Revert Lend Protocol
Draft v0.1

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Abstract

In this paper, we introduce a decentralized lending protocol specifically designed for Automated Market Maker Liquidity Providers on Uniswap v3. This protocol facilitates the acquisition of ERC-20 token loans by leveraging their liquidity provider positions as collateral, while uniquely allowing them to retain control and management of their capital within the Uniswap v3 pools.

Contents

1 Introduction

Revert Lend is a decentralized peer-to-pool lending protocol designed for Automated Market Maker Liquidity Providers. It allows users to collateralize their Uniswap v3[1] liquidity provider positions, in the form of the Uniswap NFT-Manager NFTs, and obtain loans in a protocol-determined ERC-20 token.

The protocol is specifically designed to allow Liquidity Providers to maintain control over the capital in their positions while they are collateralized. This feature facilitates uninterrupted management and optimization of LP positions, catering to the dynamic needs of liquidity providers.

2 Revert Lend Protocol

2.1 Supplying Assets

Lenders contribute the lending asset to a lending pool accessible to all borrowers. This pool adheres to the ERC-4626 Tokenized Vault Standard. Upon depositing assets, lenders receive rTokens (e.g., rUSD), representing their share of the pool.

As borrowers repay loans with accrued interest, the value of each rToken share increases. Initially, rTokens will have a 1-to-1 exchange rate with the deposited asset, but over time, as interest accrues, their value appreciates, yielding more than 1-to-1 upon redemption.

The protocol does not inherently guarantee liquidity. Instead, it utilizes the interest rate model to influence liquidity levels. This model is designed to respond dynamically to the lending pool's current conditions. Specifically, when there is a surge in demand for loans coupled with a decrease in available liquidity, the model automatically increases the interest rates charged to borrowers. This increment in borrowing costs acts as an incentive for potential lenders, encouraging them to supply more assets to the pool, and for borrowers to repay their outstanding loans.

2.2 Borrowing Assets

Uniswap v3 LPs can borrow tokens from the lending pool by collateralizing their positions in the Vault contract. This process involves transferring their LP position, represented as an NFTManager NFT position[1], to the Vault contract, enabling debt against that position's value, bounded by the minimal collateral factor of the assets involved. Loans carry variable interest rates as detailed in section 6.2 and do not require specific terms negotiation by borrowers.

2.2.1 Collateral Value

For AMM LP positions to be collateralizable, both assets in the pair must have been previously approved as valid collateral for the protocol. Each asset's collateral factor, ranging from 0 to 1, determines the maximum loan value that can be secured against it.

The collateral factor for any position is the lower value of the collateral factors of the two assets in the pair. For instance, a WBTC/DAI pair's collateral factor is the lower of the individual factors for WBTC and DAI.

$$\begin{aligned}\textbf{Collateral Value} = &\text{ Price Token0} \times \text{Qty Token0} \times \\ &\min(\text{Collateral Factor0}, \text{Collateral Factor1}) \\ &+ \text{Price Token1} \times \text{Qty Token1} \times \\ &\min(\text{Collateral Factor0}, \text{Collateral Factor1})\end{aligned} \tag{1}$$

Borrowing capacity and debt accrual are calculated per position, with each position's accounting maintained separately, even within the same account.

2.2.2 Managing Collateralized Positions

Collateralized LP positions within Revert Lend are locked in the protocol until the associated debt is fully settled. Despite this, position owners maintain full control over their positions. This includes the ability to add or withdraw liquidity, collect or compound fees, with the stipulation that the minimum required collateral value is upheld.

Furthermore, owners have the flexibility to adjust the position's price range by withdrawing liquidity and creating a new position at the desired range, or even reallocate their liquidity to a completely different asset pair. The key requirement for these modifications is that both assets in the new pair are approved as valid collateral by the protocol and that the resulting collateral value suffices to maintain a healthy loan status.

2.2.3 Risk and Liquidations

Liquidation mode in Revert Lend is activated when a position's accrued debt exceeds its borrowing capacity. Under this mode, any account can clear the debt and earn a liquidation premium, which ranges from 2% to 10% based on the position's debt-to-value ratio.

The liquidation process initially utilizes uncollected fees from the position. If these are not enough, the principal assets are tapped to cover the remaining debt and to reward the liquidator.

During liquidation, the necessary value is extracted from the position to settle the debt and pay the liquidator's premium. The assets remaining after these deductions stay within the position, which is then automatically returned to the original owner. This ensures a fair resolution, addressing the immediate financial obligations while preserving the residual value for the position owner.

2.2.4 Use cases

Collateralizing AMM LP positions enhances capital efficiency for liquidity providers in the AMM protocol. This capability enables several strategic uses:

- Capital Availability for External Investments: LPs can leverage loans for investments in other assets or protocols.
- Leveraging Positions: LPs can reinvest loaned assets back into their positions, creating leverage against the loaned asset.
- Self-Repaying Loans: As AMM positions generate yield, this can be used to repay the debt, akin to "self-repaying loans" found in other DeFi lending protocols like Alchemix[2].

2.3 Interest Rates

The Revert Lend protocol operates on a dynamic interest rate model, similar to the one initially proposed by the Compound Protocol[3], which seamlessly balances the interests of both lenders and borrowers without the need for individual negotiations.

In line with classical economic theory, the protocol's design posits that interest rates – essentially the cost of borrowing money – should naturally align with demand levels. In periods of low demand for borrowed funds, interest rates decrease, making borrowing more attractive. Conversely, when demand surges, interest rates climb in response.

3 Protocol Architecture

Revert Lend implements a nonupgradable contract design. This decision ensures the integrity of the protocol, minimizing the risk of introducing errors or modifying security trade-offs, through any future modifications.

3.1 CDP Vault for AMM LPs

Protocol users can deposit their Uniswap v3 LP positions NFTs, individually, into Collateralized Debt Positions (CDP) vaults. This enables them to secure loans in the loan asset, with their position acting as collateral.

While the LP position NFT is locked in the vault, users retain the ability to manage it, including adding or withdrawing liquidity (up to the maximum Loan-to-Value ratio), collecting or compounding fees, and adjusting their positions' selected ranges and pools.

3.2 Unified liquidity

3.2.1 Single Market Structure

Revert Lend adopts a standard single liquidity market, instead of the multi-pool designs sometimes used in other lending protocols. This unified approach brings together various types of collateral under one market, which enhances the lending process's overall efficiency and simplicity.

The unified market model prevents the typical liquidity fragmentation found in multi-pool designs. By combining all collateral types into a single pool, the design seeks to maximize liquidity utilization, leading to higher yields for lenders due to the increased efficiency of the system.

3.2.2 Risk Management in a Unified Market

Revert Lend includes a robust risk management system within this unified market framework. The system facilitates effective risk limits without the downside of liquidity fragmentation.

The combined properties of the unified market and collateral exposure limits help ensure a safe but liquid lending environment, maintaining a balance between risk management and liquidity availability for borrowers.

3.3 rTokens

When lenders deposit the lending asset, they receive minted ERC-20 tokens that represent their share of the lending pool. In the same way, lenders can redeem their rTokens and receive their deposited lending tokens with any interest accrued. The exchange rate between rTokens and the underlying lending tokens increases as interest is accrued in the lending pool, as defined in section 6.1.

3.4 ERC-4626 Tokenized Vault

Revert Lend adopts the ERC-4626[**?**] for its lending pool architecture. ERC-4626, an extension of ERC-20, establishes a framework for tokenized vaults utilizing ERC-20 tokens. In the context of Revert Lend, these tokens, referred to as rTokens, symbolize fractional ownership in a consolidated asset pool composed of the lending token. The implementation of ERC-4626 offers several advantages, notably in facilitating interoperability. By aligning with this standard, Revert Lend enhances its compatibility and ease of integration with diverse protocols and platforms seeking to leverage its yield-bearing capabilities.

4 Position Transformers

Position transformers are specialized, protocol-approved contracts that offer enhanced flexibility in managing collateral positions. Once authorized by the collateral position owner, these transformers can modify or even completely replace a position, provided that the final status of the Collateralized Debt Position (CDP) Vault is healthy.

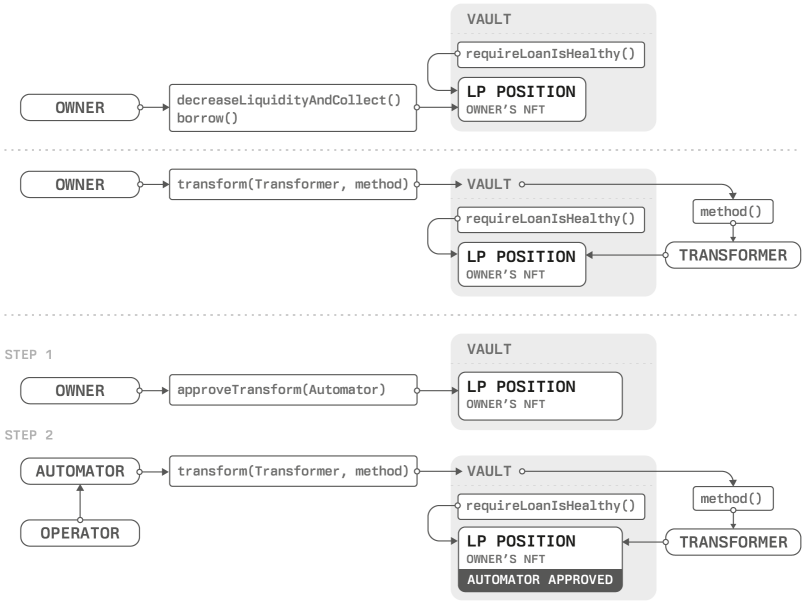

Figure 1: Managing Collateralized LP Positions

4.1 Approval and Security Measures

To ensure security and reliability, transformer contracts must first be included in the transformerAllowList by the protocol admin. This inclusion is reserved for a limited set of contracts that will have undergone rigorous auditing. Additionally, each position owner can authorize contracts to automate the execution of transformers on their behalf which is required on the Auto-Range and Auto-Compound transformers described below.

4.2 Initial Set of Transformers

At deployment, Revert Lend includes a set of transformer contracts, each serving specific functions:

- **V3Utils:** This transformer is a collection of convenience functions tailored for managing LP (Liquidity Provider) positions. It enables users to efficiently add or withdraw liquidity using any arbitrary token. Additionally, it simplifies the process of transferring liquidity across different price ranges and pools, enhancing the flexibility and control LPs have over their positions.

- **LeverageTransformer:** This contract empowers LPs to either leverage or deleverage their positions. It operates by atomically handling the intended debt, executing any necessary asset swaps, and then redepositing

back into the position. This functionality provides LPs with a seamless method to adjust their leverage levels, aligning with their risk and strategy preferences.

- **Auto-Range:** This transformer allows position owners to set trigger limits based on a percentage difference from their current range limits. When these limits are reached, the position is automatically adjusted to center around the current pool price.
- **Auto-Compound:** This transformer enables position owners to authorize Auto-compounder bots to reinvest their uncollected fees back into position liquidity. It automates the process of compounding returns, potentially enhancing yield efficiency for LPs over time.
- **Auto-Leverage**: This transformer facilitates the automated management of leverage in collateralized positions. It is designed to maintain a predefined leverage ratio, ensuring optimal exposure according to the user's strategy. Additionally, it offers protection against liquidations by automatically adjusting leverage levels in response to market fluctuations.

5 Liquidations

5.1 Criteria for Liquidation

In the Revert Lend protocol, a position becomes eligible for liquidation when the collateral's assessed value falls below the position's accrued outstanding debt. This assessment is based on the collateral value as determined by the oracle, factoring in the minimum collateral factor for each token in the pair.

The health status of a position is assessed based on this inequality:

$$\textbf{isHealthy} = \text{Collateral Value} > \text{Position Debt} \tag{2}$$

Upon entering liquidation mode, any account has the opportunity to repay the position's outstanding debt. This can be done by calling the *liquidate* function, after which they are entitled to receive a liquidation penalty as compensation. This process ensures that positions at risk are quickly and efficiently managed, maintaining the stability and integrity of the lending pool.

5.2 Progressive Liquidation Penalty

The protocol implements a progressive liquidation penalty system. This penalty serves as an incentive for liquidators and increases as the debt value approaches the collateral value. Starting at a minimum of 2%, the penalty can go up to 10%, depending on how close the debt is to the collateral value. This progressive structure fosters competition among liquidators, aiming to minimize the penalty incurred by the position being liquidated.

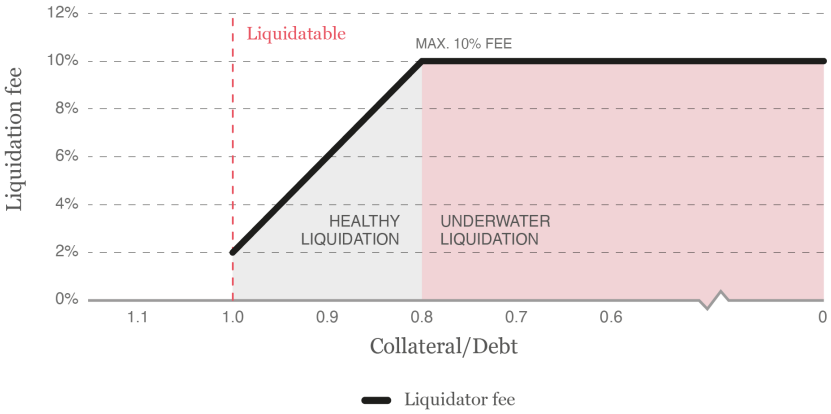

Figure 2: Liquidation Fees

5.3 Normal liquidation process

The liquidation process in Revert Lend is executed with the following steps:

1. Initially, the debt value and any applicable liquidation penalties are deducted from the total value of the liquidated position. This deduction is first made from any uncollected fees and subsequently from the principal assets of the position.

2. After settling the debt and penalty, the position's NFT, representing the residual value, is returned to the original depositor (the owner) within the same transaction.

This liquidation approach is designed to be equitable for both borrowers and liquidators. By providing a clear incentive structure, it encourages active participation from liquidators in the process. Simultaneously, it protects the interests of position owners by ensuring the return of the maximum possible value post-liquidation.

5.4 Liquidations for underwater positions

5.4.1 Reserve Liquidation Process

In Revert Lend, the Reserve Liquidation procedure is activated for positions that become 'underwater' – a scenario where the total debt of a position exceeds its value. This exceptional situation would indicate a problem in the protocol's lending operations.

During a Reserve Liquidation, the protocol utilizes its reserves, which have been built up incrementally with each debt settlement, to address the shortfall of the underwater position.

5.4.2 Handling Insufficient Reserves

If the reserves are insufficient to cover the entire debt of the underwater position, the protocol implements a strategy to reduce the total outstanding debt. This action is essential for restoring the protocol's solvency.

In this extreme situation, the protocol applies the debt reduction proportionally among all lenders. This approach is designed to be more equitable than strategies used by other lending protocols, which may lead to unequal impacts on lenders and encourage "bank run" behaviors. By distributing the impact proportionally, Revert Lend aims to ensure fair treatment for all participants and prevent disproportionate losses.

However, such an occurrence is highly unlikely and indicative of a failure within the protocol.

6 Interest Rates

6.1 Global Interest

Revert Lend employs a unified interest rate model that applies equally to all borrowers and lenders, dynamically adapting to shifts in supply and demand.

The protocol tracks historical interest rates using three global state variables: ***lastDebtExchangeRate96***, ***lastLendExchangeRate96***, and ***lastExchangeRateUpdate***. These variables are recalculated to reflect any changes in interest rates due to user actions such as deposits, redemptions, borrowings, repayments, or liquidations involving the lending asset.

6.1.1 Debt Exchange Rate Update

$$\begin{aligned} \text{timeElapsed} &= \text{block.timestamp} - \text{lastExchangeRateUpdate} \\ \text{rateMultiplier} &= \text{timeElapsed} \times \text{borrowRate} \\ \text{lastDebtExchangeRate} &= \text{oldDebtExchangeRate} + \\ &\quad \text{oldDebtExchangeRate} \times \text{rateMultiplier} \end{aligned}$$

This equation computes the debt exchange rate by adding the interest accrued since the last rate adjustment. The interest is calculated based on the elapsed time and the current Borrow Rate as provided by the Interest Rate Model.

6.1.2 Lending Exchange Rate Update

$$\begin{aligned} \text{timeElapsed} &= \text{block.timestamp} - \text{lastExchangeRateUpdate} \\ \text{rateMultiplier} &= \text{timeElapsed} \times \text{supplyRate} \\ \text{lastLendExchangeRate} &= \text{oldLendExchangeRate} + \\ &\quad \text{oldLendExchangeRate} \times \text{rateMultiplier} \end{aligned}$$

In a similar manner, this equation computes the lending exchange rate by factoring in the interest accrued on the old lending rate, using the time elapsed and the supply rate.

6.2 Interest Rate Model

The interest rate model is the algorithm used to determine the borrow rate and lending rate for the Revert Lend protocol. This model is essential for aligning the rates with the current state of the lending pool.

6.2.1 Utilization Rate

The Utilization Rate is the proportion of borrowed assets to the total available assets within the protocol. It is an indicator of outstanding loans relative to the supply of funds and plays an instrumental role in determining the interest rates for both borrowers and lenders.

$$\text{Utilization Rate} = \frac{\text{Total Borrowed Assets}}{\text{Total Available Assets} + \text{Total Borrowed Assets}} \tag{3}$$

6.2.2 Kink

The kink is a defined utilization rate threshold. It functions as a pivotal point in the interest rate curve, marking the transition from a lower to a higher interest rate regime. It is strategically set to balance borrower demand with lender supply, ensuring the protocol's liquidity remains healthy.

6.2.3 Base Rate

The Base Rate represents an optional minimal Borrow Rate the protocol can define.

6.2.4 Borrow Rate

The Borrow Rate is the rate per second that borrowers accrue as additional debt.

$$\begin{aligned}\textbf{Borrow Rate} = {} & \text{Base Rate Per Second} \\ & + (\text{Utilization Rate} \times \text{Multiplier Per Second})\end{aligned} \tag{4}$$

When the utilization rate is greater than the kink the Borrow Rate is calculated as:

$$\begin{aligned}\textbf{Borrow Rate} = &\text{ Normal Rate up to Kink} \\ &+ (\text{Excess Utilization Rate} \times \text{Jump Multiplier Per Second})\end{aligned} \tag{5}$$

Where Normal Rate up to Kink is calculated as:

$$\textbf{Normal Rate} = (\text{Kink} \times \text{Multiplier Per Second}) + \text{Base Rate Per Second} \tag{6}$$

and Excess Utilization Rate is the portion of the utilization rate that exceeds the kink. It's calculated as:

$$\textbf{Excess Utilization Rate} = \text{Utilization Rate} - \text{Kink} \tag{7}$$

Jump Multiplier Per Second is the higher multiplier rate applied when the utilization rate crosses the kink threshold.

6.2.5 Supply Rate

The Supply Rate represents the distribution of the Borrow Rate to all the lenders and is therefore the utilization rate fraction of the Borrow Rate

$$\textbf{Supply Rate} = \text{Utilization Rate} \times \text{Borrow Rate} \tag{8}$$

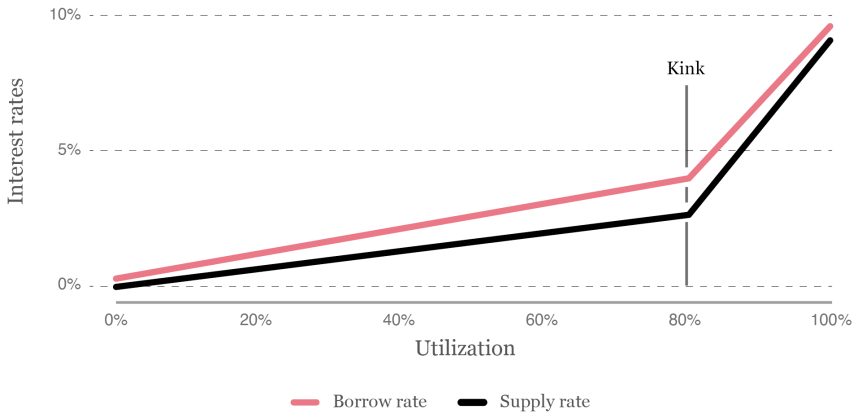

Figure 3: Interest Rate By Utilization

7 Caps and Limits

7.1 Collateral Exposure Limits

The collateral exposure limits are an important risk management tool within Revert Lend's unified liquidity framework. These limits set a defined ceiling on the maximum value of loans that can be issued against each type of collateral. Protocol admins establish these limits when introducing new collateral types, ensuring a controlled risk profile for the lending pool.

7.1.1 Operational Mechanics

Upon issuing a loan, the loan value is accounted for in the cumulative total of loans secured against the collateral position's underlying assets. For every loan transaction, whether it's an issuance or a repayment, the respective amount is adjusted in the global tally for each asset in the collateralized position. This process ensures adherence to the individual exposure limits for each collateral type, regardless of the position moving out of range fully to either of the underlying assets.

When a collateral exposure limit is reached, the protocol automatically suspends the issuance of new loans and prohibits increases in loan values for that specific collateral type.

7.1.2 Example Scenario

Consider WBTC (Wrapped Bitcoin) with a collateral exposure cap of 5 million USD. If the total loan amount for WBTC-inclusive positions (like ETH/WBTC, DAI/WBTC, USDC/WBTC) reaches 4.9 million USD, only an additional 100K

USD could be loaned against WBTC collateral. This enforcement remains strict, unaffected by WBTC's price changes or the total value of collateralized WBTC positions.

7.2 Global Lend Limit

The Global Lend Limit is designed to control the total value that can be lent out across all positions and collateral types in the platform. This cap plays a vital role in managing the overarching risk and maintaining the liquidity balance of the lending pool.

Functionally, the Global Lend Limit acts as a regulatory mechanism, especially in emergencies. By setting this limit to 0, the platform can effectively implement a temporary halt on the issuance of new loans. This preventive measure allows for swift and decisive action in response to potential anomalies.

7.3 Max Daily Debt Increase (MDDI)

The Max Daily Debt Increase (MDDI) determines the maximum increase in the total value of loans issued by the protocol within a 24-hour period. Set at 10%, this cap ensures that the maximum loan amount provided can only grow by 10% of the total stablecoin deposits in any given 24-hour period.

7.3.1 Purpose and Emergency Use

MDDI functions as an emergency backstop to protect in case of a catastrophic exploit, whether due to unforeseen errors in the protocol's logic or the exploitation of counterparty risk in one of the collateral tokens.

7.3.2 Minimal Initial Value

While the total value of the protocol is very low, the MDDI can be ignored by setting a minimal value for loans before the MDDI check is required.

7.3.3 Example Scenario

For instance, consider a scenario where a malicious actor discovers a vulnerability allowing them to manipulate the price of a collateral token. With MDDI in place, the maximum that the total loan amount could increase due to such an exploit is capped. For example, if the total lending pool is 25 million USD, the MDDI restricts any increase in loans to a maximum of 2.5 million USD (10% of the total lending deposits) in a 24-hour period. In the event of such a catastrophic exploit, this means the potential loss for the lending pool is limited to the MDDI amount.

8 Oracle

8.1 Oracle Selection and Functionality

Revert Lend's oracle system for each collateral asset incorporates two primary sources: a Chainlink price feed and a Uniswap v3 pool TWAP (Time-Weighted Average Price) oracle. This dual-source structure allows for versatile configuration, enabling the protocol to either use one of these price sources independently or in tandem. When configured to work together, one source acts as the primary price feed while the other serves as a safeguard for maximum price deviation.

8.1.1 Safety Mechanism Activation

Should the difference between these two price feeds exceed a predefined threshold, the initiation and processing of new loans or liquidations involving the affected collateral will be paused. This precautionary pause will be automatically enforced until the price divergence is corrected, or the oracle is modified to address the underlying issue.

8.1.2 Purpose of the Dual-Oracle System

The dual-oracle system with Chainlink and Uniswap AMM pool TWAP provides a robust and reliable framework for asset valuation. It not only ensures precision in price feeds but also adds an extra layer of security against price manipulation or anomalies in market data. By setting a clear deviation threshold for protocol actions, the protocol enhances its resilience against market volatility and potential oracle exploits.

Furthermore, the protocol includes a safeguard mechanism to ensure the integrity of collateral valuations. It verifies that the implied price in the liquidity pool of a collateralized position does not deviate from the oracle-reported prices of the underlying tokens by more than a predefined threshold, determined by 'maxPoolPriceDifference.' This check is designed to prevent any instantaneous price manipulations within the pool, which could otherwise lead to inaccurate computations of the underlying token amounts for collateralized positions.

9 Governance

Initially, a team multi-sig will exercise centralized control over the protocol, including decisions about collateral assets. Gradually, this will shift to full community and stakeholder governance over the admin functions. These are the parameters and functions currently controlled by the admin for each of the relevant protocol contracts

9.1 Vault

9.1.1 setLimits

setLimits can be used to increase or decrease the Global Lend Limit or Global Debt Limit. While this does not affect existing deposits or loans, in an emergency these could be set to below the current amounts so that no new loans or deposits can be made.

- **globalLendLimit:** Limits the total lending token amount that can be deposited. It limits new deposits but does not affect existing ones.
- **globalDebtLimit:** Limits the total amount of outstanding loans. New loans are halted once this limit is reached, but existing loans remain unaffected.
- **dailyDebtIncreaseLimitMin:** This is part of the MDDI mechanic. Defines the minimum amount of total loan value for which the debt is always allowed to increase per day. This is set to avoid a very low start so that while the total amounts are still low enough, the debts can increase at a higher rate than what would be allowed by the MDDI.

9.1.2 setReserveFactor and setReserveProtectionFactor

- Adjusts the Reserve Factor, the percentage difference between supply and borrow interest rates.
- The Reserve Protection defines the minimum amount that must be kept in reserves, from what is accumulated by the difference between supply and borrow rates, to be used in case of emergency if a position needs to be liquidated while underwater.

9.1.3 setTokenConfig (Vault)

This function enables the protocol owner to update or set configurations for each collateral asset available in the vault. The parameters that can be adjusted for each token include:

- **collateralFactor:** Determines the maximum ratio of a specific token that can be counted as collateral.
- **collateralValueLimit:** Sets the maximum exposure limit for each token, expressed as a fraction of the lending pool.

9.1.4 setTransformer

Adds a new transformer to the transformerAllowList

9.1.5 withdrawReserves

Allows the admin to withdraw excess reserves, equating to protocol profits, while maintaining the minimum defined by the reserveProtectionFactor.

9.2 Oracle

Oracle parameters are set per collateral token. The following parameters are modifiable by the protocol admin.

9.2.1 setTokenConfig (Oracle)

This function is used to configure or update the settings for each collateral token within the oracle system. The modifiable parameters include:

- **Token:** Specifies the address of the collateral token for which the configuration is being set.
- **AggregatorV3Interface:** Designates the Chainlink feed to be used as the price oracle for the specified collateral token.
- **maxFeedAge:** Sets the maximum duration, in seconds, for which a Chainlink oracle price feed is considered valid.
- **Pool:** Defines the Uniswap v3 pool to be used for the TWAP (Time-Weighted Average Price)
- **twapSeconds:** Determines the time window, in seconds, for calculating the TWAP from the Uniswap v3 pool.
- **Mode:** Selects the operational mode for the oracle.
- **maxDifference:** Maximum acceptable deviation between primary price and verification price.

9.2.2 setOracleMode

This function allows the protocol admin to update the mode for each collateral token's oracle. The mode determines how the oracle price is sourced and verified. The available modes are CHAINLINK_TWAP_VERIFY, TWAP_CHAINLINK_VERIFY, CHAINLINK, and TWAP.

9.2.3 setMaxPoolPriceDifference

Allows the protocol Admin to configure maxPoolPriceDifference, which determines the maximum amount that a position's implied pool price can deviate from the oracle-provided token prices.

9.3 Interest Rate Model

The configurable parameters are listed below and explained in section 6.2.

- **baseRatePerYear**
- **multiplierPerYear**
- **jumpMultiplierPerYear**
- **kink**

References

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