MetaLend <> Katana Price Oracle Risk Analysis

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Key Points

- In order for MetaLend to safely rely on Katana Price feeds for AXS and RON to ETH pricing, collateral and borrow/lend limits must be set
- By integrating with chainlink price feeds, MetaLend could safely increase these caps by a factor of 50-100

Introduction

Ronin's Katana Dex uses Uniswap V2's AMM implementation, which applies the Constant Product Formula to calculate spot price and liquidity across supported trading pairs. As such, for any given pair, conversions of a non-trivial size relative to the size of their liquidity pools can have substantial price impacts on trading pair spot prices.

In this analysis, we explore the risks and trade offs that arise if Metalend's DeFi lending protocol were to rely on Katana's spot price oracle as opposed to Chainlink's price oracle for ERC-20 token pricing. We conclude with some suggested mitigation strategies that should be used to limit the impact of those risks on both Katana and MetaLend users.

At a high level:

- There exists a profitable arbitrage strategy for a user with the means to make a large trade on the Katana Dex (we discuss the ETH/RON and ETH/AXS trading pairs specifically) with the intention of creating a price impact. An arbitrageur can leverage that price impact to force borrowers into shortfall, and liquidate them to receive MetaLend's liquidation discount on their collateral as a source of revenue
- Execution of such a strategy would increase price volatility of trading pairs on Katana, which could harm LPs providing liquidity to that trading pair as well as users looking to trade on Katana at fair market prices

- Relying on Katana without any TWAP (time weighted average pricing) of the trading pairs also exposes Metalend users to significantly increased price volatility and possibly early liquidation, outside of the intentional arbitrage strategies explored here
- As a short term mitigation strategy, Metalend will institute restrictive collateral and borrow caps on all ERC-20 tokens, starting with a 50,000 AXS collateral cap and a 3,000,000 RON borrow cap. These caps would likely be safely increased by a factor of 50-100x if Chainlink price oracles became available for use on Ronin

Spot Price Mechanics

As mentioned above, Katana applies the Constant Product Formula to maintain liquidity and pricing dynamics for trading pairs. As such, we can express any given pair's liquidity as:

$$A \cdot B = L^2$$

where A and B are the amounts of token X and token Y in their respective liquidity pools, and L is the liquidity parameter.

Then we note that the spot price of token X (in terms of token Y) can be expressed as:

$$\frac{B}{A}$$

Now assume a Katana user wants to convert b tokens of token Y to token X, they will receive an amount a of token X that satisfies

$$a = \frac{A(1-\sigma)b}{B + (1-\sigma)b}$$

where σ denotes the fee of the pool.

In doing so, the user will change the spot price of the pool to

$$p' = \frac{B + b}{A - a}$$

and will lose an amount a_c for the conversion relative to the spot price, where x can be expressed as

$$a_c = \frac{A}{B}b - a = \frac{A}{B}b - \frac{A(1-\sigma)b}{B + (1-\sigma)b}$$

This can be thought of as the cost of the trade which created the given price impact.

Risk of Price Manipulation

If we assume that, given the above formulae, an arbitrageur would be able to:

- Change the effective price of a trading pair for at least one block (where no other user counteracts the price change in the same block)
- Change the effective price of the given trading pair without impacting it enough to reflect an overall change to the price of token X
- Liquidate users in shortfall on Metalend. Specifically users that either borrow token X against their Axie or Axie Land (who's appraisals are calculated in ETH, and token Yin this context is ETH), or use token X as collateral to borrow ETH.

Then the following arbitrage strategy could be profitable:

1. Convert b ETH to token X, incurring a loss of a_c and changing the spot price of token X to p', an increase of $PI = (\frac{p'}{p} - 1)$ or $(PI * 100)$ percent
2. A Metalend borrower that borrowed token X against an amount C in collateral denominated in ETH, and was $z\%$ below their LTV limit can now be liquidated by the arbitrageur when $PI > 0.01z$
3. The arbitrageur profits $((PI - 0.01z) * C * d) - a_c$ where d is the discount factor offered as a liquidation incentive by Metalend

Risk Mitigation

In order to mitigate risk under this scenario, we can abstract away from individual Metalend users and consider C to be the total collateral in the protocol (not just collateral held by one user) and set z equal to 0, therefore assuming the protocol is at max LTV wrt token X.

Under that set up, we'd like to pick a maximum collateral limit CL (or in the similar case of borrowing, a borrow limit BL) such that the cost of creating a price impact, denoted a_c, is larger than the profit opportunity or

$$PI * CL * d < a_c$$

Unfortunately, this does not hold for all PI at any reasonable CL (above a trivial amount) since Katana's trading fees are very low at 0.3%, so it is fairly inexpensive to create minor price impacts (ie $a_c << PI$ for small PI). As such, if we set a max PI that the protocol is willing to tolerate, call it PIL, we can ensure that

$$\forall PI > PIL, PI * CL * d < a_c$$

where CL is non-trivial.

Note: the max collateral limit that satisfies the above inequality for some PIL should be considered a strict upper bound to the collateral limit that is used in the protocol. Since Katana's liquidity pool depth varies significantly over time, the cost of price impact a_c will vary significantly as well. In addition, an arbitrageur could attempt to magnify price impacts by sacrificing collateral discount revenue for further price impacts, compounding the net price impact on a trading pair.

AXS Collateral Limit

Consider the AXS/ETH trading pair and set $PIL = 0.03$ and discount factor of $d = 0.1$.

Then using Katana to convert from AXS to ETH, we follow the conversion route from AXS to RON to ETH. And it would cost a user 503 AXS to create a price impact of approximately 3%, so our collateral limit comes out to approximately $160,000$ AXS.

Since liquidity pools are subject to change and this trading path depends on two different trading pairs (thereby increasing the volatility of the cost of creating a price impact) we should conservatively set an initial collateral limit at 30% of this upper bound, at approximately $50,000$ AXS.

RON Borrow Limit

By similar logic, we can consider the RON/ETH pair and compute a borrow limit to cap the profit opportunity from the arbitrage strategy mentioned above.

Taking again $PIL = 0.03$ and $d = 0.1$, in the case of RON we find that the current cost of this price impact comes out to $22,000$ RON. This sets our CL at $7,300,000$ RON. Again accounting for possible future changes in liquidity creating volatility in the cost of price impact as before, we can set the limit to a more conservative 40% of this value at approximately $3,000,000$ RON.