpha Finance [20] came out with a very interesting solution: compute the Fair LP Price based on combining the Fair Asset Price and the Fair Asset Reserves. The Fair Asset Price can be fetched from various on-chain and off-chain sources, such as decentralized oracles or centralized feed. On the other hand, the Fair Asset Reserves are calculated by determining the reserves ratio in terms of the ratio of the underlying assets' fair prices. It is worth noticing that this calculation depends on the choice that each protocol makes while choosing the swap mechanism.

2.2 Collateralization

In every Ratio Vault, the position of the user is defined by two factors, the pledged collateral C and the amount of debt D, i.e.,

$$\mathcal{POS} = \mathcal{POS}(\{C, D\}) . \tag{10}$$

As mentioned before, Ratio is a collateralized debt position platform, where users can lock LP tokens as collateral in Ratio Vaults and, in exchange, may mint USDr tokens. The system is always over-collateralized, i.e., the dollar value of the locked collateral exceeds the dollar value of the issued USDr.

For every Ratio Vault, we define the Collateralization Ratio CR as a function of σ, the portfolio realized variance of the LP token as defined in Eq. (5), i.e.,

$$CR = 1 + \lambda \cdot \sigma(\{w_i, \sigma_i; t\}) , \tag{11}$$

where λ is a parameter defined by the protocol. Note that CR is always bigger than one to ensure an over-collateralized loan.

We address the non-stationarity nature of the portfolio weights by performing a Montecarlo simulation by calculating M realizations of σ, where N portfolio weights are generated at random using the constraint in Eq. (2), and averaging out the results.

2.3 3Pool Stablecoin LP

As an example, we consider a 3-asset stablecoin LP composed of USDC, USDT, and DAI. We use daily close data extracted via Coingecko's API [21], and for simplicity in this analysis, we concentrate on a 45-day window. The correlation matrix between the assets above over this period is captured in Fig. (1).

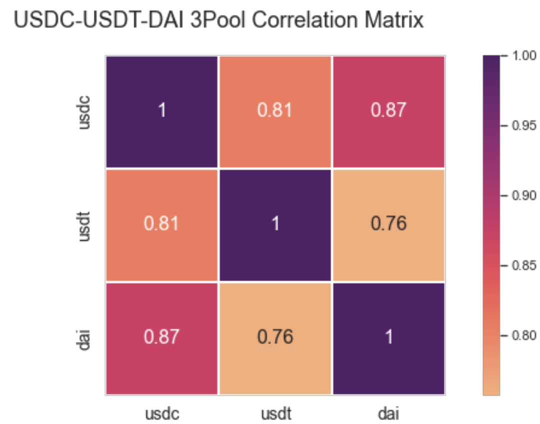

Figure 1: 3Pool Stablecoin LP correlation matrix. Assets are USDC, USDT and DAI and is calculated over a 45 day range.

Since all these tokens are pegged to the US dollar, it is natural that correlations are high. However, correlations can change drastically in periods where any of these assets have lost their peg[2].

Another exciting feature of Ratio's unique approach is the understanding that, due to the ever-changing market conditions, the weights in the LP should change over time. These changes happen regardless of the time window of analysis, but for stablecoin tokens, the returns distribution is somewhat similar for different choices, as shown in Fig. (2).

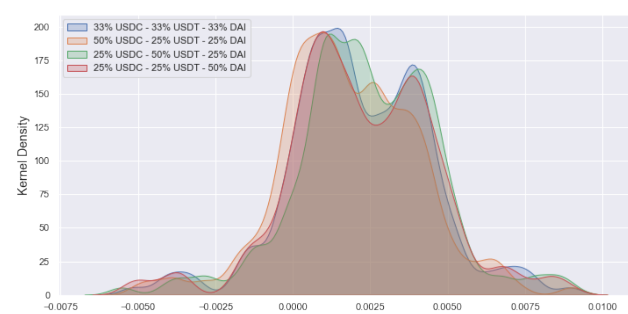

Figure 2: Return Kernel Density of 3Pool Stablecoin LPs for different portfolio weights.

In Fig. (2), we show two critical results: first, the probability distribution of returns is non-gaussian, and second, assigning different weights to the portfolios yields slightly different probability distributions. The first result is obvious, and the second result is a consequence of having an LP of stablecoins. Considering $\lambda = 1$ in Eq. (11), we find that the collateralization ratio for the USDC-USDT-DAI

[2] One interesting example was in July 2018 where the USDT-USD pair was trading around $1.25 per token or the price action of almost all stablecoins at the end of January 2022

pool is $CR \approx 103\%$. In further iterations of the protocol, we will analyze riskier assets and will carefully evaluate the credit risk for them.

3 Protocol Functionality Overview

The core Ratio system consists of smart contracts, written in Anchor version 0.18.0 (Cargo version 1.55.0), deployable to the Solana blockchain. As a decentralized platform, all transactions and smart-contracts will be made freely available to the public. The user interface is designed to be friendly to the novice or expert DeFi user and has functionality attractive to investors with any level of experience with crypto and yield farming.

The collateralization ratio derived from the LP risk quantification determines the necessary over-collateralization of the loan between Ratio and the user. It is important to emphasize that after opening a Ratio Vault, users may mint USDr tokens. Furthermore, the amount of USDr which can be minted is a function of the collateralization ratio, and it is given by

$$LV = \frac{PX_{LP}(t)}{CR}, \tag{12}$$

where PX_{LP} is the dollar value of the LP at the time t, and CR is the collateralization ratio defined in Eq. (11). Ratio Vaults are locked for the duration of the USDr stablecoin loan. When the loan has been repaid, the user is free to withdraw their collateral.

As soon as a user locks collateral into a Ratio Vault, it is redeployed to a yield farm corresponding to the collateral type to begin farming rewards for the user. Yield farming rewards are a primary benefit of using Ratio, and these rewards can be harvested at any time regardless of the status of the Ratio Vault.

The Ratio system regularly updates the asset/USD prices via a calculated average of different price oracle data feeds. The collateral price is determined by the underlying asset prices and the sizes of the respective pools on the collateral platform.

4 Governance

Ratio will begin with centralized control of the protocol (such as whitelisting initial collateral types), and over time, will transition to complete community and stakeholder control.

4.1 Token Economics

There are two tokens associated with the protocol:

> **USDr** is a soft pegged token to the US dollar used to issue and repay debt between the user and the protocol. Users can lock collateral in Ratio Vaults, mint USDr stablecoin tokens to their personal Solana wallet address, and use the tokens in the Solana ecosystem.

> **RATIO** is an SPL governance coin that allows holders to participate in on-chain governance of the Ratio Protocol. RATIO holders own and control the Ratio Protocol, serve as the stewards of the Treasury, and are rewarded from the protocol itself.

Ratio Finance is controlled by the RATIO token, which provides governance rights, and incentivizes liquidity provision of USDr. The RATIO token represents future-collective distributed ownership of the Ratio Protocol. RATIO will also be used to control internal RATIO emissions for various forms of collateral that are accepted on the Ratio Finance platform. The mechanisms behind this will resemble Curve Finance's Stable AMM reward structure [22].

4.2 USDr

USDr is the first algorithmically risk-adjusted collateralized debt position. USDr has high utility by allowing protocols to gain exposure to a basket of yield-bearing collateral with a dollar-facing denomination on their platforms. Due to the fact that the collateralization of USDr is risk-adjusted, it serves as a proxy for the underlying assets that collateralize it.

In essence, protocols that wish to analyze the risk of any collateral can bypass the hassles associated with appropriate risk quantification by accepting USDr as collateral. USDr is an excellent debt instrument because it is backed up by yield-bearing assets and overcollateralized through protocol-owned risk management algorithms that adjust in real-time. USDr can leverage existing liquidity, short positions for delta neutral yield farming, or give protocols exposure to a diverse basket of yield-bearing assets.

Given that USDr is over-collateralized by a diverse basket of stable assets, it also mitigates any single stablecoin's risk (as shown by the recent de-pegging of several prominent stablecoins).

4.3 Treasury

The Ratio Protocol Treasury serves as the "Federal Reserve" of the Protocol. The Treasury uses funds to reward RATIO token holders, give out community grants, buy back RATIO tokens, and bail out solvent Vaults in the case of total default (which should rarely occur due to stringent over-collateralization and auto-liquidation). Assets from the Treasury may also be spent promoting the Ratio ecosystem, purchasing insurance for the network or Ratio Vaults, and bug bounties.

5 Conclusions

In conclusion, introducing the Ratio protocol will de-risk the decentralized finance ecosystem. By providing quantitative and qualitative ratings of yield-bearing collateral such as LP positions, retail and institutional investors can make more educated decisions and design complex financial derivatives through the Ratio Finance platform. Ratio's CDP solution USDr creates a unique, risk-adjusted stablecoin that allows users to mitigate and hedge their risk effectively. Ratio Risk Ratings will continue to develop over time and become a backbone of the Open Finance movement.

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