IX Swap - Uniswap pools behavior analysis

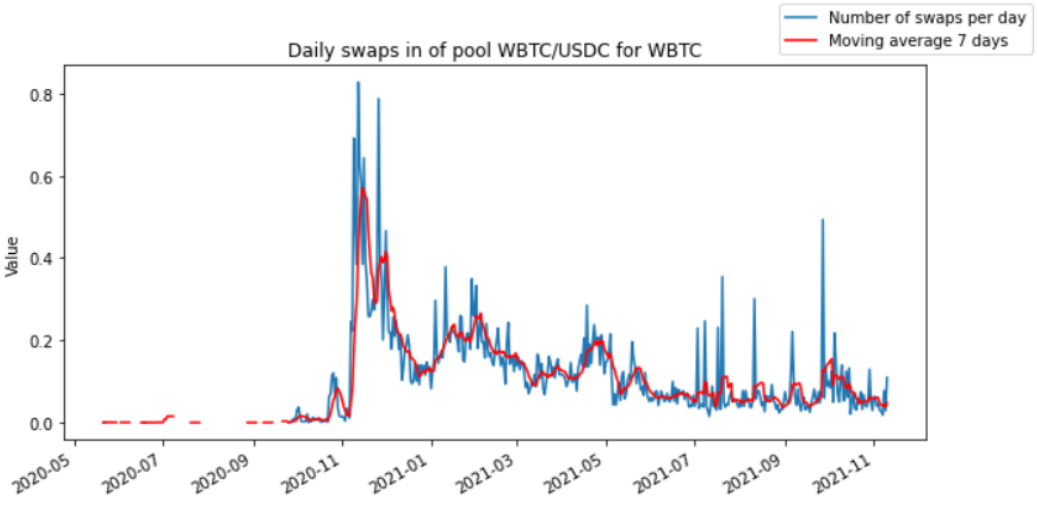
Introduction

Situation on the cryptomarket differs from one token to another, requiring analysis of the popular and long-living pools of the tokens from different industries that have different recognition on the market. For that current report contains information about 3 pool types:

- Classic tokens, representing popular blockchains, coins representing USD dollar equivalent, or business startups with blockchain;
- NFT, representing different platforms and areas;
- Meme-tokens, that are created as a market reaction to some important event, person, or to some joke. Those ones have the least predictable markets.

Pools analysis

WBTC/USDC



Picture 1: WBTC swapping in operations in the WBTC/USDC pool

Picture presented above greatly represents pool lifecycle moments. In the beginning there is an unclear picture considering that the pool is just formed and there is no swapping in transactions happening, causing distribution uncertainty and instability. At the center of the distribution can be seen the rise of the distribution, representing high traders interest. The third part of the distribution covers traders interest drop, representing a more stable situation.

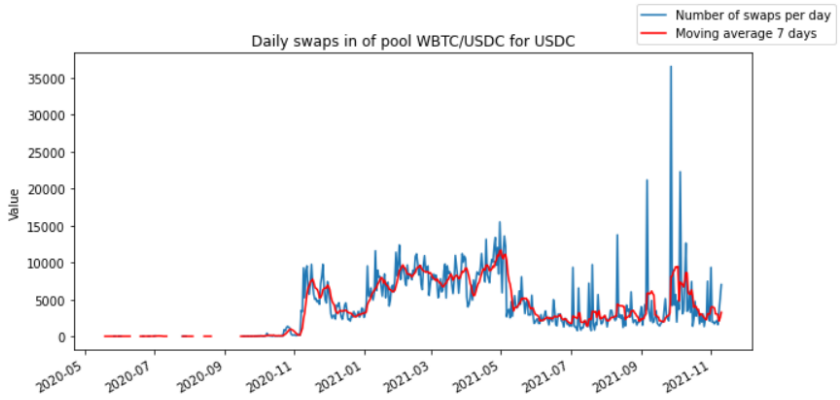
For correct interpretation of the distribution it is important to consider the BitCoin price, which is high and therefore values on the Y-axis are high if they will be converted into USD equivalent.

Picture 2: BitCoin price distribution in the WBTC/USDC pool

Looking at the swapping in distribution of the WBTC keeping in mind the WBTC price distribution explains a lot about traders behavior. For example, the extreme rise of swapping in operations with WBTC in the time interval between November 2020 and March 2021 is caused by a great BitCoin price rise. The interesting moment is that the pool price for BitCoin is almost exactly matching the distribution that was registered on the market, meaning that pool token price distribution converges to the general-market price distribution with small deviations. Considering the rise of the BitCoin price many traders decided to change their BitCoins into USDC. After the “hot” trading moment, when extreme price rise caused extreme swapping in rise, traders were still trading WBTC higher compared to previous periods while the BitCoin price was rising. After March 2021, when BitCoin price stabilized, the traders behavior changed to lower swapping in operations, causing traders to keep their tokens waiting for better prices.

Picture 3: CoinDesk BitCoin price distribution chart

Distribution of the USDC swapping in operations also has a great rise during BitCoin price rise and has stabilized after first BitCoin price stabilization and second BitCoin price decrease. Small rise of swapping in operations for both USDC and WBTC in the September-November 2021 period was also caused by rise of the BitCoin price



Picture 4: USDC price distribution in the WBTC/USDC pool

The same rise of the token price caused a rise in the reserves of the WBTC/USDC pool. Conform distribution can be seen that the best part of the WBTC/USDC lifecycle was registered between November 2020 and May 2021. Liquidity providers get some profits from rising pool reserves, which explains reserves distribution: traders decided to take a max profit out of rise of the transactions frequency and values, removing their financial resources when pool behavior became less attractive for them.

In the previous graph the token price conform reserves daily updates distribution looks similar to the real-price distribution, but each swap has its own token price based on the current pool reserves value. There are many transactions happening during the day, changing reserves

after each transaction, meaning that each transaction causes a price shift and reserves shift. Considering that, it was decided to perform a price distribution analysis of the estimated price per swap operation.

How to estimate the swap operations prices and find their increase rates

There are two data fields that will be used in analysis - amount_in and amount_out. Can be applied a formula using those data fields to find current token price:

$$Current\ token\ price\ =\ \frac{amount\ out}{amount\ in}$$

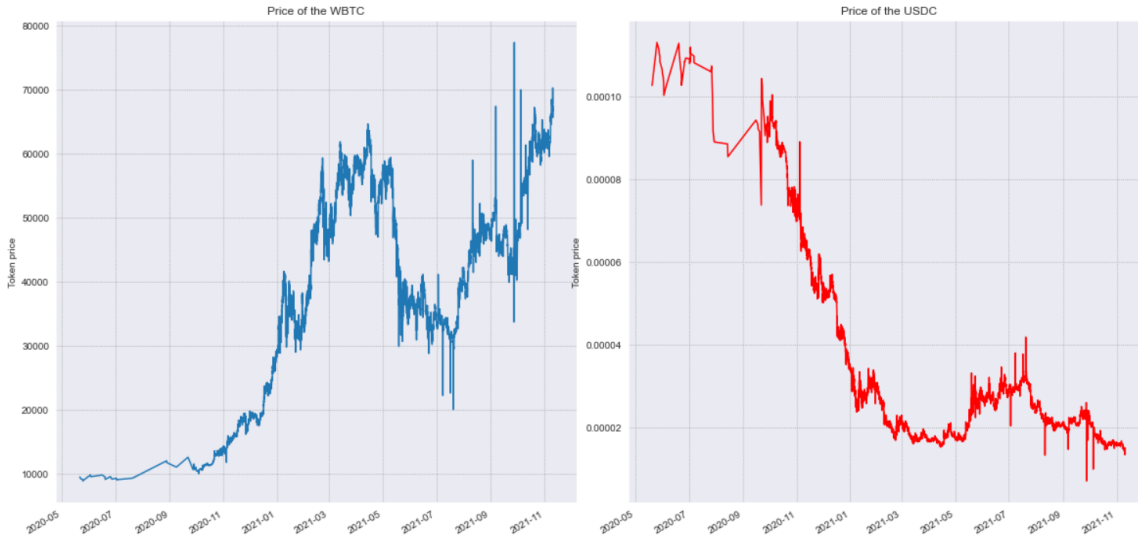
The *current token price* is representing the token_in price in the token_out equivalent. Using this method for each transaction can be found the current token price that was calculated on the Uniswap platform. Knowing current token prices can be found price change rate, which can be important in constructing prices change rates, using the formula:

$$Token\ price\ change\ rate\ =\ \frac{current\ token\ price\ -\ previous\ token\ price}{previous\ token\ price}\ *\ 100\ (\%)$$

Token price change rate will be represented in percentages.

How swap operations prices distribution differs from the reserve-based token prices

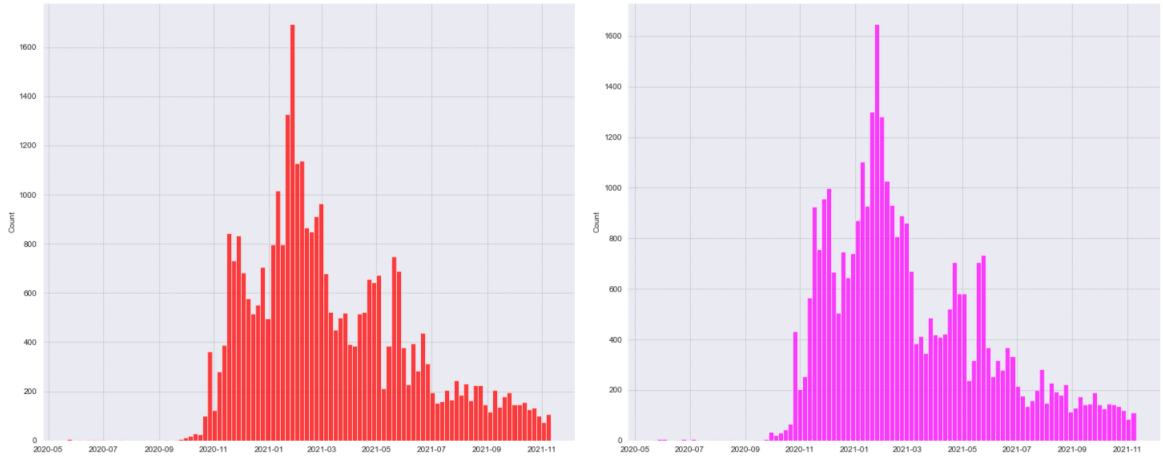
After visualizing the token price, estimated conform swap operations can clearly be seen the difference between reserve-based token prices and swap-based ones.



Picture 5: Swap price distributions for WBTC/USDC

Comparing the presented WBTC swap prices chart with WBTC reserve-based prices chart, it is observable that swap-based prices are a more ‘noisy’ analogue of the reserve-based ones. It happens due to the daily price changes happening because of exchange operations and that pool adapts to the current situation on the market. “Smoothing” the line will create an almost identical chart to the reserve-based one.

Daily prices deviations are different: in one cases the deviation is small (for example, the WBTC swap price deviation is smaller until May-June 2021) and in other there are anomalous price rises and drops (like August-November 2021 WBTC swap price changes). Keeping in mind swaps values can be observed that great price deviation is happening during low activity periods in the pools. The Authors’ opinion is that this phenomenon is happening due to the presence of the balancing algorithm during high-activity periods (TWAP-based one). To ensure that low swapping values in the picture 4 chart is explained by decrease of swapping operations below is presented the swap operations count histograms.

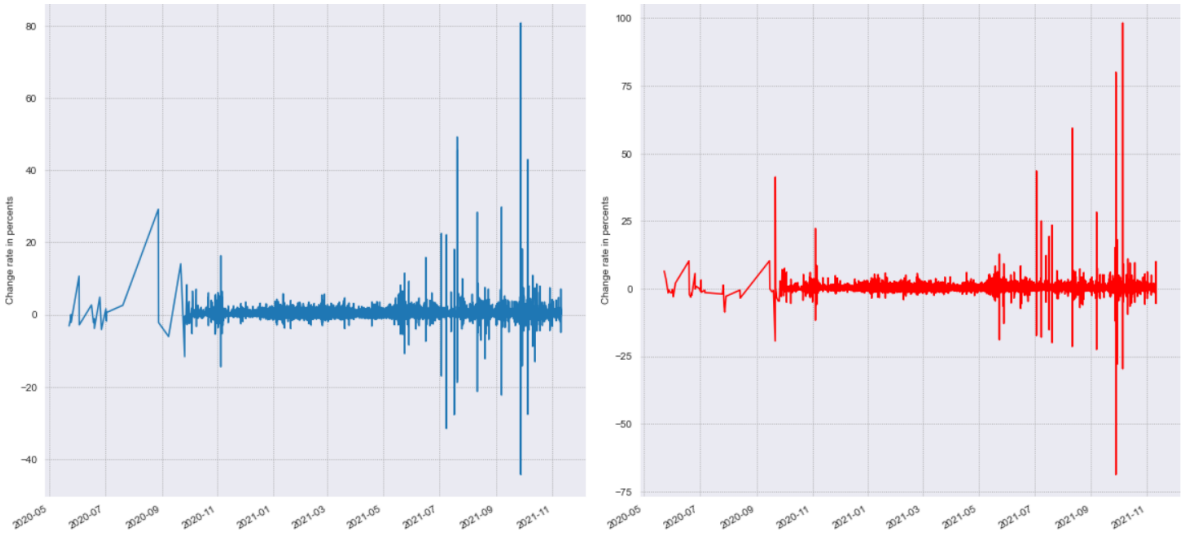


Picture 6: Swap operations count distribution, left chart represents WBTC swap operations count distribution, right chart represents USDC swap operations count distribution

The transactions count is almost identical to the transaction values per timestamps in the picture 4 graph, ensuring previously estimated theory and raising up the assumption about destabilization of transactions in low-activity periods.

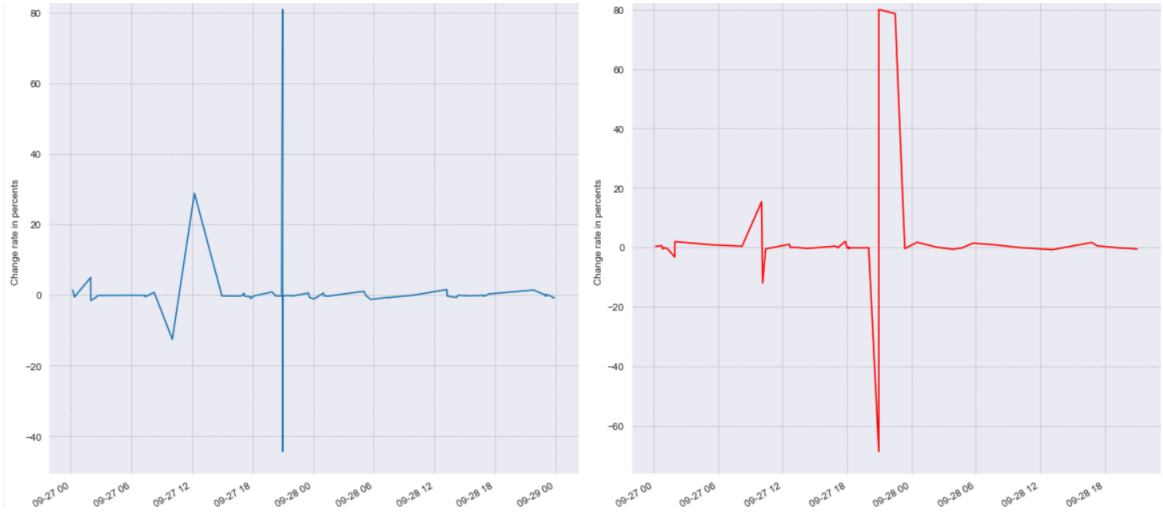
Strange moment or possible attack on the market (MEV)

To check how price deviation looks from the change rates perspective, the change rates distributions are presented below.



Picture 7: swap-based prices change rates distributions, left chart represents WBTC swap operations price change rates, right chart represents USDC swap operations price change rates

During visual analysis authors were interested in a closer look into the period, when price change rates were around 60-80% (it is a too high price change), and authors created additional charts with closer look into 27-28 September 2021.



Picture 8: Swap-based price change rates, left chart represents WBTC swap-price change rates, right chart represents USDC swap-price change rates

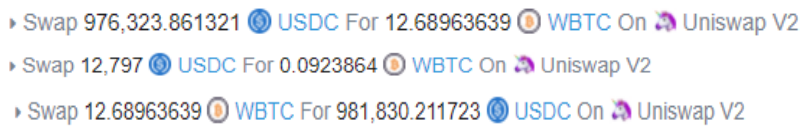
Drop and next rise of the token price caused authors to pay attention to this situation.

	token_in	token_out	amount_in	amount_out	amount_usd	timestamp	first_to_second_price	price_change_rate
65603	USDC	WBTC	6000.000000	0.138634	6005.143255	2021-09-27 20:01:41	0.000023	220.049757
65607	WBTC	USDC	0.006960	297.845610	297.760491	2021-09-27 20:53:21	42791.511683	-44.694234
65608	USDC	WBTC	12797.000000	0.092386	12787.458570	2021-09-27 20:58:07	0.000007	-44.455047
65609	USDC	WBTC	976323.861321	12.689636	975595.915259	2021-09-27 20:58:07	0.000013	-44.027899
65610	WBTC	USDC	12.689636	981830.211723	981098.160132	2021-09-27 20:58:07	77372.604033	79.600818
66006	USDC	WBTC	5875.205194	0.059231	5878.316962	2021-10-05 09:00:00	0.000010	-49.583526

Picture 9: Swap transactions history fragment, covering presented rise and drop of the token price with strange pattern

Conform presented fragment can be seen transaction nr. 65608 where trader requested exchange of 12 797 USDC to WBTC. BitCoin price for 28 September is 42 247.36 USD. The reserve-based BitCoin price is almost the same (considering that USDC is a stable coin representing USD analogue on the crypto market and that pool balance converges to the real-market situation), but trader got 0.092386 WBTC instead of around 0.3 WBTC, which is ⅓ out of the real-price and around 6-8 thousand USD loss. The next operation changes almost 1 million USDC to the WBTC, getting 12.689636 WBTC and right after that performing reverse operation, changing 12.689636 WBTC to USDC. As a result of those two operations, the trader got almost 6 thousand dollars profit, which is similar to the sum lost by the previous trader.

One important highlight is that by extracting the historical data through the uniswap subgraph, only the transaction timestamp is available (which is the same for all transactions within a block), meaning that the execution order of the transactions inside the block is lost. Because of this, these transactions were checked manually on Etherescan in order to get their execution order.



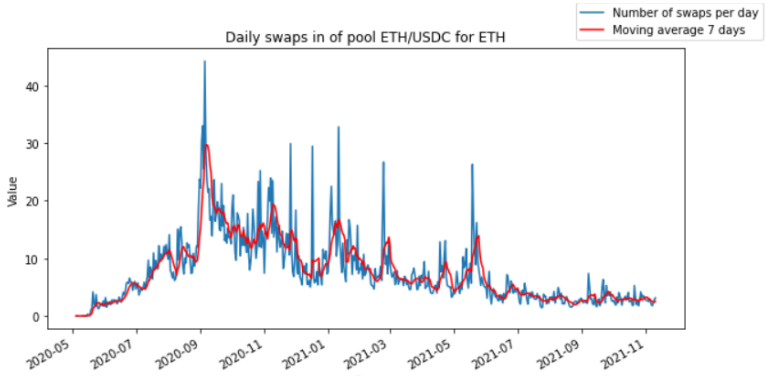
Picture 10: transaction history from Etherscan about possible MEV attack

Here (t1, t2, t3), it can be observed, how the swap transaction of the user got 'sandwiched' by the MEV-bot transactions. The execution order that would allow making the profit is ensured by bundling the transactions together (including the one sent by another user) and setting a high fee. This vulnerability cannot be exploited when the slippage parameter for the swap transaction is set or the reserves of the pools are very big (as it would require an extremely large transaction to cause a significant price impact).

This attack happened, due to the situation when the trader requested a too high transaction value compared to the available reserves in the pool. Conform reserves data for the current pool requested transaction is around ⅔ of available USDC token reserves in the pool, meaning that trader caused a strong change in token balance and therefore price.

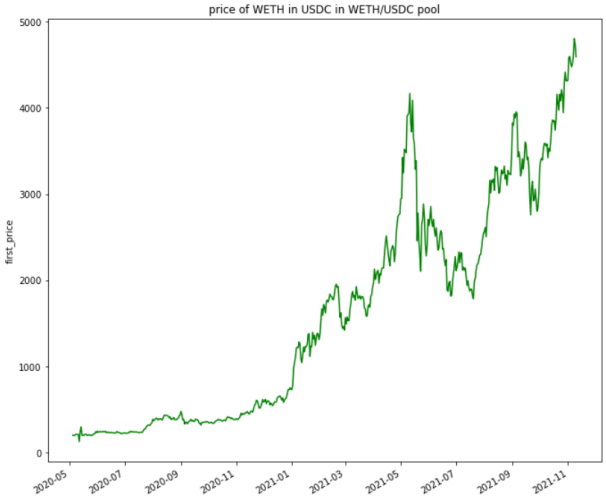
ETH/USDC

The distribution of the ETH/USDC pool is more clear and readable, considering that distribution from the start has a great transaction frequency. Ethereum swapping in operations has a more stable and readable distribution compared to the WBTC one.



Picture 11: ETH swapping in distribution in ETH/USDC pool

The Ethereum price in the WETH/USDC pool has a similar positive trend as WBTC price distribution, but relative rise and drops are much stronger in the current case. Percentage of changes is much higher.



Picture 12: WETH price distribution for WETH/USDC pool

Changes in the price of Ethereum inside WETH/USDC pool has the same rule as changes of the BitCoin price in WBTC/USDC pool - distribution of token price inside the pool converges to the general-market Ethereum price.

Picture 13: CoinDesk Ethereum price distribution

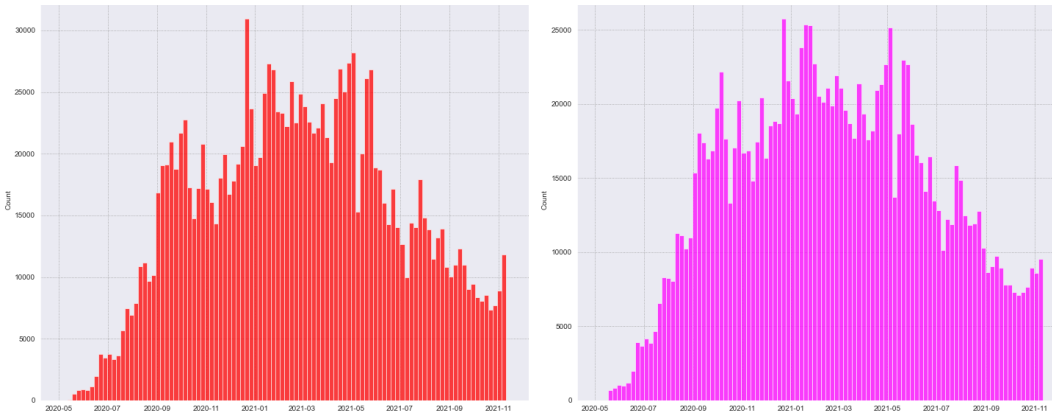
Why MEV was not detected in the current pool

Comparing Ethereum price based on the reserves balance can be seen that there is a distribution similar to the real-market one. Considering that the previous pool had a big price deviation it was decided to compare swap-based prices with reserve-based ones.

Picture 14: swap-based price distributions for WETH/USDC

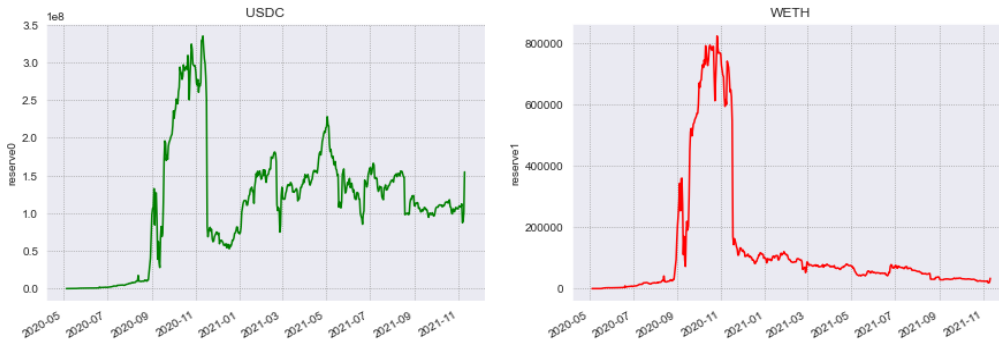
Price drops present in both charts are python errors that appeared during division processes, causing incorrect deviations present on the charts. Ignoring this error, there is still an

observable high deviation of the price, but distribution is more stable compared to the previous case of WBTC/USDC pool. This difference can be explained by the higher transaction frequency and its distribution that is relatively high over the entire present time period. This causes more stable and efficient work of the balancing algorithms, used to control transactions and reduce possibility of market destabilizing.



Picture 15: swaps count distribution, left chart represents WETH swaps count, right chart represents USDC swaps count

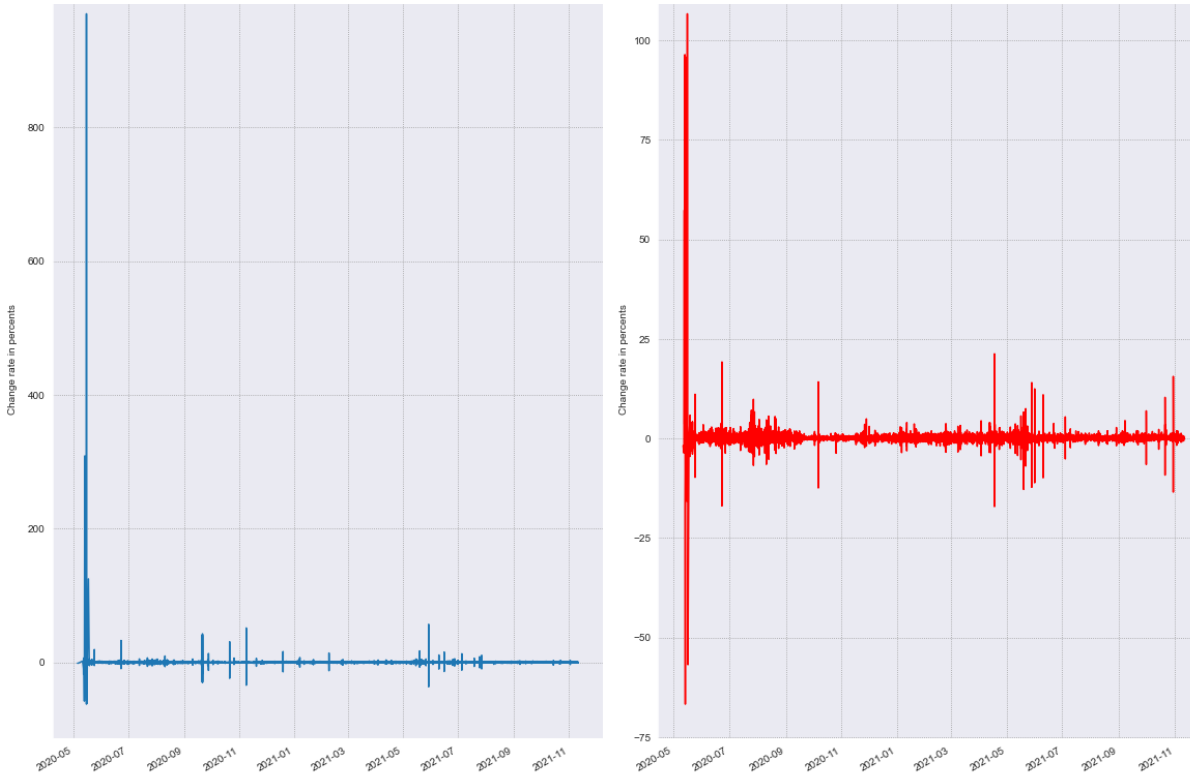
Compared to the WBTC/USDC pool there is only an initialization stage low activity period. Non-presence of possible attacks or deviations is caused by activity of previously mentioned optimization and control algorithms. Another reason for the non-presence of strange transactions similar to the MEV attack is high reserves values, shown in the distributions below.



Picture 16: Reserves distribution in the WETH/USDC pool

The distribution of the pool reserves has relatively higher values compared to the WBTC/USDC distributions. USDC reserves have high values and their distribution is more stable compared to the WBTC/USDC pool, there are higher values through the entire period and transaction frequency is higher, setting a better environment for performing swap operations and

ensuring uninterrupted work of balancing algorithms. Plotting change rates of the price shows how balancing algorithms perform in this case.

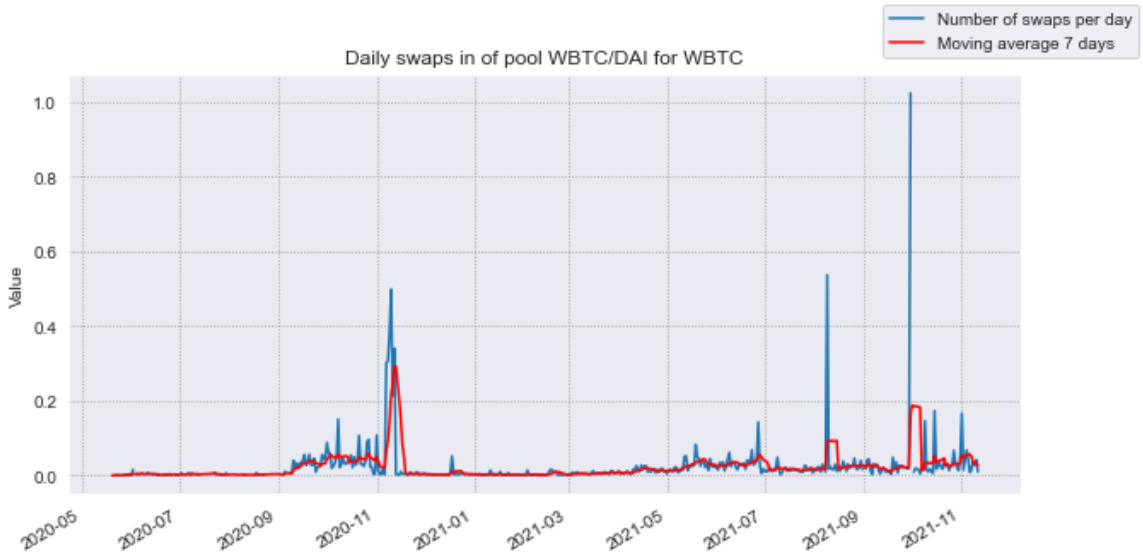


Picture 17: Swap prices change rates distributions, left chart for WETH and right one for USDC

In the beginning of the pool lifecycle there are present high changes in the token price, considering that pool activity is not balanced and there are still present high deviations, considering that users are not limited in their swap operations values by TWAP mechanism and pool reserves at initial stage are low, meaning that sensitivity of the token price is higher to any possible swap activity. It is important to note that presented distributions were filtered from possible error deviations caused by python division results.

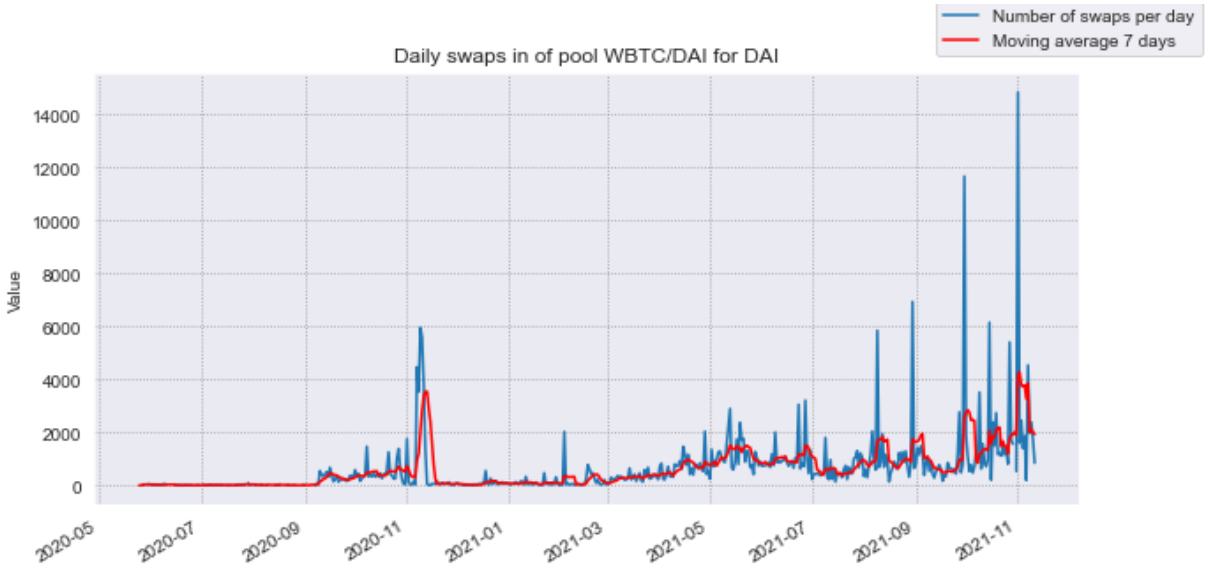
WBTC/DAI

Previously was reviewed behavior of the WBTC/DAI pool, containing USDC stablecoin. To show how different behavior can be in two different pools can be used a pool whereas stablecoin is used DAI token.



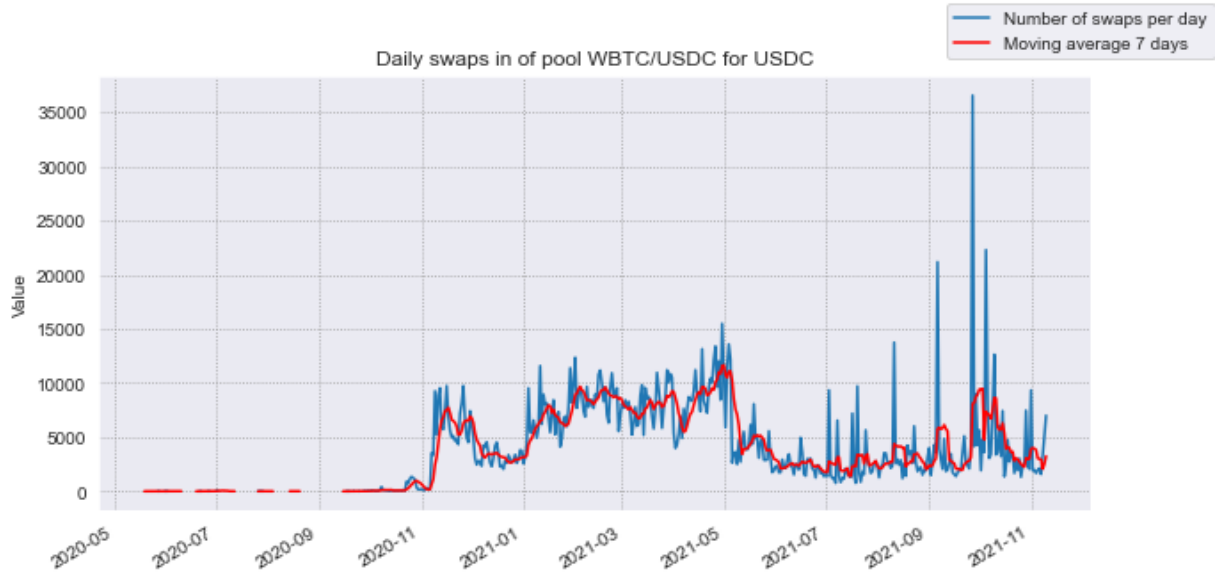
Picture 18: Swaps distribution in the WBTC/DAI pool for WBTC

The distribution of the swaps inside WBTC/DAI pool has a low activity even considering the price of WBTC. Daily values are not overcoming barriers of the 0.1 WBTC, meaning that daily swaps are not overcoming the 4-6 thousands of USD dollars, while WBTC/USDC pool had values overcoming 0.1 barrier and multiple cases of overcoming even 0.2 WBTC (and many cases of higher values). Current distribution has only two small periods of higher activity, reaching to the 0.2-0.4 WBTC during September-December 2020 and August-October 2021, corresponding to BitCoin price rise during respective periods.



Picture 19: Swaps distribution in the WBTC/DAI pool for DAI

DAI distribution of the daily swaps is not representing high activity of the pool. There are small rises happening during the rise of the BitCoin token price on the market, but the highest activity periods are not reaching medium activity values from the WBTC/USDC pool for USDC swaps.

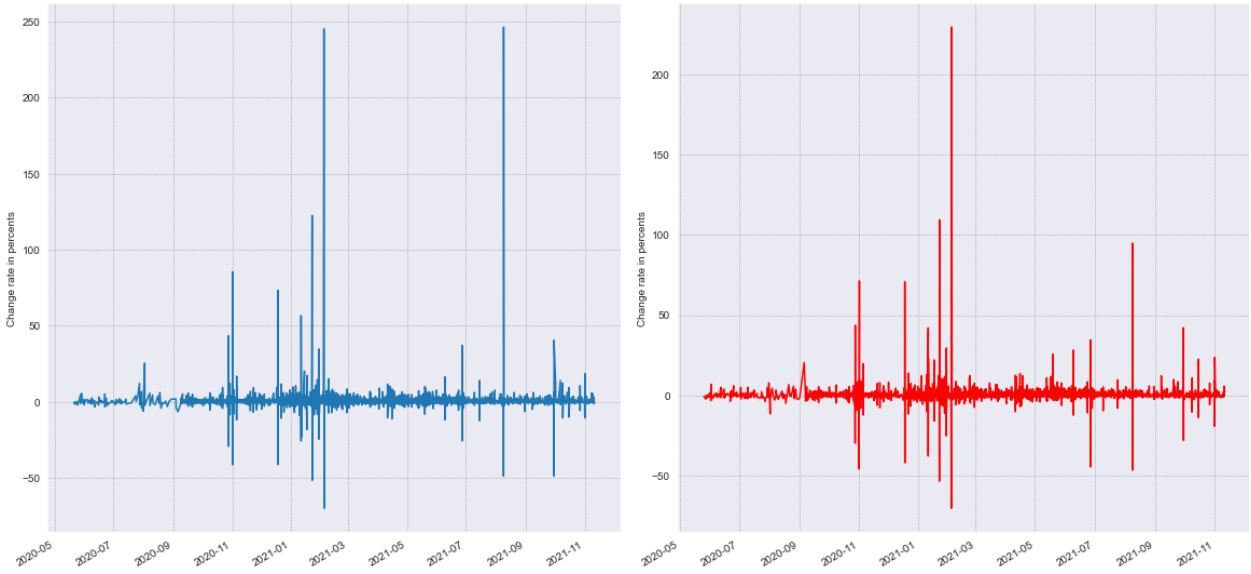


Picture 20: WBTC/USDC swaps distribution for USDC

Comparing these two pools activities can be seen how lower is activity in the WBTC/DAI pool, explaining extreme rises and drops in the swap price distribution.

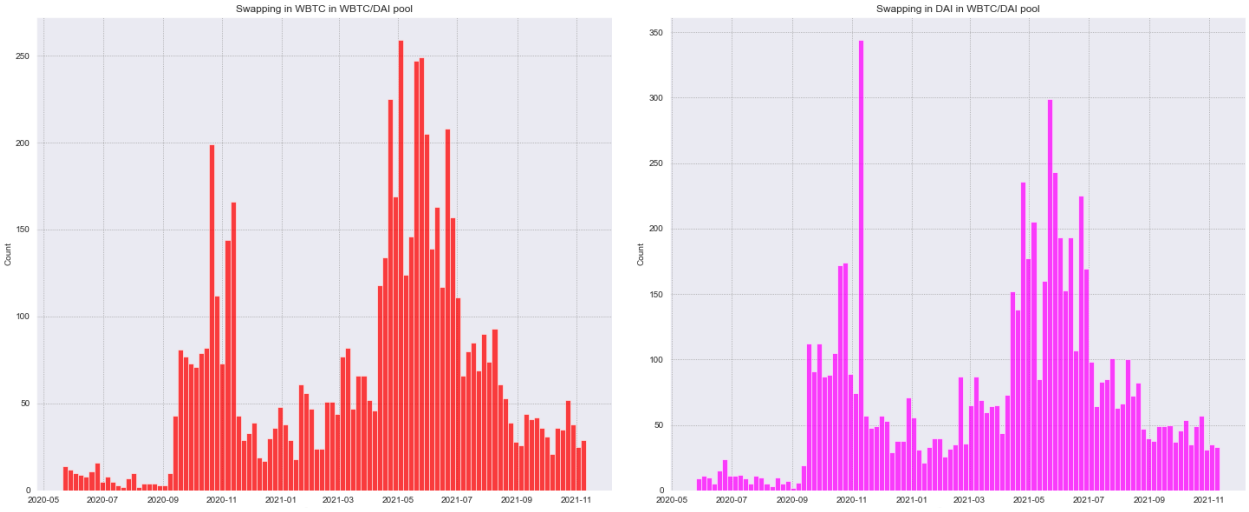
Picture 21: WBTC/DAI swap prices distribution

WBTC swap price distribution and DAI swap price distribution are unstable, having extreme price rises and drops, explainable by small pool activity, reducing deviation during high-activity periods.



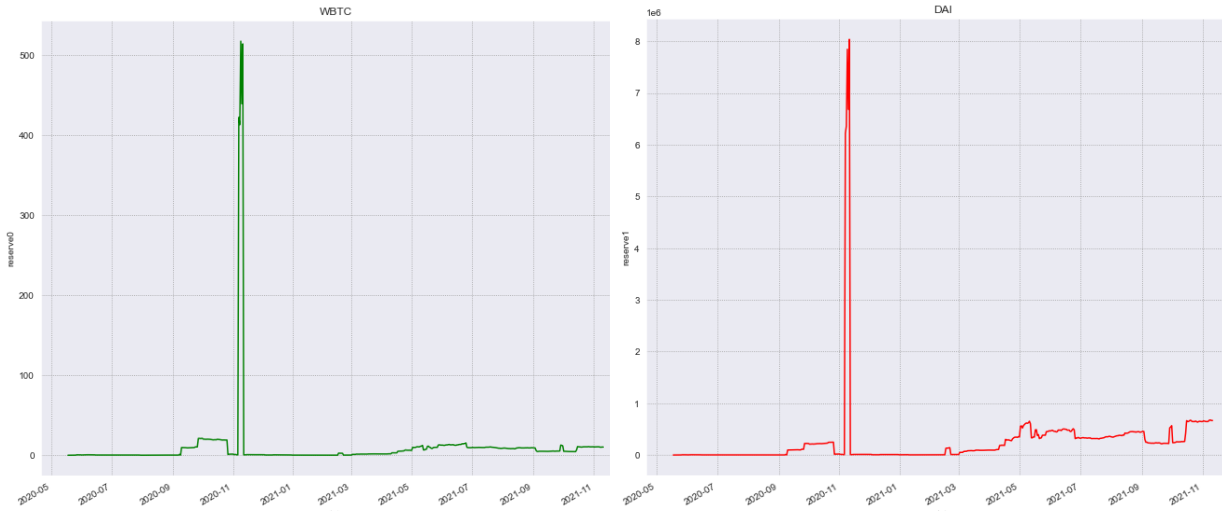
Picture 22: Swap price change rates for WBTC/DAI pool, left chart represents WBTC swap price, right chart represents DAI swap price

Change rates are higher during low activity periods and one more proof of this phenomenon is present in the transaction count distributions.



Picture 23: Swap transaction count for WBTC/DAI pool, left chart represents WBTC, right chart represents DAI

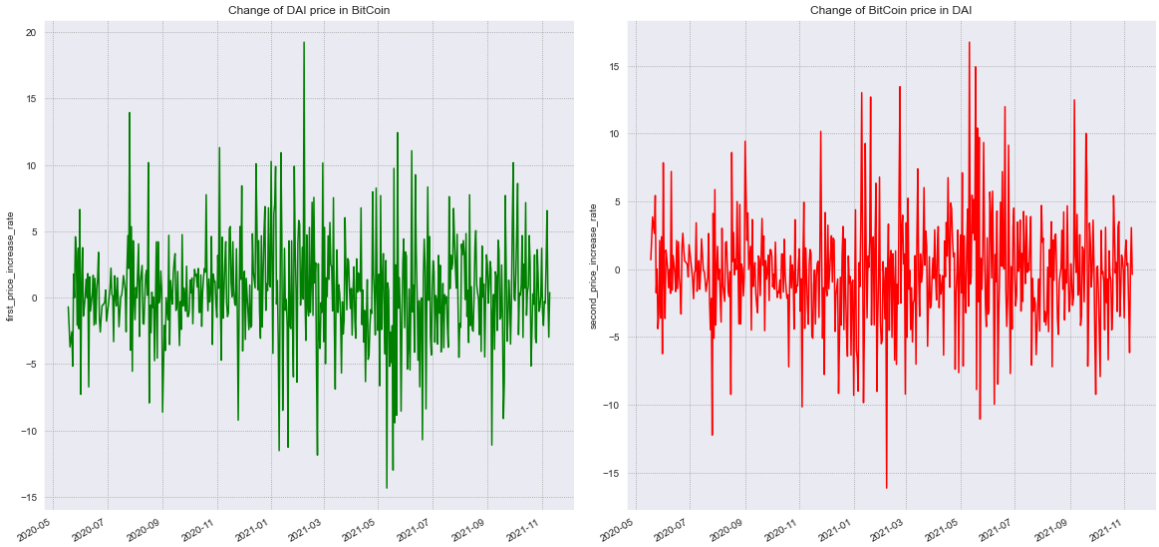
The high activity periods are covering time periods of smallest swap price change rates, meaning that balancing technologies are applied to the pool, while low activity periods are represented with higher swap price change rates.



Picture 24: reserves for WBTC/DAI pool, left chart represents WBTC reserves, right chart represents DAI reserves

Conform presented distribution can be seen as another reason for high change rates during low activity periods - there are smaller pool reserves during those periods, meaning that high change rates are a result of several factors.

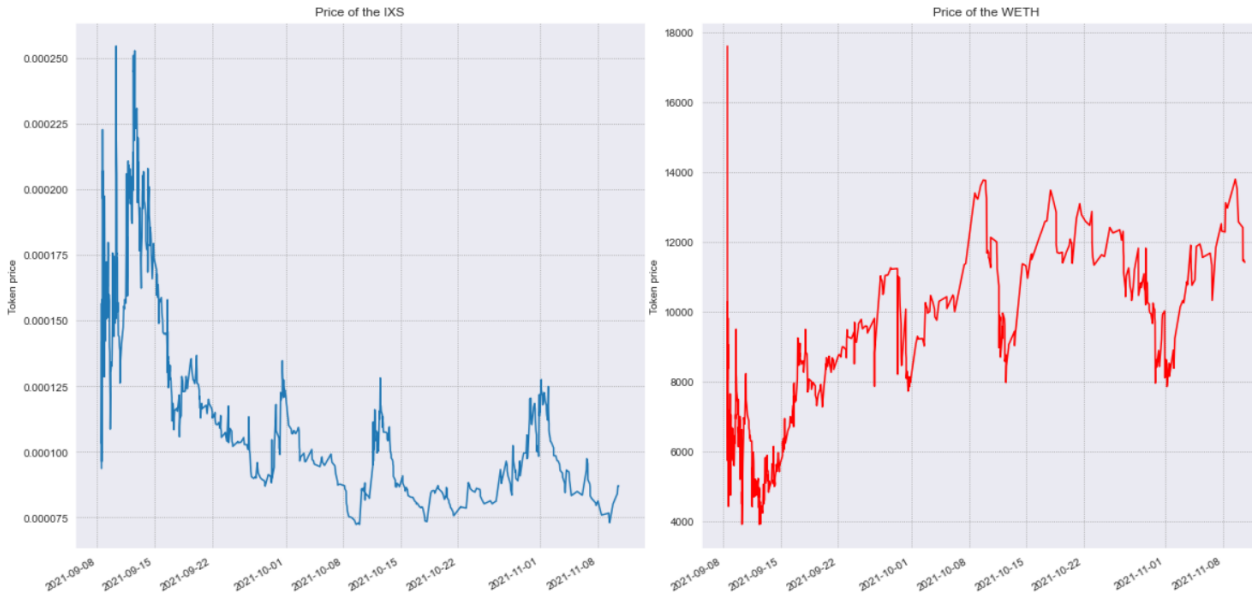
Due to the low reserves, bigger low activity periods and unstable behavior, reserve-based prices in this pool are also unstable.



Picture 25: reserve-based prices for the WBTC/DAI pool, left chart represents the WBTC price distribution, right chart represents the DAI price distribution

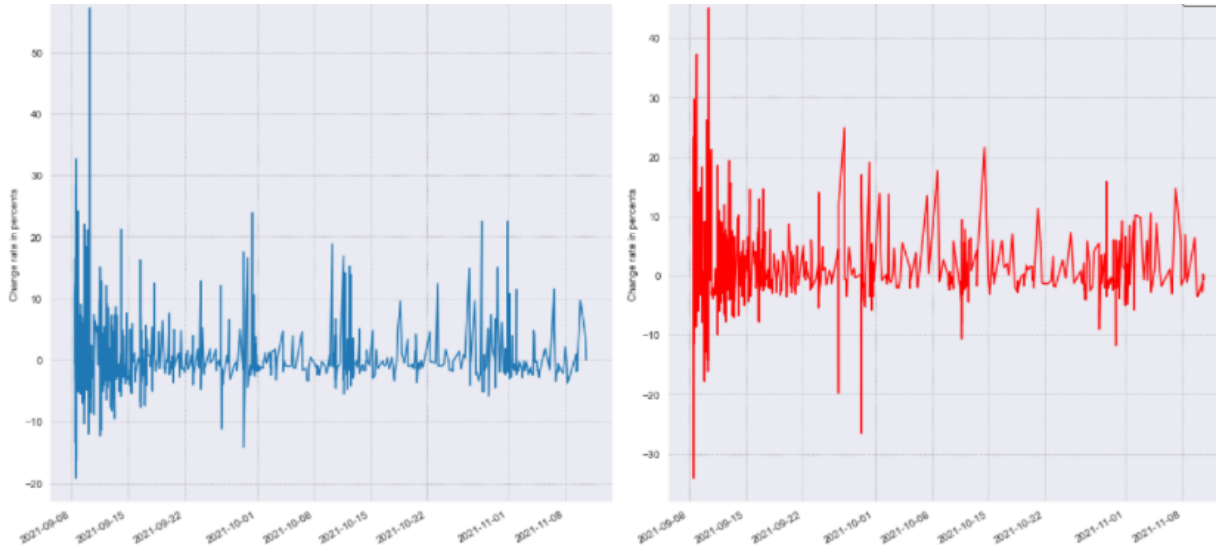
IXS/WETH or how first 2.5 months of token lifecycle look like

For checking the difference between behavior of different altcoins it was decided to pick the IXS/WETH pool.



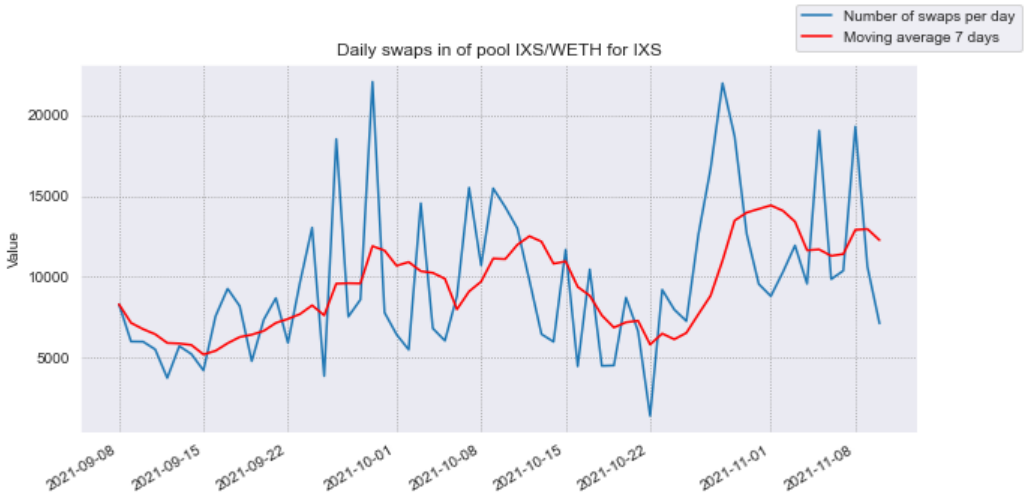
Picture 26: swap prices distributions for IXS/WETH pool

Compared to previously reviewed pools, swap price distributions have a better picture with relatively smaller price deviations, having only bigger changes in the beginning of the IXS/WETH pool lifecycle, but price distribution is still unstable.



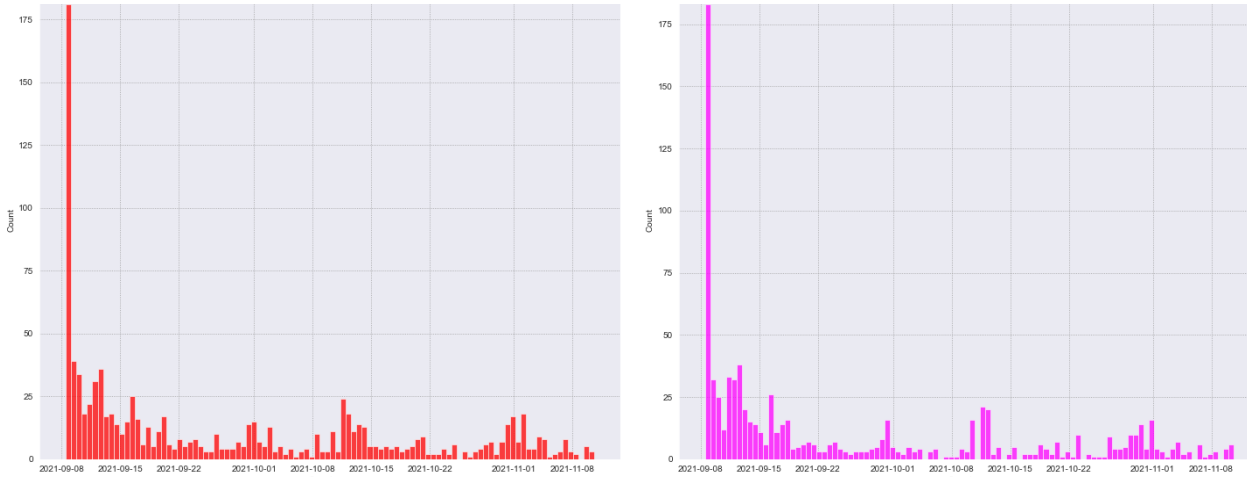
Picture 27: swap price change rates distributions for IXS/WETH pool, left chart represents IXS swap price change rates, right one represents WETH swap price change rates

Conform presented distributions of the swap price change rates beginning of the pool lifecycle is a high-deviation period with big changes in the price. Increase of the transaction frequency decreases those deviations, but to check this moment it is required to check transaction frequency and pool size for the current pool.



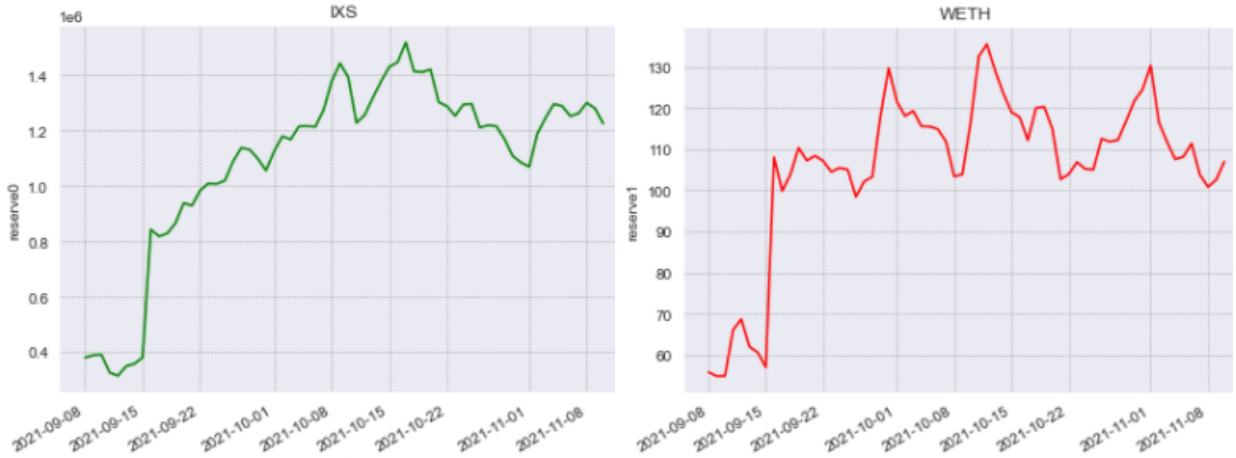
Picture 28: swaps distribution in IXS/WETH pool for IXS

Transaction activity is relatively low. To ensure it, below is the transaction frequency distribution.



Picture 29: swaps transaction count distributions for IXS/WETH pool, left chart represents the IXS swap transaction count, right one represents the WETH swap transaction count

The distribution of the transactions count shows current low activity in the pool, but frequency is relatively stable. This stable transaction frequency causes more stable behavior, but distribution still requires stabilization.

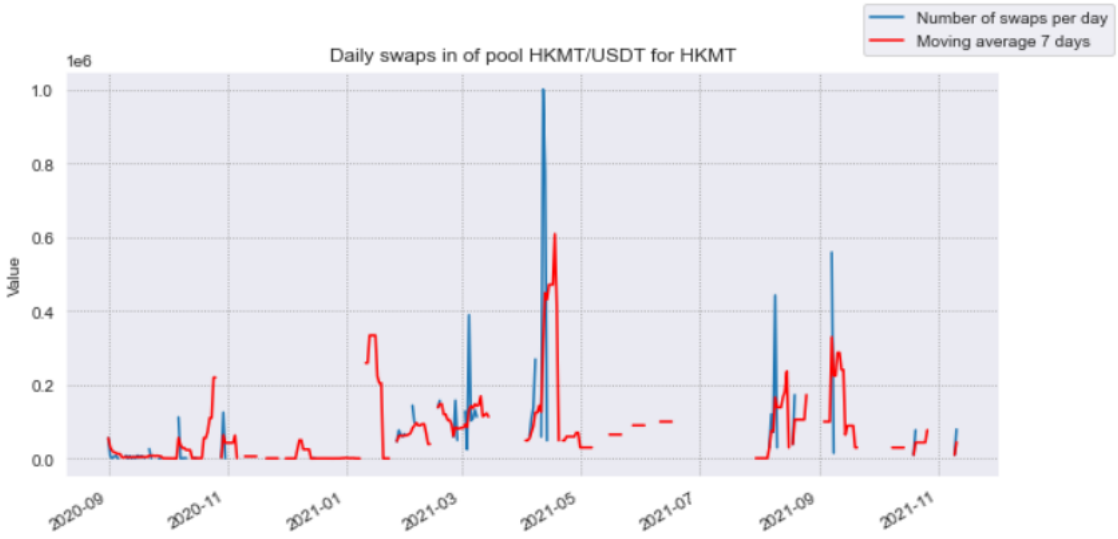


Picture 30: reserves for the IXS/WETH pool, left chart represents the IXS reserves, right one represents the WETH reserves

Another big reason that caused swap price stabilization is the increase of pool reserves, making the pool more stable. Variance increases are matching the moments of the reserves drops.

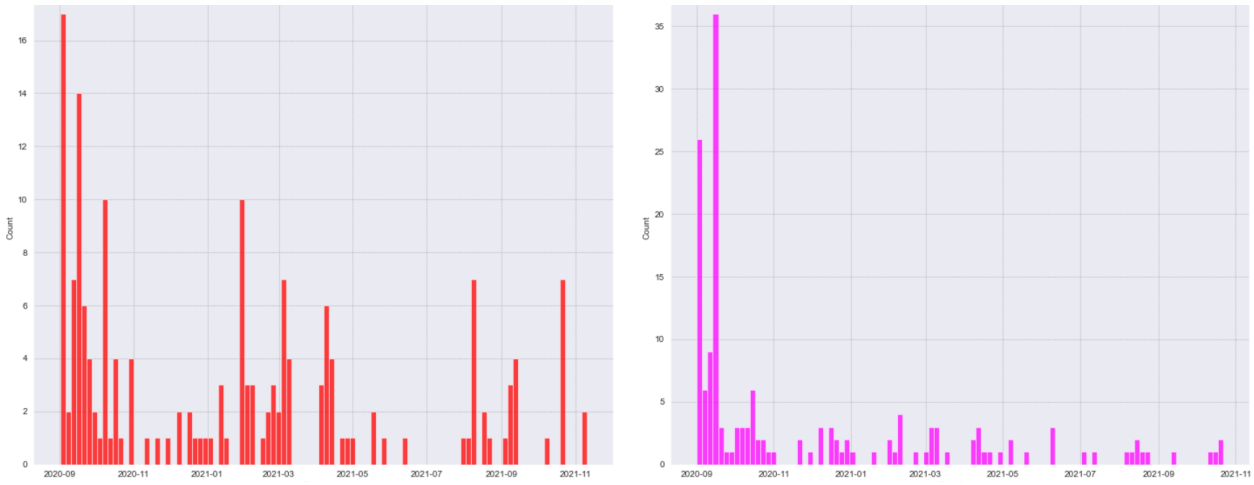
HKMT/USDT or case of low transaction frequency with giant reserves

Next pool chosen for the analysis was the HKMT/USDT pool. This is an interesting example of a low activity stable pool that had no extreme rises and drops.



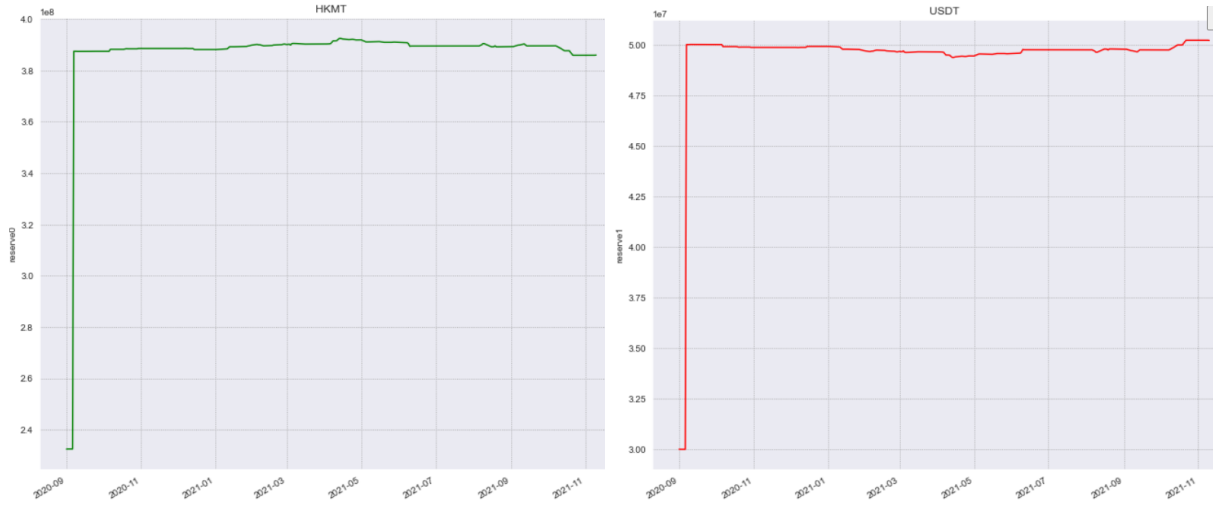
Picture 31: Swaps operations activity in the HKMT/USDT pool for HKMT

Conform presented chart, there are multiple time gaps in the swaps activity. This demonstrates a regular low activity in the pool. To ensure that, below is present the transaction count distribution.



Picture 32: Swap transactions count for HKMT/USDT pool, left chart shows the HKMT swaps, right chart shows the USDT swaps

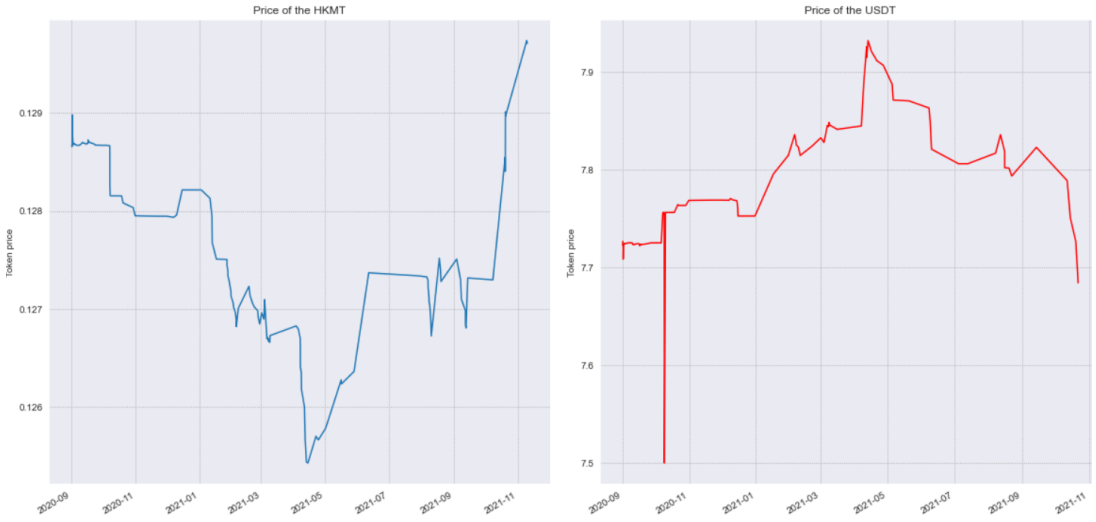
Transaction count distribution demonstrates small transaction frequency. Current pool can become an efficient target for the MEV attack from this perspective, but it is necessary to check pool behavior from the pool reserves perspective.



Picture 33: Reserves of the HKMT/USDT pool, left chart represents the HKMT reserves, right chart represents the USDT reserves

Reserves distribution lowers ability of performing efficient MEV attack, due to the high reserves values and their stable distribution, keeping almost the same through the entire 1-year

period. In order to check if such an attack can happen or if there are unstable periods it is required to analyze swap price distribution and its change rate.



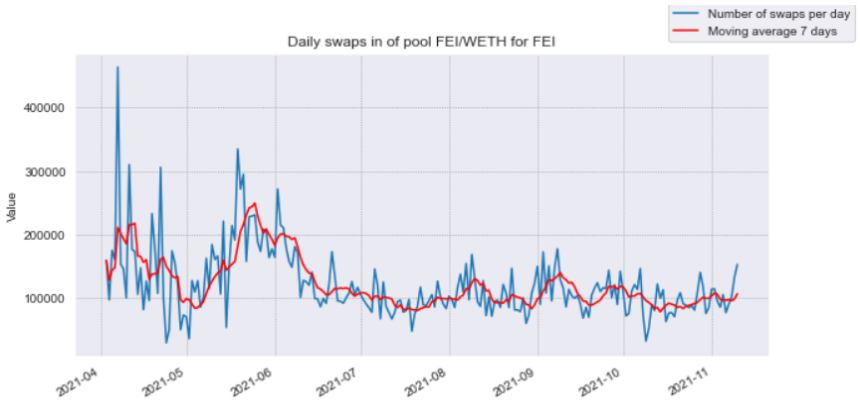
Picture 34: Swap price distribution of the HKMT/USDT pool

Conform price distribution can be seen that rises and drops are relatively small and there are not big rises/drops present in the distribution. This is an interesting case considering pool properties and low transaction frequency.

Taking into account the stable distribution of the reserves available in the pool, swap prices distributions have negative dependencies.

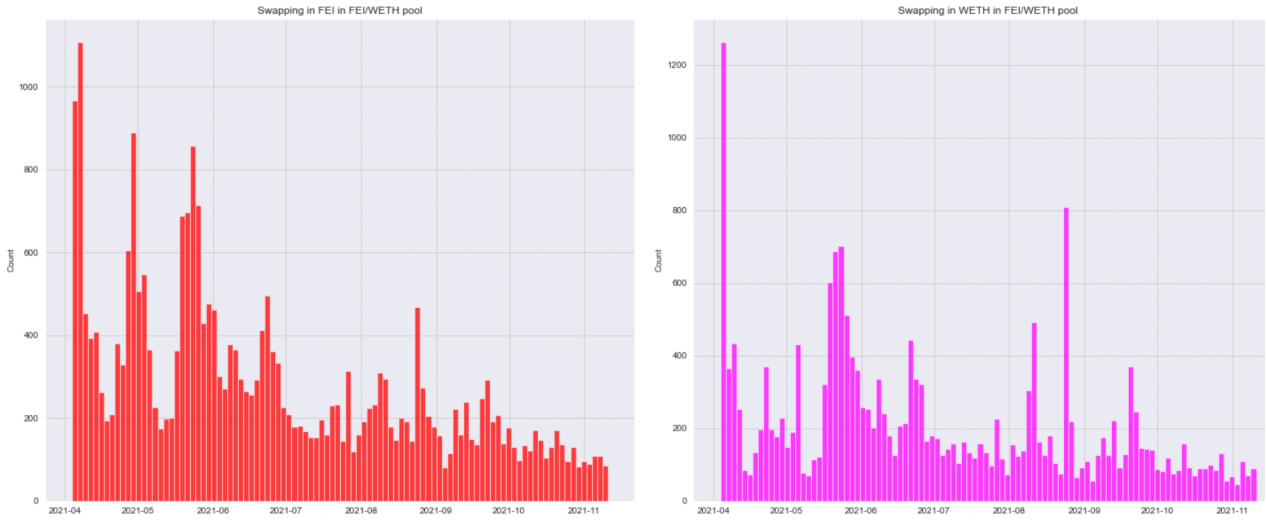
FEI/WETH

Another pool that will be used to compare its behavior relative to Ethereum is the FEI/ETH pool. FEI is a stablecoin, meaning that its distributions should have the same pattern as ETH/USDC pool, where Ethereum stablecoin was also attached to another stablecoin.



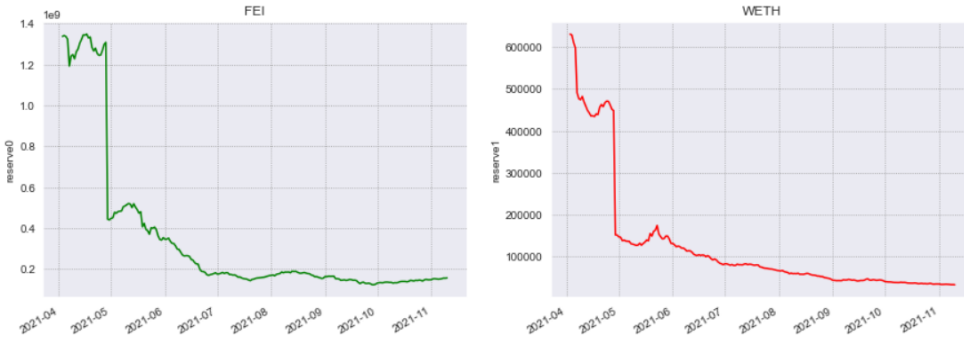
Picture 35: FEI/ETH swap transaction activity for the FEI

Swap transactions activity is higher compared to the ETH/USDC pool. Transaction values per day are higher, meaning higher transaction frequency and bigger token values used in transaction history.



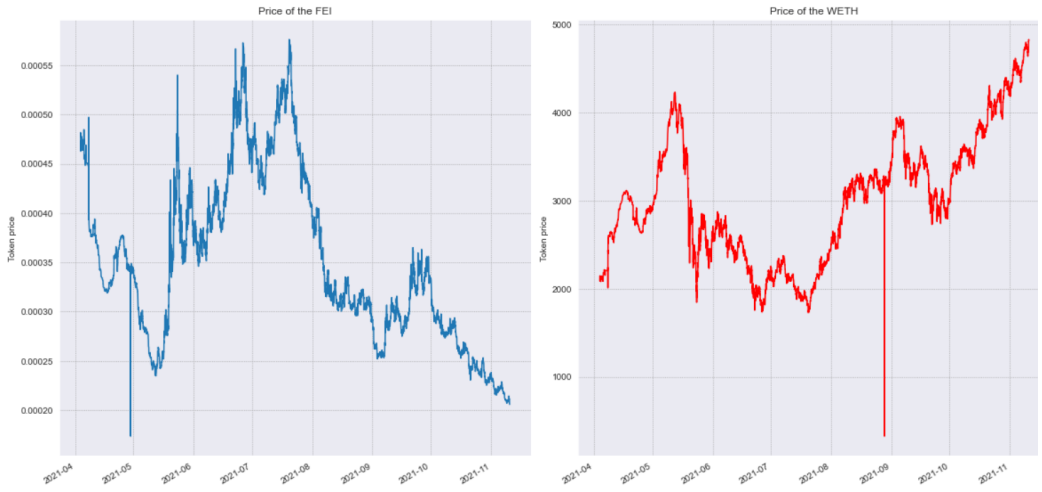
Picture 36: swap transaction count distribution for FEI/ETH pool

Transaction count demonstrates high transaction frequency and that there are anomalous periods of the transaction frequency rises, when transaction count rises in two, or more times. Considering pool activity it is unlikely that someone will be able to perform a MEV attack and to ensure that it is required to check pool reserves.



Picture 37: reserves distribution for the FEI/ETH pool

Distributions demonstrate that the current situation of the pool is less attractive than before: amount of available resources has greatly decreased during the end of April-start of May 2021, and distributions were slowly decreasing till August 2021, when distributions stabilized. Even considering the negative trend in reserves distributions, reserves are high enough to protect the pool from possible MEV attack. Still, if the negative trend continues, reserves could reach such small values that it would raise the danger of performing the MEV attack.



Picture 38: swap prices distribution for FEI/ETH pool

The swap prices distribution has normal deviations and overall distribution looks stable enough. The extreme drop present in the Ethereum price was caused by a strange drop of the price in the transaction presented below.

	token_in	token_out	amount_in	amount_out	amount_usd	timestamp	first_to_second_price	price_change_rate
39686	WETH	FEI	0.001	3.248770	3.243474	2021-08-28 09:16:41	3248.770000	0.216102
39687	WETH	FEI	0.001	3.248774	3.243331	2021-08-28 09:16:56	3248.773553	0.000109
39688	WETH	FEI	0.001	0.324877	3.243483	2021-08-28 09:21:48	324.877000	-90.000011

Picture 39: small transaction history fragment, covering a strange operation discovered in the pool

This operation is strange, because no mint/burn operation, no MEV-similar transactions were found close to this time period. Looking closer into the price can see that the amount_out value was shifted by one digit to the right (or like divided by 10). This can be an error present in the Uniswap history. This error creates “noise” in the real price history.

	token_in	token_out	amount_in	amount_out	amount_usd	timestamp	first_to_second_price	price_change_rate
39685	FEI	WETH	1985.876412	0.607615	1967.602022	2021-08-28 08:51:02	0.000306	-0.021607
39686	WETH	FEI	0.001000	3.248770	3.243474	2021-08-28 09:16:41	3248.770000	0.216102
39687	WETH	FEI	0.001000	3.248774	3.243331	2021-08-28 09:16:56	3248.773553	0.000109
39688	WETH	FEI	0.001000	0.324877	3.243483	2021-08-28 09:21:48	324.877000	-90.000011
39689	FEI	WETH	675.085714	0.206551	670.307283	2021-08-28 09:34:22	0.000306	-0.001645
39690	FEI	WETH	55447.930505	16.959115	55008.932388	2021-08-28 09:37:41	0.000306	-0.034819
39691	FEI	WETH	41410.764742	12.658133	41057.913311	2021-08-28 10:14:43	0.000306	-0.060177
39692	FEI	WETH	63307.251626	19.338709	62739.037399	2021-08-28 10:15:51	0.000305	-0.065000
39693	FEI	WETH	51356.475263	15.676892	50855.477426	2021-08-28 10:16:25	0.000305	-0.071184
39694	WETH	FEI	1.550000	5048.731674	5027.088786	2021-08-28 10:52:39	3257.246241	902.609062
39695	FEI	WETH	35508.129978	10.833920	35096.951096	2021-08-28 11:18:48	0.000305	-0.047638
39696	WETH	FEI	100.000000	325199.345732	323666.025517	2021-08-28 11:42:09	3251.993457	-0.161265

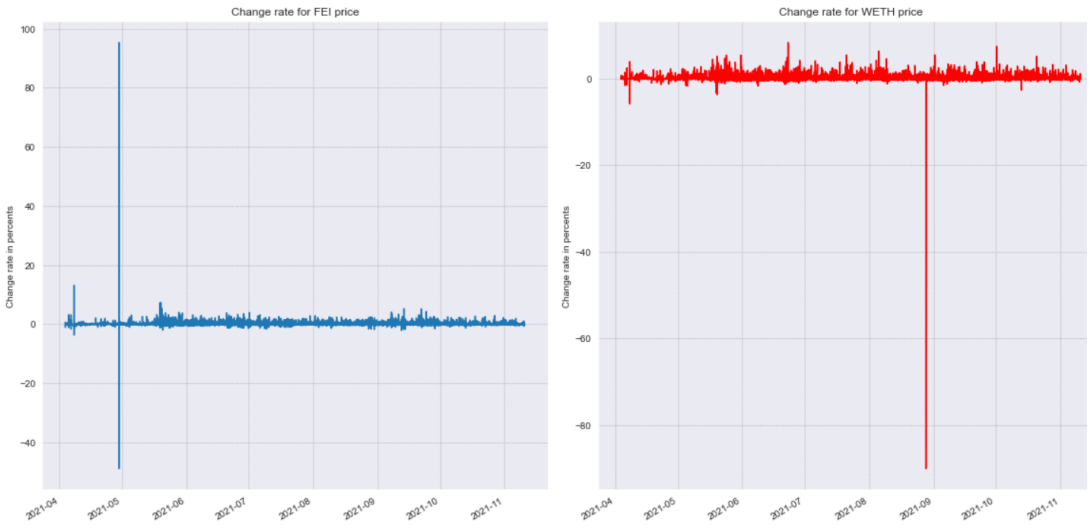
Picture 40: small transaction history fragment, covering a strange operation discovered in the pool and its influence over the transaction history

Conform presented transactions there are no MEV-like operations, but transaction history is now “noised” by this operation. To ensure that swap price has a similar distribution with the real price on the market below is presented a reserve-based price distribution.

As can be seen on the chart below, reserve-based price distribution is almost identical to the swap-based price distribution and similar to the real-market price evolution. Pool distributions converge and adapt to match a real-market situation.

Picture 41: reserve-based price distribution for the FEI/ETH pool

Price deviation from the percentages perspective demonstrates stable price distribution with some ‘error’ moments that were caused either by bugs in the system or by drops/rises caused by reserves changes. Some extreme rises and drops were also removed from the distribution (division errors and so on).

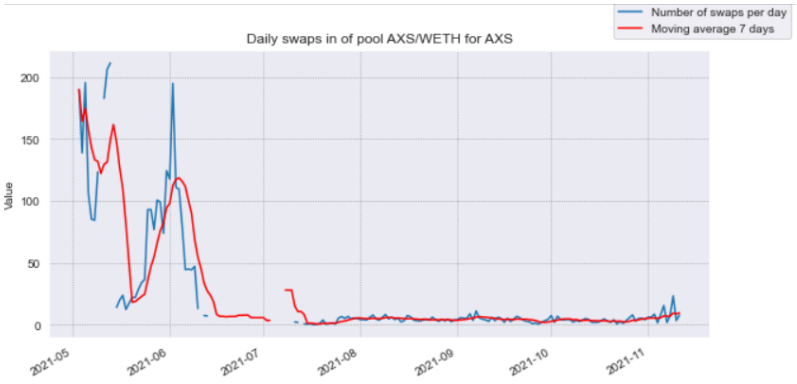


Picture 42: swap-based price change rates distributions for the FEI/ETH pool

AXS/WETH (NFT) or a bad case of unstable behavior of game token

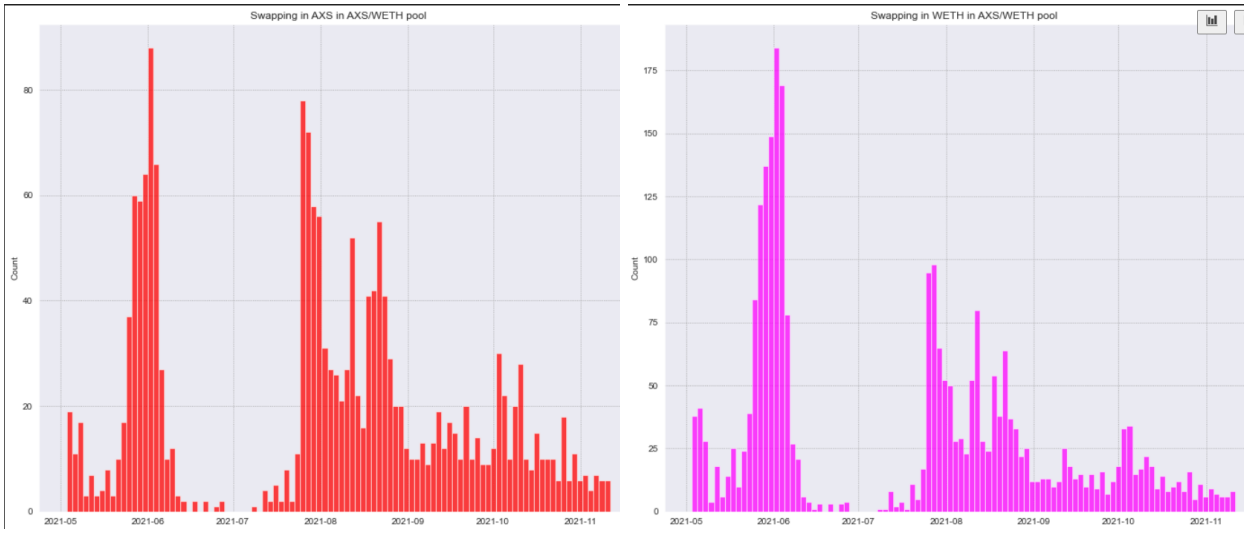
AXS token is an NFT token used in the Axie Infinity online game, where users (or players) need to purchase some creatures called “Axies” or to raise them, battle each other or to sell them. Axie Infinity inner economy is based on using NFT-based AXS (Axie Infinity Shards) or SLP (Smooth Love Potion). This game contains one of the most expensive NFT collections.

Authors discovered that this token is present on the Uniswap V2 as AXS/ETH pool and it was considered as a good option to check how this pool performed at Uniswap.



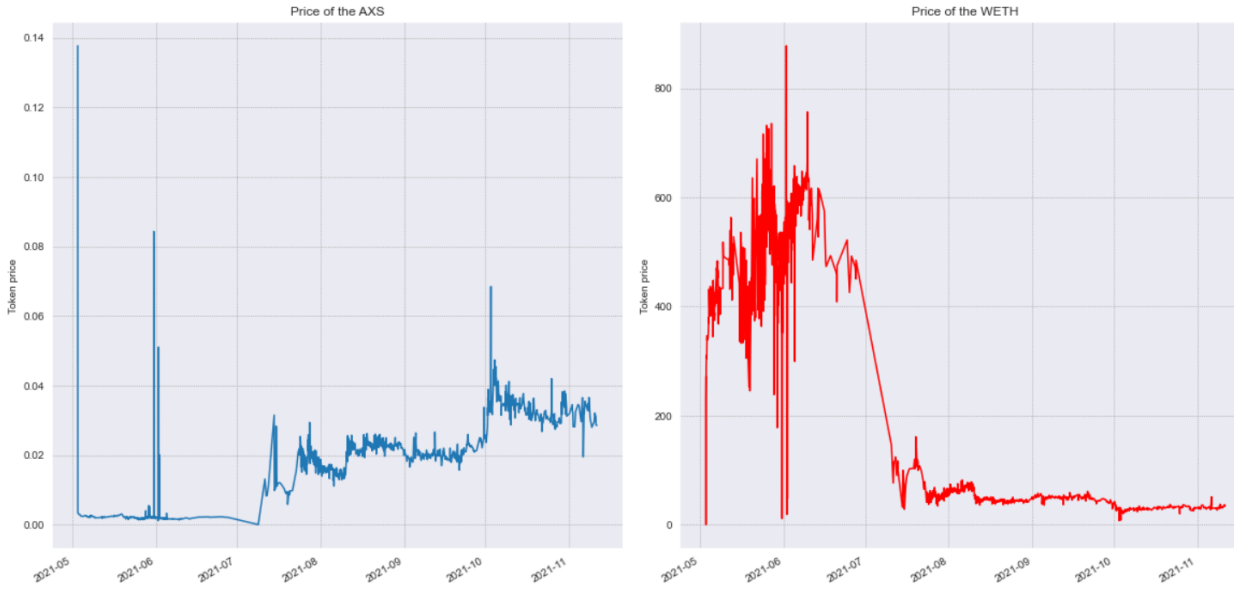
Picture 43: swap operations distribution for the AXS/ETH pool

Swap operations distribution is unstable in the AXS/ETH pool, considering that until August 2021 there were multiple gaps in the data, defining low transaction activity. Below is presented the transaction count distribution for the AXS/ETH pool.



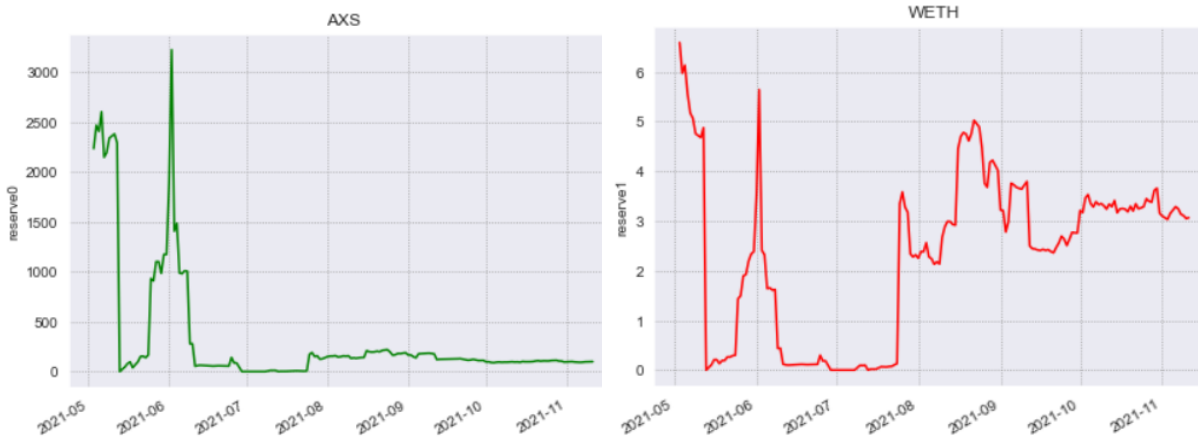
Picture 44: swap operations count distribution for the AXS/ETH pool

Swap operations count distribution show that there is an unstable behavior until August 2021, after which distribution has stabilized and behavior is more stable compared to the start of the pool lifecycle. The interesting moment is that looking at the swap price distribution chart without any changes shows a strange picture of extreme drops and rises in the token price, that can be explained by the reserves removal, which in the current case caused some anomalous changes in the distribution. Removal of those anomalies causes distribution optimization, with the next representation.



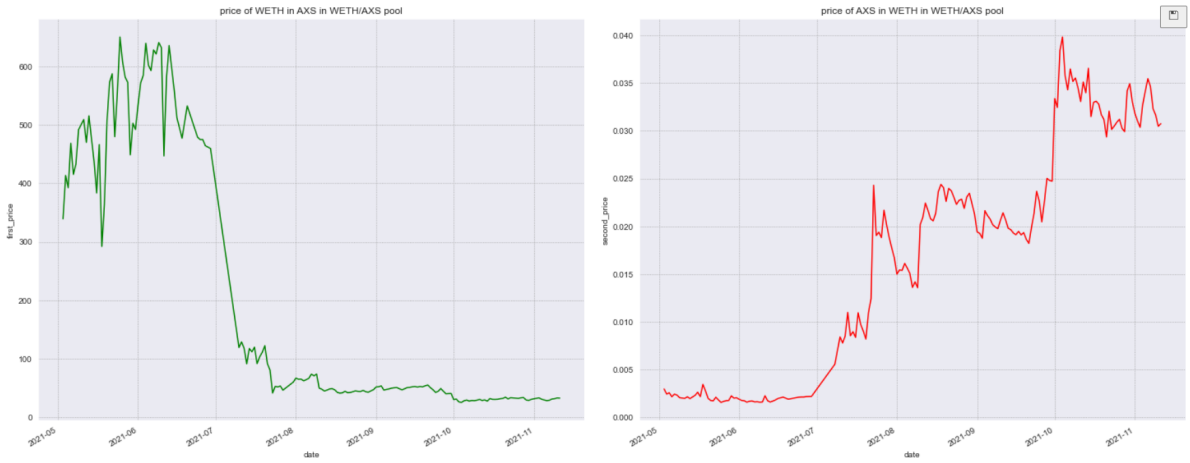
Picture 45: Swap price distributions of the AXS/ETH pool

Distributions show unstable and highly changeable behavior in the pool, which can be explained by the small transaction frequency in the beginning, but another suggestion is that there are big changes in the reserves distribution present during the extreme drops and rises.



Picture 46: AXS/ETH reserves distributions

Reserves distributions demonstrate previously estimated thought about possible extreme pool changes that caused drops and rises in the prices. Conform presented distributions can be seen that tokens balance had extreme drops in time intervals middle May - start of June 2021 and middle June - end of August 2021. Conform presented distributions the situation stabilized starting from August 2021.



Picture 47: reserve-based tokens price distributions in the AXS/ETH pool

Present price distributions form a more clear picture about price evolution through time and it is required to compare this price evolution with the situation on the market.

Picture 48: CoinCodex price distribution for AXS token

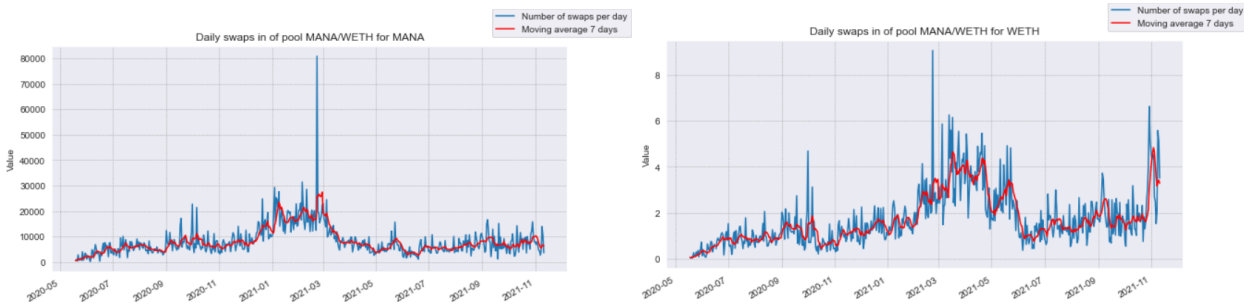
Real-market price distribution shows the same shape, tendency and shapes as the one present in the pool meaning that in this case pool also converges to the real-market price and distribution with possible deviations during pool lifecycle start and some anomalies.

MANA/WETH (NFT) or possible new trend

MANA token is a cryptocurrency used for performing trades inside the Decentraland meta-universe. This token is popular considering the current popularity of the meta-worlds and had a stable price distribution over the time, which can be seen in the chart below.

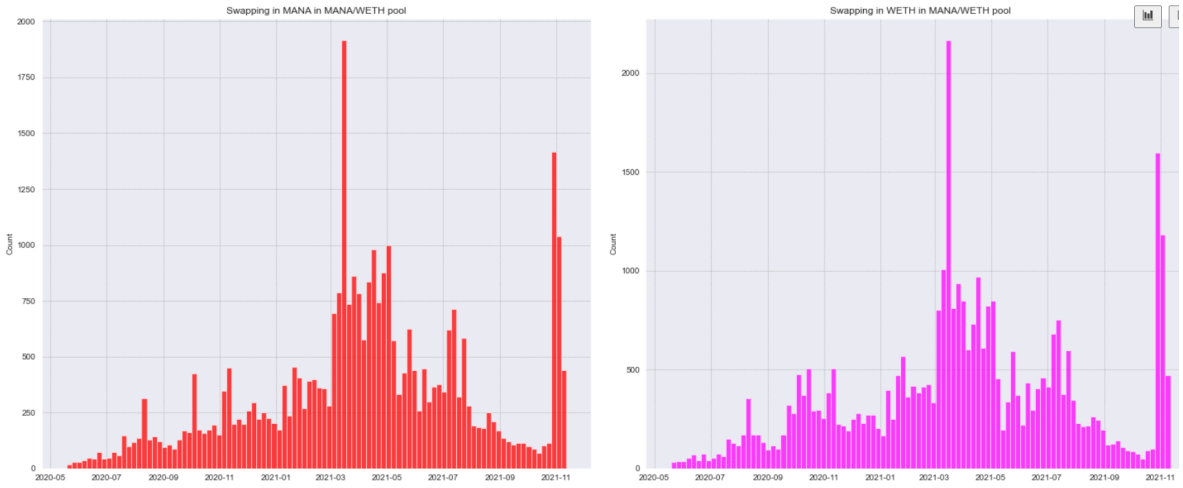
Picture 49: MANA to USD dollar price distribution for the last year taken from CoinBase

After the Meta-universe presentation from Facebook, popularity of the similar projects has greatly increased due to their already present implementations and their activity (in case of Decentraland it originally appeared in 2015 and publicly opened in February 2020). Considering such a great rise in NFT tokens popularity due to their use in such meta-worlds, it would be interesting to analyze behavior of the MANA/ETH pool.



Picture 50: Swap operations distributions in the MANA/ETH pool

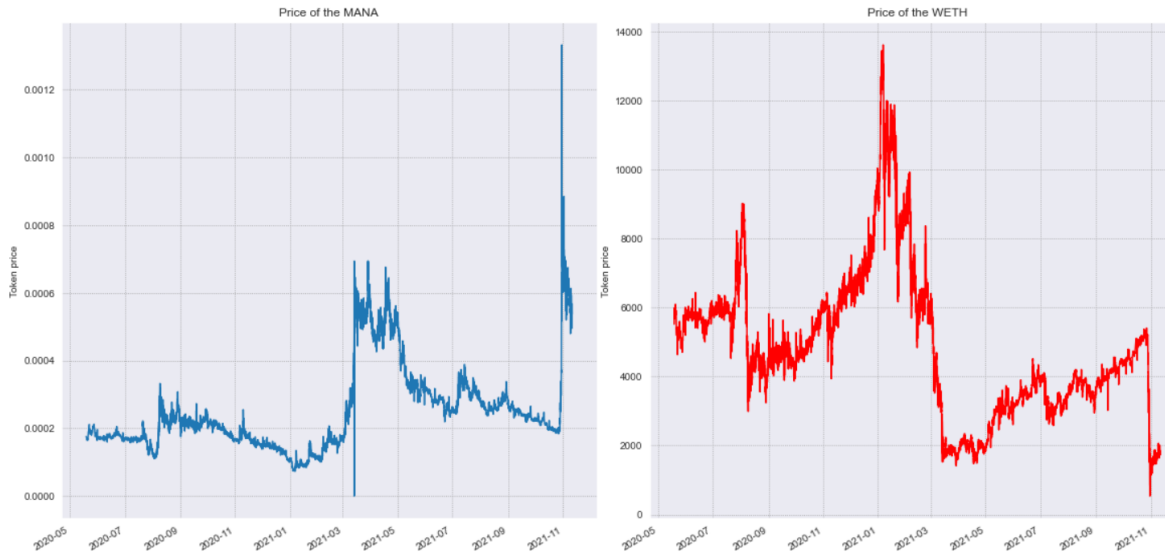
Distribution of swapping operations is stable, contains traceable trends and by the first look balancing algorithms should work properly with this pool, to check it below is reviewed transaction count distribution.



Picture 51: Swap operations count distribution in the MANA/ETH pool

Transaction count distribution forms a picture where transactions have great rises and drops. Here it can be seen that balancing algorithms could have problems in the time intervals of transaction frequency drops.

Swap-based prices shown in the distributions below have high deviations with extreme token price rises and drops. MANA distribution contains one strange price drop to 0 value.



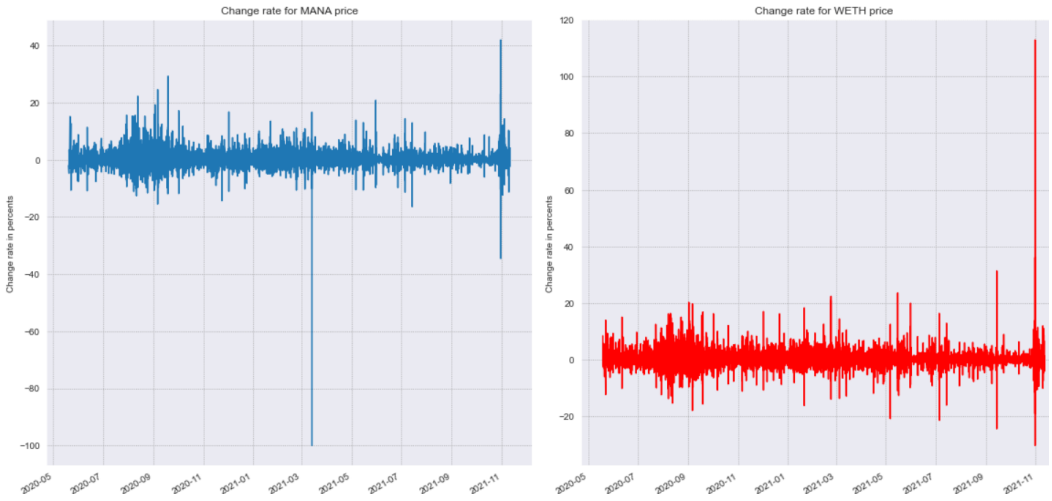
Picture 52: swap-based price distribution for MANA/ETH pool

There are some strange transactions present in the distribution, where token price has fallen to 0 and then there is a rise of token price back to normal, creating disturbances in the distribution and new columns of price and change rate.

27068	MANA	WETH	2000.000000	1.136979	2170.167679	2021-03-13 19:09:10	0.000568	-0.176687
27069	WETH	MANA	5.204430	8965.561539	9933.337789	2021-03-13 19:09:36	1722.678904	0.142927
27070	WETH	MANA	7.623683	13263.677761	14550.800596	2021-03-13 19:09:36	1739.799160	0.993816
27071	MANA	WETH	2716.312984	0.000000	0.000000	2021-03-13 19:10:01	0.000000	-100.000000
27072	MANA	WETH	50000.000000	28.334055	54079.794313	2021-03-13 19:10:20	0.000567	inf
27073	WETH	MANA	25.577208	44965.488679	48802.655818	2021-03-13 19:10:20	1758.029630	1.047849
27074	MANA	WETH	17472.569911	10.000000	19079.221647	2021-03-13 19:10:38	0.000572	0.996074

Picture 53: transaction history, where strange price drops were detected

Such anomalies cause an unstable behavior of the change rate distribution. Strange changes in price will be better seen using the price rate distributions plots.



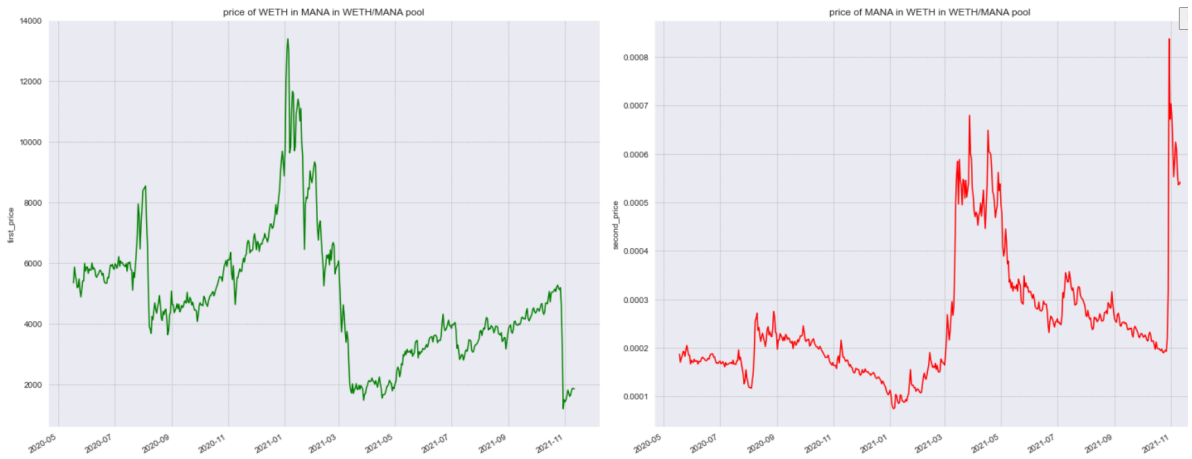
Picture 54: swap-price change rates distributions for MANA/ETH pool

Previously mentioned drop in the price is represented on the swap price change rate for MANA as a drop to -100%. This is the only case of strange behavior for the MANA token, but there is a strange rise in the WETH price close to the end of pool story. This strange rise is explained by the extreme rise of the MANA price several times.

65432	MANA	WETH	15305.398848	14.349235	6.290683e+04	2021-10-31 01:19:14	0.000938	1.059439
65433	MANA	WETH	11828.063868	10.822690	4.744651e+04	2021-10-31 01:19:23	0.000915	-2.402775
65434	WETH	MANA	6.114025	6672.638237	2.680457e+04	2021-10-31 01:19:59	1091.365951	3.404224
65435	WETH	MANA	416.647577	322138.347555	1.826339e+06	2021-10-31 01:20:52	773.167457	-29.155985
65436	MANA	WETH	7133.002242	6.691679	2.933240e+04	2021-10-31 01:20:52	0.000938	2.527687
65437	WETH	MANA	29.120000	15716.287485	1.276450e+05	2021-10-31 01:20:52	539.707675	-30.195242
65438	MANA	WETH	322138.348763	429.238601	1.881530e+06	2021-10-31 01:20:52	0.001332	42.034423
65439	WETH	MANA	36.558669	42008.467382	1.599674e+05	2021-10-31 01:21:50	1149.069929	112.905983
65440	MANA	WETH	51207.000000	44.659091	1.957418e+05	2021-10-31 01:21:50	0.000872	-34.547807
65441	MANA	WETH	12400.864864	11.431987	5.010665e+04	2021-10-31 01:21:50	0.000922	5.703456
65442	WETH	MANA	0.728104	773.773337	3.185725e+03	2021-10-31 01:21:50	1062.724200	-7.514402
65443	WETH	MANA	21.140815	22948.207694	9.249896e+04	2021-10-31 01:21:50	1085.493025	2.142496
65444	MANA	WETH	10504.176570	9.739990	4.261609e+04	2021-10-31 01:22:24	0.000927	0.583501
65445	WETH	MANA	11.338632	12137.112588	4.961075e+04	2021-10-31 01:22:27	1070.421246	-1.388473

Picture 55: drop of Ethereum price relative to MANA token happening due to the MANA token price rise several times

There are no other strange moments in the swap transaction history of both MANA and ETH token distributions in the MANA/ETH pool. To ensure that price distribution in the pool is similar with the real one below is presented reserve-based price distributions.



Picture 56: Reserve-based price distributions in the MANA/ETH pool

Price distribution in the pool looks similar to the real-market one, meaning that pool as in previous cases converges its price distributions to the real ones.

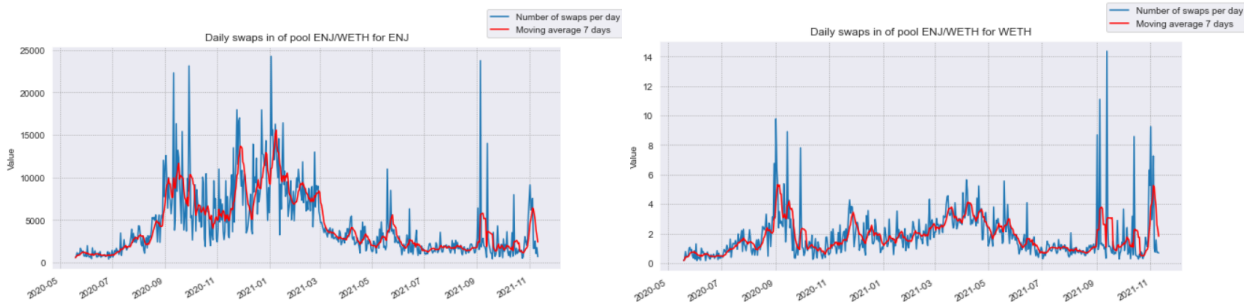
Conform presented information can be seen that pool sometimes has relatively low transaction frequency, meaning that there are options to perform MEV attack and to check that it is required to check pool reserves.

Picture 57: Reserves of the MANA/ETH pool

Present reserves in the pool have a positive trend, meaning that reserves increase through time, increasing pool stability. There are present reserves drops and rises, causing pool destabilization.

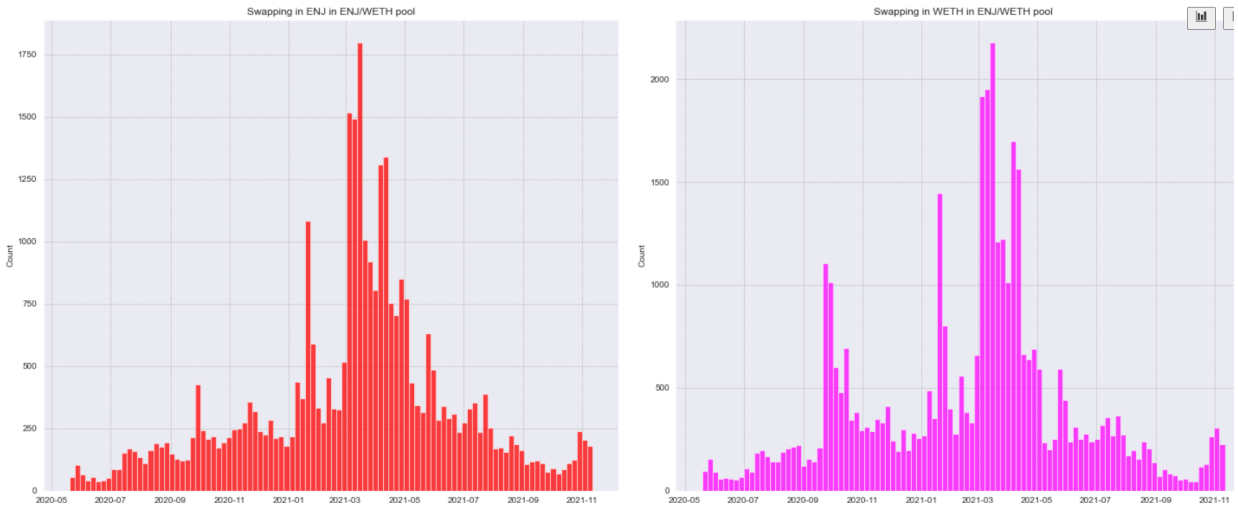
ENJ/WETH (NFT or STO) or how high popularity causes frauders bigger attention

ENJ token is the token used by an Enjin NFT platform that allows users to sell their digital goods on the market getting ENJ tokens for them. After that, those tokens can be exchanged for other tokens. From one perspective this can be considered as NFT token, due to its presence on the NFT platform, its use for selling or getting rights to different digital goods, but from another point of view this can be considered as the STO token, due to its use by a platform/organization on its NFT market. The token was released in June 2018. There was an ENJ/ETH pool present in the Uniswap V2.



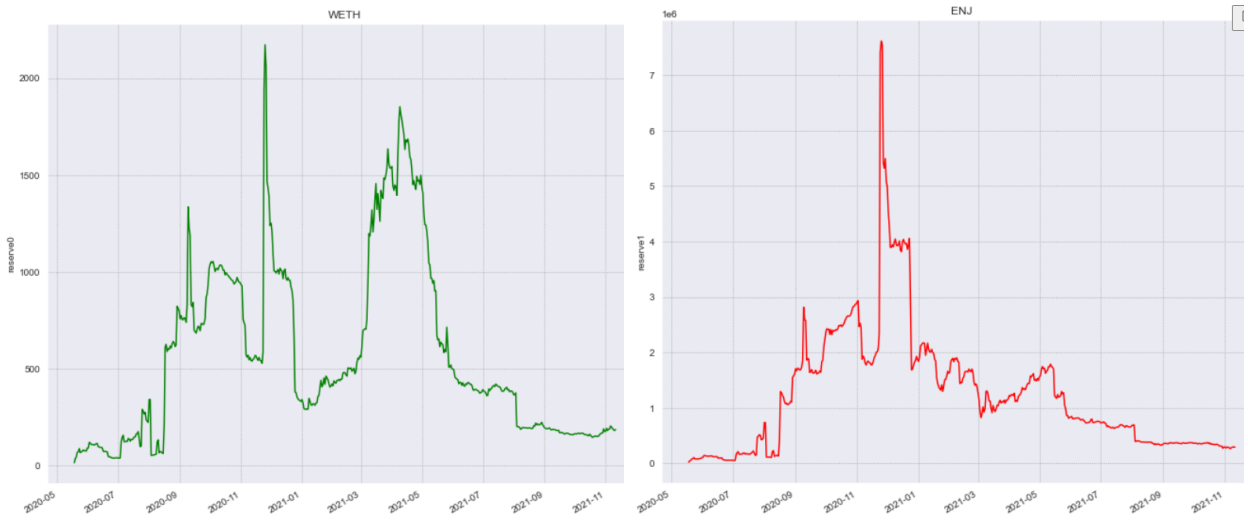
Picture 58: swap operations distribution for ENJ/ETH pool

Conform presented distribution pool had high activity between September 2020 and March 2021. Another small rise was registered between September and November 2021. Other periods have low transaction frequency.



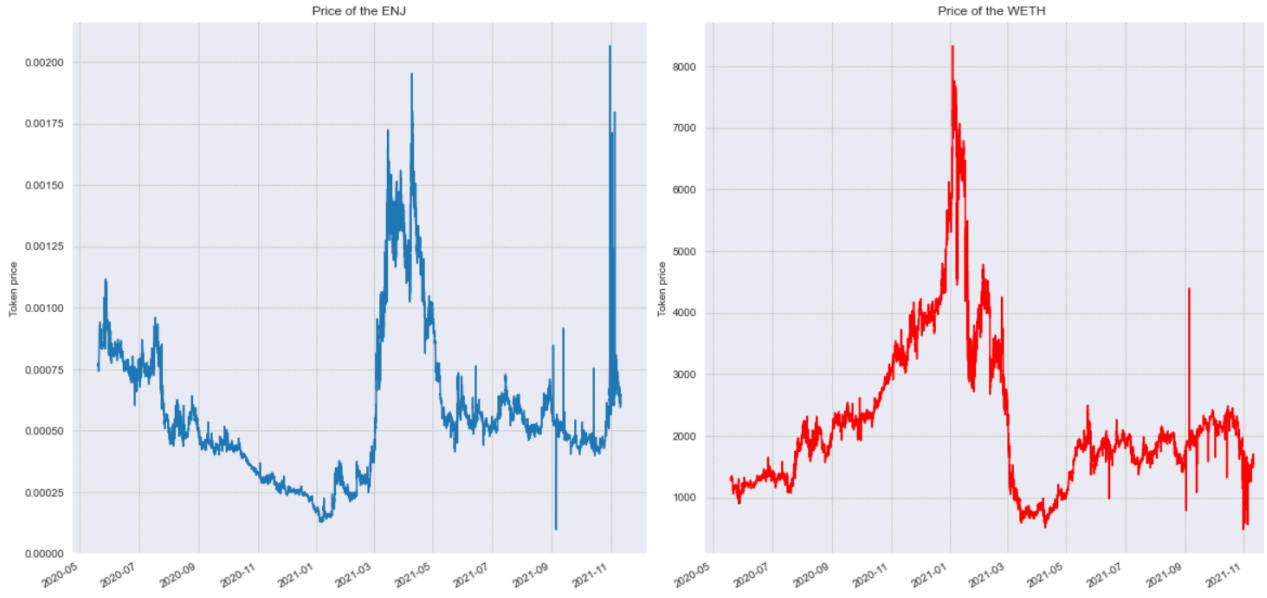
Picture 59: swap operations count distribution for ENJ/ETH pool

Transaction count also has unstable distribution. There is a high transaction frequency between February and May 2021. Considering transaction count, frequency is relatively high enough to consider pool safety from performing MEV attacks. To ensure this moment it is required to review pool reserves and tokens swap price distributions.



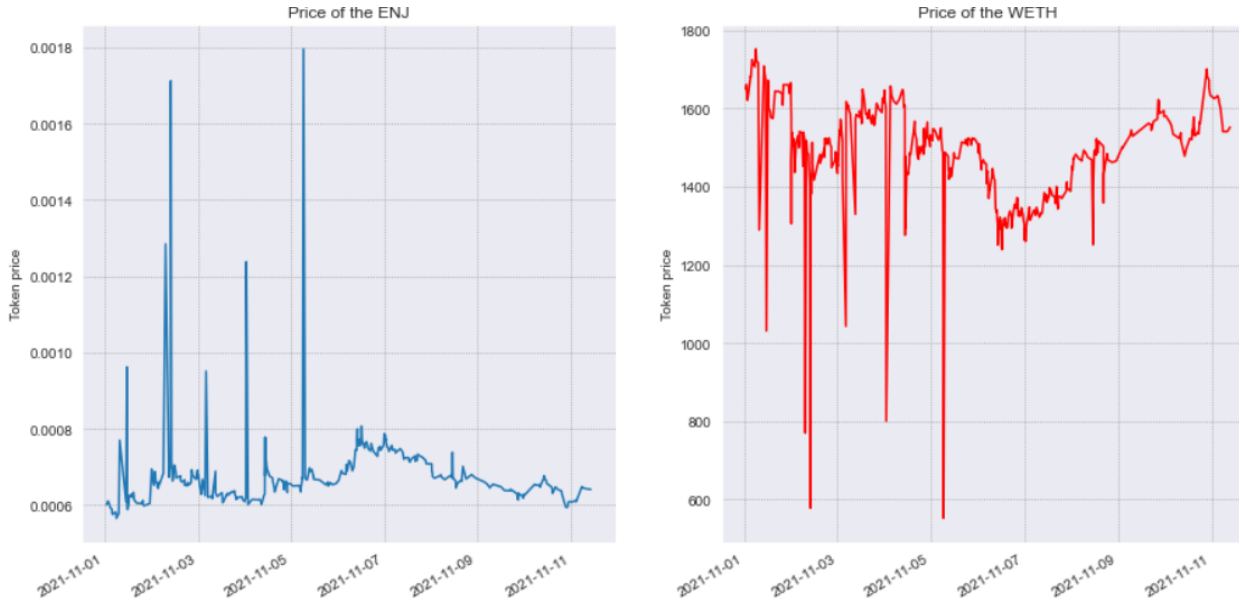
Picture 60: Reserves distribution in the ENJ/ETH pool

Distribution of the reserves has high rises and drops with unstable behavior. Reserves compared to previous pools is relatively low, meaning that currently the pool is unstable and price deviations should increase during last periods of pool history.



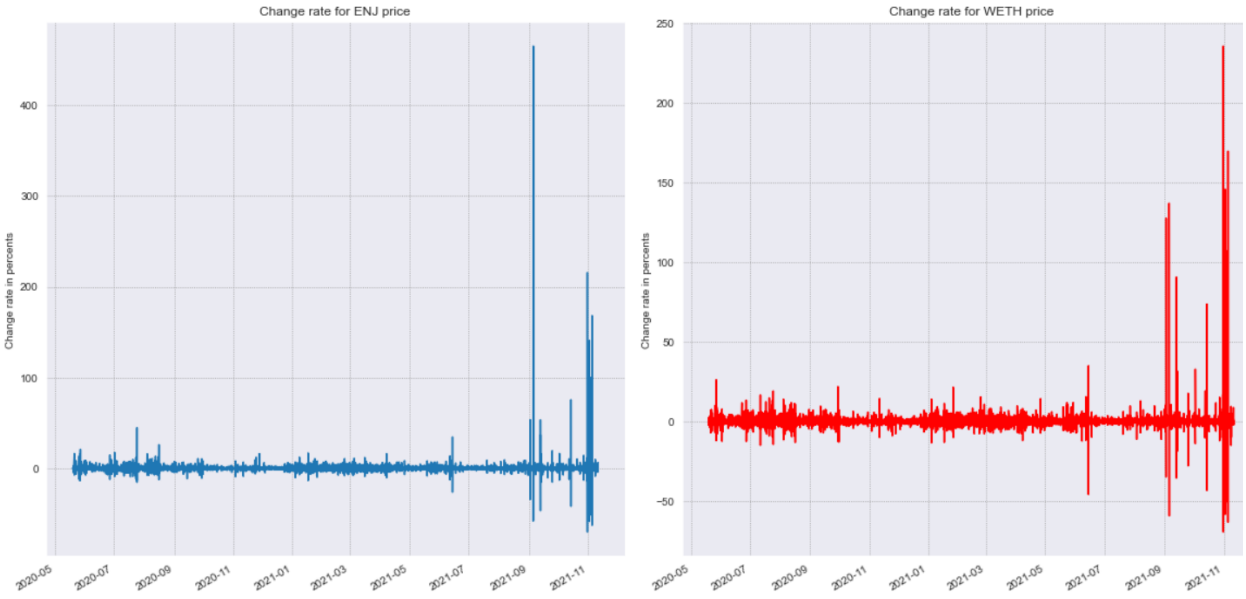
Picture 61: Swap price distribution in the ENJ/ETH pool

Price deviation during the start of the pool lifecycle and in the periods with big reserves available is smaller, compared to last periods, where reserves are much smaller and transaction frequency is smaller. During November 2021 there were high price rises that authors decided to look into.



Picture 62: Swap price distribution for ENJ/ETH pool during November 2021

To understand how strong were the price changes below is presented the price change rate distribution.



Picture 63: swap price change rate distribution for ENJ/ETH pool

There are anomalous increases in the price present in the distribution (rise of ENJ price by more than 400%). Below is a small transaction history fragment around this extreme price rise.

	token_in	token_out	amount_in	amount_out	amount_usd	timestamp	first_to_second_price	price_change_rate
70631	WETH	ENJ	1.552766	2878.020377	6092.616166	2021-09-05 15:09:16	1853.480325	-0.569779
70632	ENJ	WETH	474572.006540	109.616662	430127.429565	2021-09-05 15:09:16	0.000231	-56.410171
70633	WETH	ENJ	109.616662	481516.825905	430115.158190	2021-09-05 15:09:16	4392.733891	136.999219
70634	ENJ	WETH	10000.000000	0.975833	3829.093330	2021-09-05 15:09:16	0.000098	-57.752508
70635	ENJ	WETH	6922.774734	3.814684	14990.139483	2021-09-05 19:17:48	0.000551	464.680682
70636	WETH	ENJ	3.758762	6778.452031	14770.390903	2021-09-05 19:17:48	1803.373549	-58.946442
70637	WETH	ENJ	0.357279	656.105357	1407.173618	2021-09-05 19:39:04	1836.395730	1.831134
70638	WETH	ENJ	1.448645	2635.588884	5703.993978	2021-09-05 19:46:36	1819.347138	-0.928372
70639	ENJ	WETH	409.449076	0.225125	885.536575	2021-09-05 20:13:50	0.000550	-0.219327

Picture 64: transaction history fragment covering anomalous rise of the ENJ token price

Such a price deviation can be explained by the fact that pool reserves are small. Transactions nr. 70632 and nr. 70633 are another MEV attack. This can be seen due to the fact that transactions nr. 70631, 70632, 70633 have the same timestamp like they were executed in one block, price decrease for the 70631 is too big, while the person that performed transactions 70632 and 70633 has a much higher token price (almost 136% higher) leading to getting a profit equal to 14 000 USD dollars (attacker around 7000 ENJ tokens, while their price for 5 September 2021 was around 2 USD dollars). This attack caused strong price deviation that was stabilized only after the next 5-10 transactions.

MEV attack in this case was also performed due to the low pool reserves and low transaction frequency. Another reason why this pool was chosen - both Ethereum and ENJ tokens are popular ones that can be easily exchanged or sold on other platforms.

	token_in	token_out	amount_in	amount_out	amount_usd	timestamp	first_to_second_price	price_change_rate
72781	ENJ	WETH	4223.478413	2.765395	1.193130e+04	2021-10-31 08:09:56	0.000655	-1.918353
72782	WETH	ENJ	0.198250	305.217692	8.492489e+02	2021-10-31 08:44:51	1539.559608	5.799831
72783	WETH	ENJ	0.320000	491.263774	1.370114e+03	2021-10-31 08:55:39	1535.199294	-0.283218
72784	WETH	ENJ	406.412201	193519.686440	1.734995e+06	2021-10-31 09:23:04	476.166035	-68.983438
72785	ENJ	WETH	197625.424650	408.295164	1.743033e+06	2021-10-31 09:23:04	0.002066	215.532801
72786	ENJ	WETH	3782.493673	2.361826	1.006688e+04	2021-10-31 09:43:28	0.000624	-69.776951
72787	WETH	ENJ	1.741229	2781.632271	7.424980e+03	2021-10-31 09:45:57	1597.510990	235.494528
72788	WETH	ENJ	0.898985	1415.216577	3.830516e+03	2021-10-31 09:52:26	1574.237437	-1.456863
72789	WETH	ENJ	0.247812	387.649542	1.055465e+03	2021-10-31 09:53:16	1564.285667	-0.632164

Picture 65: transaction history fragment covering anomalous rises ENJ price and WETH price in ENJ/ETH pool

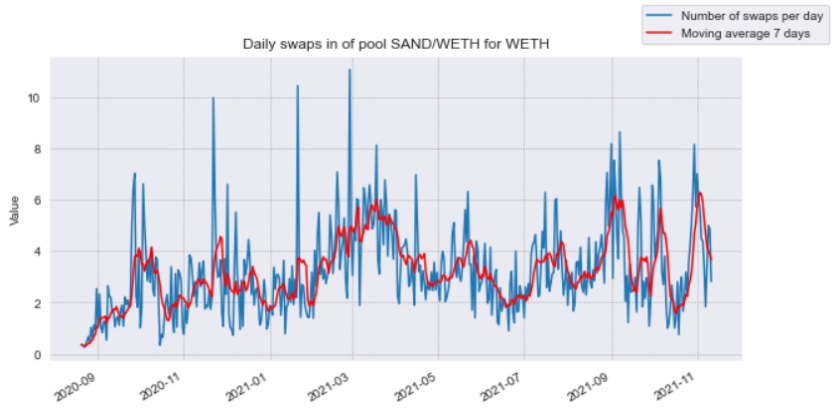
The presented transaction period is showing how small reserves allow big price deviations even from small transaction values. It is dangerous to perform swap operations in such pools considering that without setting a slippage factor a person is able to lose a lot of tokens due to change in token price.

Picture 66: reserves-based price distribution in the ENJ/ETH pool

Reserve-based price deviations are relatively high, showing how small pool reserves cause bigger price deviations. Considering that this pool contains popular tokens, small reserves and small transaction frequency there is a high chance of performing an efficient MEV attack.

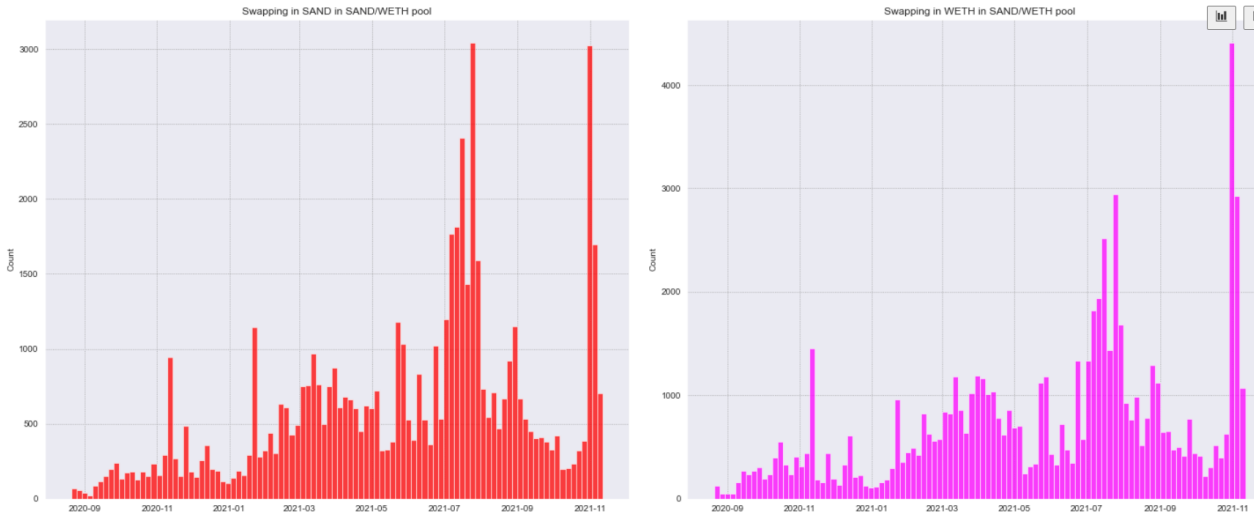
SAND/WETH (NFT) or a good case of NFT for art platform

SAND token is a NFT token used inside the Sandbox platform. This is a platform for creating voxel-based models that can be sold on this platform. This platform has its own metaverse that will be opened for each person during the end of November and December 2021. Considering the last moment, the token should have a price rise during this period and if the launch will be successful - after that. This token was found on the Uniswap V2 in pair with Ethereum.



Picture 67: Swap operations activity in the SAND/ETH pool

The distribution of the SAND/ETH pool is relatively high and there are multiple high activity periods.

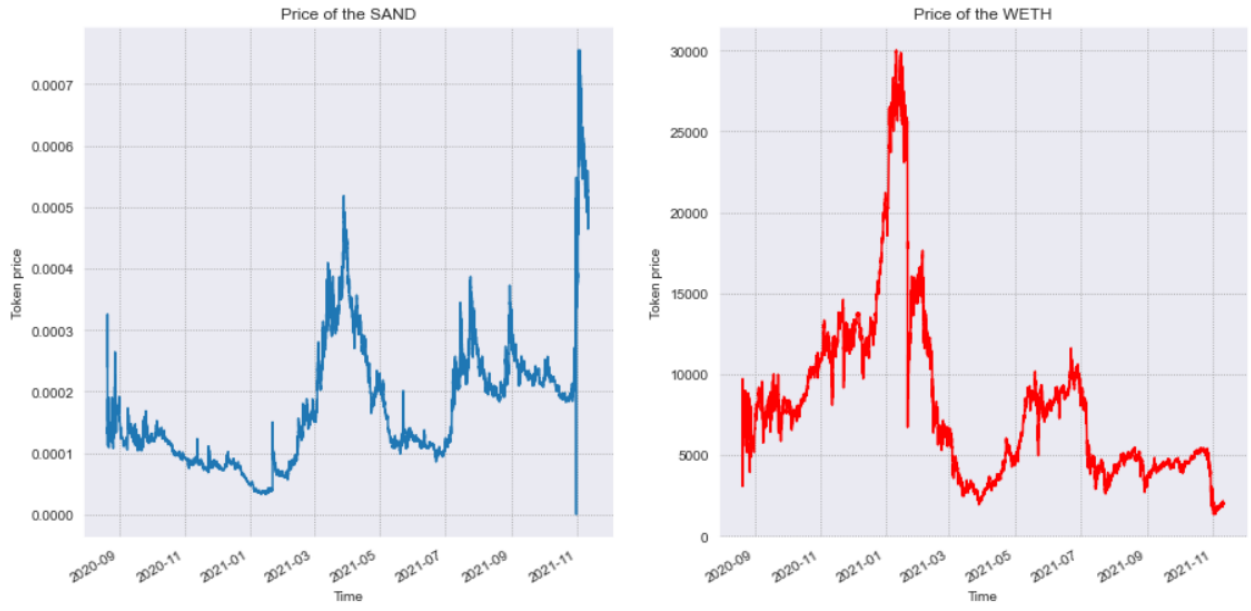


Picture 68: Swap transaction count distributions for SAND/ETH pool

First story half contains low transaction frequency, defining possible MEV attack. To check if this can be performed it is required to show reserves distribution.

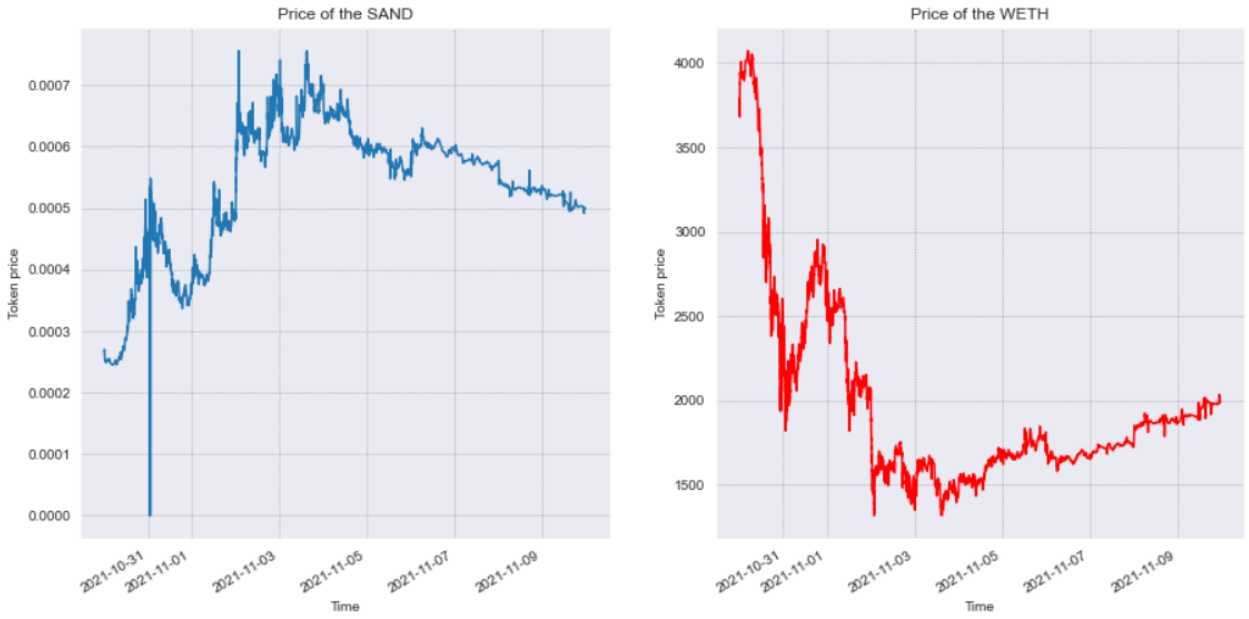
Picture 69: Reserves distribution in the SAND/ETH pool

Conform reserves distribution there is a low chance of performing an efficient MEV attack. This happens due to higher transaction values required for performing an efficient MEV attack, considering that a person should request an exchange that is able to break price distribution. To ensure that there was no MEV attack present in the pool, below are presented the swap price distribution and swap price change rates.



Picture 70: swap price distribution of the SAND/ETH pool

The presented price distribution shows anomalous changes in the SAND token price registered during the end of October and start of November 2021.



Picture 71: swap price distribution for end of October and start of November 2021 for the SAND/ETH pool

Distributions look stable, only SAND token has anomaly where SAND price drops to 0.

	token_in	token_out	amount_in	amount_out	amount_usd	timestamp	first_to_second_price	price_change_rate
117404	WETH	SAND	21.100019	44641.233396	92555.965801	2021-10-31 00:52:13	2115.696400	-1.911173
117405	SAND	WETH	5595.962492	2.652918	11637.116131	2021-10-31 00:52:13	0.000474	4.089153
117406	WETH	SAND	29.626893	61870.909727	129959.398479	2021-10-31 00:52:13	2088.336062	-1.293207
117407	SAND	WETH	44641.233858	21.293956	93406.680883	2021-10-31 00:52:13	0.000477	0.616957
117408	SAND	WETH	3916.743254	1.854685	8130.549345	2021-10-31 00:52:50	0.000474	-0.728411
117409	SAND	WETH	6561.684308	3.103175	13603.663758	2021-10-31 00:52:50	0.000473	-0.127535
117410	SAND	WETH	8251.727824	0.000000	0.000000	2021-10-31 00:53:14	0.000000	-100.000000
117411	SAND	WETH	2443.336608	1.154240	5060.441550	2021-10-31 00:53:14	0.000472	inf
117412	WETH	SAND	39.967903	85138.668516	174915.017002	2021-10-31 00:53:25	2130.176017	2.003507
117413	SAND	WETH	92157.729719	43.040572	188668.553513	2021-10-31 00:53:25	0.000467	-1.137114
117414	WETH	SAND	12.660852	26562.020660	55408.790528	2021-10-31 00:53:25	2097.964684	-1.512144
117415	WETH	SAND	17.121700	35726.873816	74964.823206	2021-10-31 00:54:24	2086.642904	-0.539655
117416	SAND	WETH	7839.143629	0.000000	0.000000	2021-10-31 00:54:24	0.000000	-100.000000
117417	SAND	WETH	2321.170427	1.101217	4821.514055	2021-10-31 00:54:24	0.000474	inf
117418	SAND	WETH	91566.427665	43.325763	189695.425244	2021-10-31 00:54:29	0.000473	-0.265784
117419	SAND	WETH	7447.186981	0.000000	0.000000	2021-10-31 00:54:29	0.000000	-100.000000
117420	SAND	WETH	2205.112064	1.031506	4516.294486	2021-10-31 00:54:29	0.000468	inf
117421	WETH	SAND	11.261579	23867.430591	49306.731400	2021-10-31 00:55:02	2119.368118	1.568319

Picture 72: transaction history fragment with strange drops in token prices

There are strange transactions happening in shown transaction history, considering that there are some swaps, where the amount of our token is equal to 0, breaking the price evolution.

	token_in	token_out	amount_in	amount_out	amount_usd	timestamp	first_to_second_price	price_change_rate
117501	WETH	SAND	2.700287	5178.375269	11832.059300	2021-10-31 01:10:19	1917.712864	2.934607
117502	WETH	SAND	22.643621	43155.494032	99265.781694	2021-10-31 01:10:28	1905.856578	-0.618251
117503	SAND	WETH	7074.861385	0.000000	0.000000	2021-10-31 01:10:28	0.000000	-100.000000
117504	SAND	WETH	2094.866455	1.098376	4815.092901	2021-10-31 01:10:28	0.000524	inf
117505	WETH	SAND	1.880000	3563.456345	8241.600121	2021-10-31 01:10:28	1895.455503	-0.545743
117506	SAND	WETH	25000.002277	13.074511	57316.433696	2021-10-31 01:10:37	0.000523	-0.255081
117507	SAND	WETH	6721.118792	0.000000	0.000000	2021-10-31 01:10:37	0.000000	-100.000000
117508	SAND	WETH	1990.123273	1.037190	4546.866459	2021-10-31 01:10:37	0.000521	inf
117509	WETH	SAND	1.626885	3068.409774	7132.541043	2021-10-31 01:11:04	1886.064141	-0.495467
117510	WETH	SAND	12.000000	22557.883510	52610.039293	2021-10-31 01:11:04	1879.823626	-0.330875
117511	WETH	SAND	22.568046	42817.679177	98942.148901	2021-10-31 01:11:04	1897.270113	0.928092
117512	WETH	SAND	5.609624	10500.000000	24597.428130	2021-10-31 01:11:14	1871.783303	-1.343341
117513	SAND	WETH	88109.608000	46.326718	203164.553079	2021-10-31 01:11:44	0.000526	0.885728

Picture 73: transaction history fragment with strange drops in token prices

There are strange transactions that have the same 0 value of out_token similar to the previous shown transaction history fragment.

There were no MEV attacks detected, defining that transaction frequency and reserves does not allow performing efficient MEV attacks. This is a stable pool with positive trends. Considering news mentioned in the subchapter beginning will cause additional price rise and positive distribution trend.

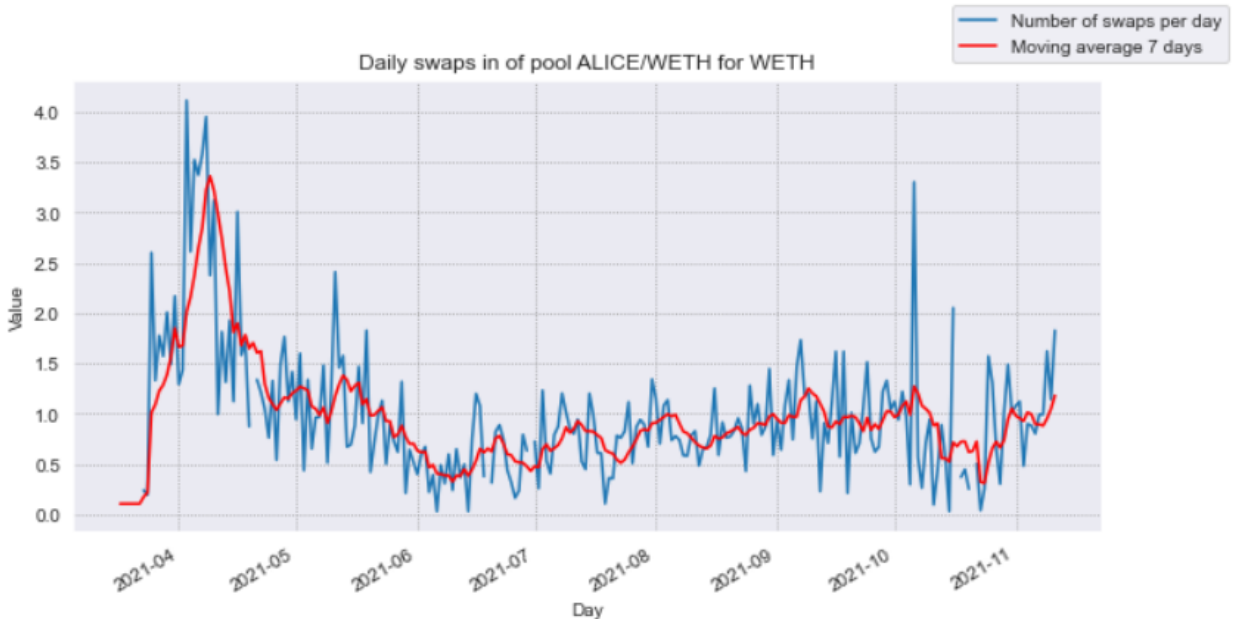
Picture 74: reserve-based price distribution of the SAND/ETH pool

This is the only case when reserve-based price was different from the real-market one. In the current SAND price distribution can see an anomalous rise between March-May 2021, while real price had a small rise compared to present rise in the pool. After this period the distribution looks similar to the real one.

Picture 75: real-market price evolution of the SAND token conform coinmarketcap.com

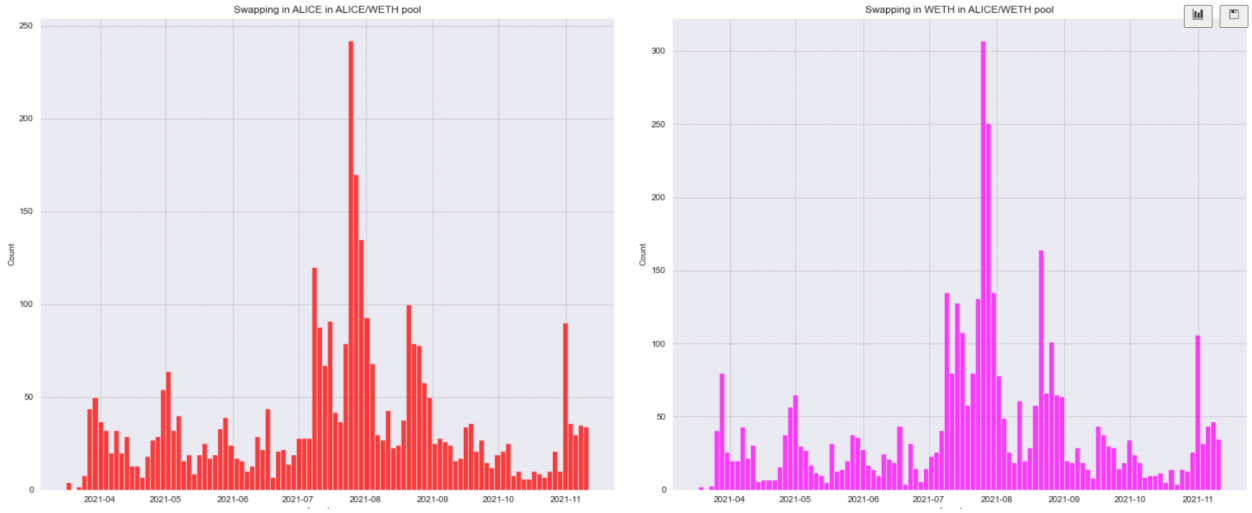
ALICE/WETH (NFT) or how unstable game tokens can be

There are multiple farming simulators on the gaming market that are popular and generate great profits to owners of those projects. This popular gaming direction also arrived to NFT, as “My Neighbor Alice” project, which is a farming/building game. ALICE token is used as an “in-game” currency for purchasing goods. This currency was found on the Uniswap V2 as a part of the ALICE/ETH pool.



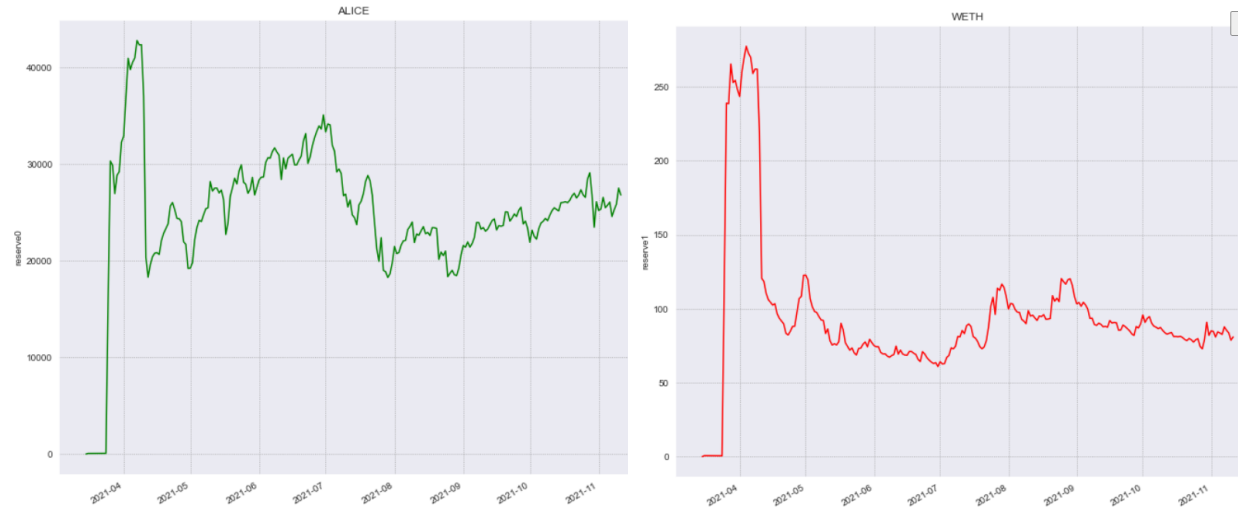
Picture 76: Swap operations activity in the ALICE/ETH pool

Activity present in the ALICE/ETH pool is relatively low, compared to the other pools, due to low capitalization of trades per day, meaning that there are either small values in transactions, or that there is a low transaction frequency.



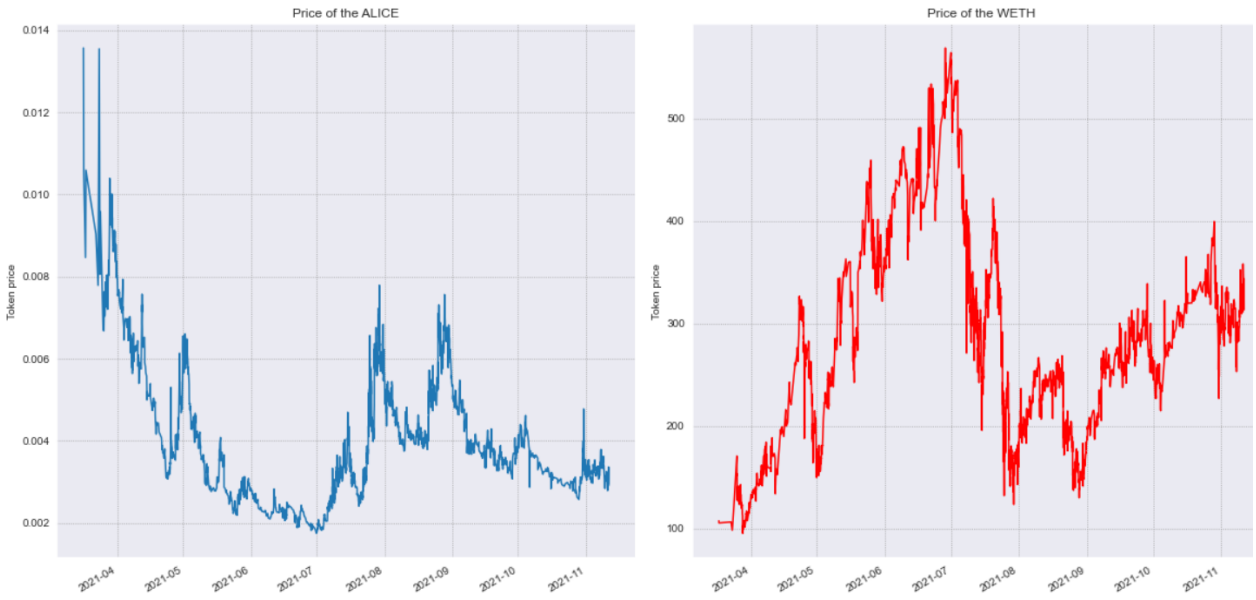
Picture 77: swap transaction count distribution in the ALICE/ETH pool

Transaction frequency is low with great transaction count rise between July-September 2021. During this period transaction history is relatively high but in other periods there is a small transaction count. Considering that it is important to check pool reserves and possible presence of MEV attacks.



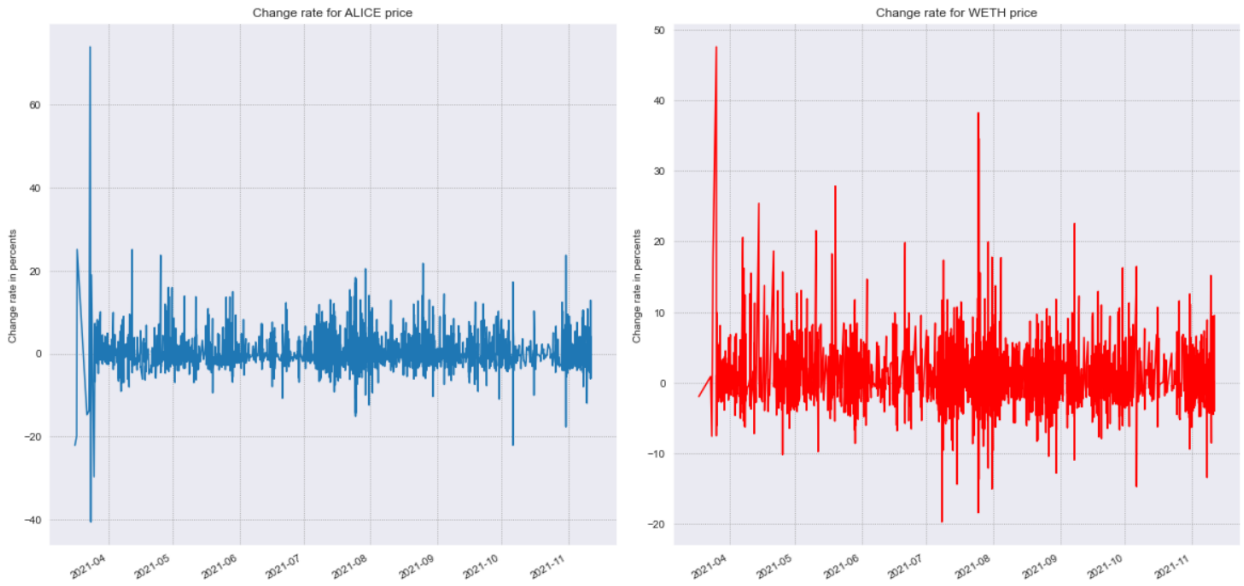
Picture 78: Reserves distribution for ALICE/ETH pool

Reserves present in the pool are relatively small and even considering their stable distribution their values are small to ensure safe trading without MEV attacks. To check their presence below are presented swap price distributions and swap price change rates.



Picture 79: swap price distributions in the ALICE/ETH pool

Conform present distributions there are no strange extreme drops or rises in the token prices, but the price deviations are relatively high, making distributions unstable. Considering that, below is the swap price change rates distribution.



Picture 80: swap price change rate for ALICE/ETH pool

The noise present in the distribution and its high values show how unstable the current pool is. It means that this pool can be an easy target for heavy MEV attacks, but the reason why this pool is not attacked by the MEV is that the pool is not popular. Amount of transactions is more-less stable, but transaction frequency is small, present tokens are not widely popular

compared to previous ones. Still, with the rise of popularity and token price, the current pool can become an easy target for performing MEV attacks.

DOGE/WETH (Meme-token) or how joke became a serious project

Easy to get, easy to lose, hard to forget

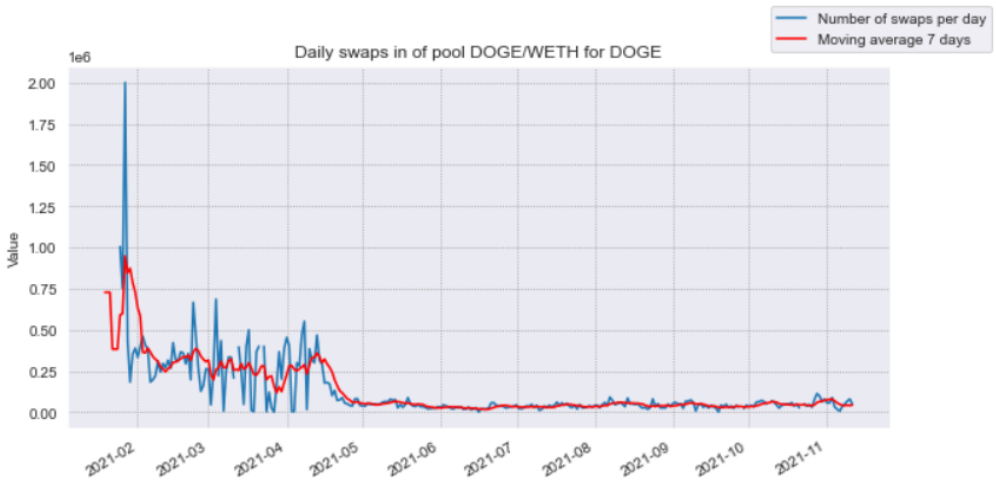
All previous cases represented pools of altcoins, NFT and stablecoins. Those tokens represent complex cases, when behind the token are some organization, communities, companies, start-ups, complex media or even meta-worlds. But there is another case of tokens, one that contains the most unstable, unpredictable and strange behaviors - meme tokens.

Meme tokens are created to hype around some popular memes and their price is almost in all of the cases speculative, meaning that their prices are based on supply and demand. This supply and demand is not controlled. Due to those market properties meme-tokens are an easy way to get big profits in a short time, but from another point of view this is an easy way to lose financial resources due to unpredictable fast token price drops or other unique market situations.

Due to presence of the MEV attacks, some transaction frequency drops that cause TWAP mitigation mechanisms inactivity in previous cases it is important to consider such cases and analyze their behavior. Each pool will be reviewed also from the history perspective to understand why some distribution changes have occurred.

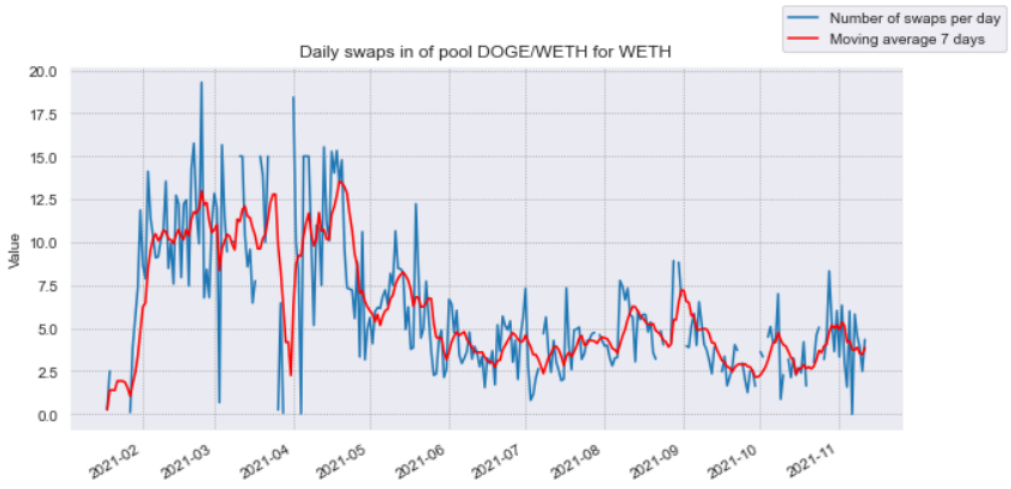
How Twitter activity and Reddit communities are able to rise and drop token price

As a first meme-token for analysis was chosen a DOGE coin - a project that was launched in December 2013 as a “joke” by two software engineers. Pool DOGE/WETH was found on the Uniswap V2 and below are presented the swaps transactions distributions.



Picture 81: swap operations distribution of the DOGE/WETH pool for DOGE

Until the middle of April 2021 there are higher transaction token values. After the middle of April 2021 happened a big decrease of swap activity and distribution became stable, but token values are much smaller.

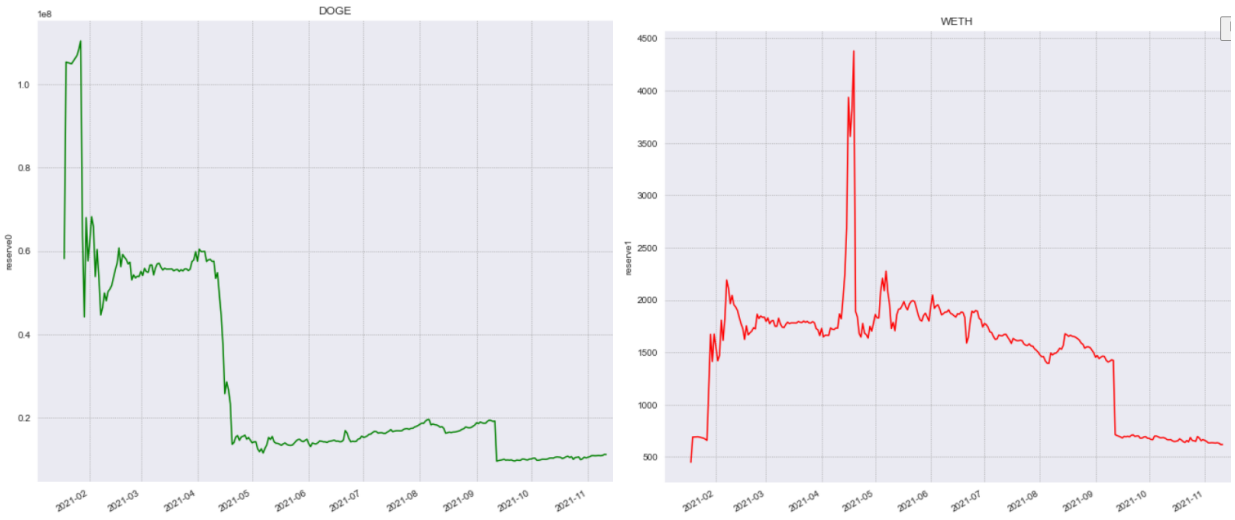


Picture 82: swap operations distribution of the DOGE/WETH pool for WETH

Swap operations distribution for WETH token has higher values, considering the WETH token price capitalization of the pool keeps relatively high, but the distribution is dropping starting from the middle of April 2021.

Considering those market changes authors decided to check what changes caused such drops in distributions. Starting from 2019 this token has been actively mentioned by many popular persons, like Elon Musk, Snoop Dogg, Jin Simmons and many other popular persons, mentioning their either interest in this token or showing that they have some tokens in their wallets. During the Spring 2021 token price has greatly increased after multiple tweets from Elon Musk (also about the fact that he bought some coins for his son), when SpaceX decided to “send this coin to the moon”, when Dallas Mavericks became the first NBA club that started selling tickets for DogeCoin, and when a popular traders group “WallStreetBets” (responsible for one of the biggest share price pumps with GameStop shares) opened for a short time discussions about DogeCoin (links: 1, 2, 3, 4, 5, 6). Such an interest in token raised a token price, causing multiple changes not only on the market but also in the current pool.

Drop in the swap distribution is caused by the token price raise, causing people to perform swap operations with smaller token values. Another moment is that token price changes caused burns in pool reserves, presented below.



Picture 83: reserves distributions for DOGE/WETH pool

Conform presented distributions there was a great drop in reserves around the middle of April 2021. There is an additional drop of the reserves around the middle of September 2021.

Picture 84: DOGE coin price distribution for last year taken from CoinDesk

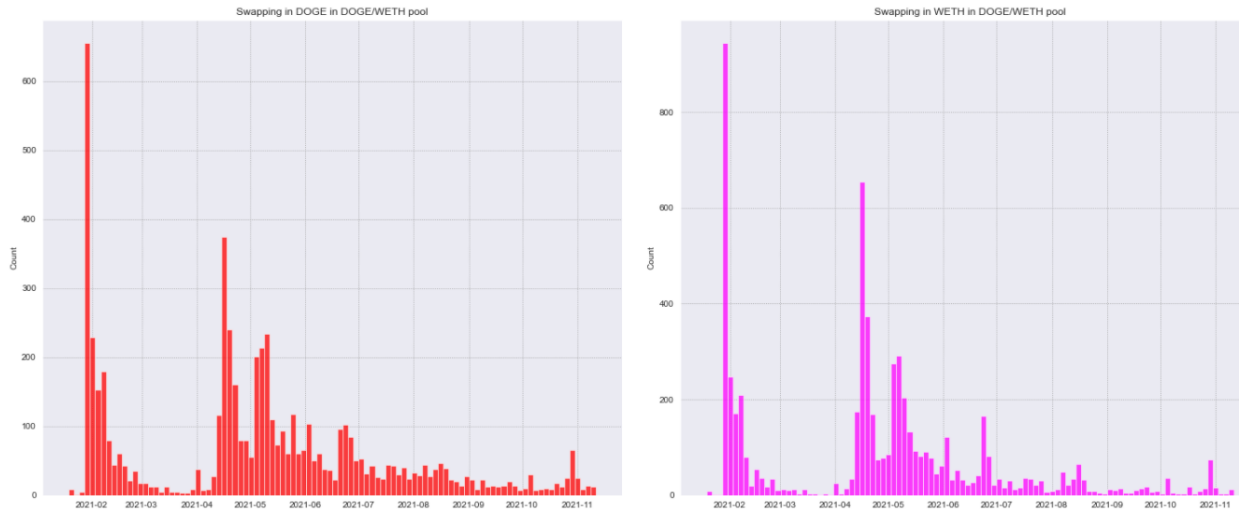
Conform presented price distribution DOGE had a drop around September 2021, causing decrease of reserves. One of the reasons why the price decreased is some critique coming from popular persons, raising questions about current token operation fees, asking for their decrease to ease token operations (link).

Picture 85: reserve-based price distributions in the DOGE/WETH pool

The price distributions of the pool have some differences compared to the real-market price distribution. DOGE price had a peak around May and start of July 2021, but starting from the September 2021 pool-based price is slowly decreasing while real price had local rise during October and small decrease around November.

Picture 86: swap-based price distributions for the DOGE/WETH pool

Presented distributions demonstrate high deviation of values around high-activity periods, showing high traders interest and their desire to exchange the tokens. After anomalous price rise distribution becomes stable and there are no extreme deviations in token price. To ensure that this is caused by high transaction frequency below is presented the transaction count distributions.



Picture 87: transaction count distributions for the DOGE/WETH pool

Conform presented distributions there are some transaction frequency rises. Most of the time transaction count is small and therefore there is an option of performing MEV attack over the pool, considering the possibility of too big time gap between transactions, but according to the presented swap-based token prices distributions there were no MEV attacks.

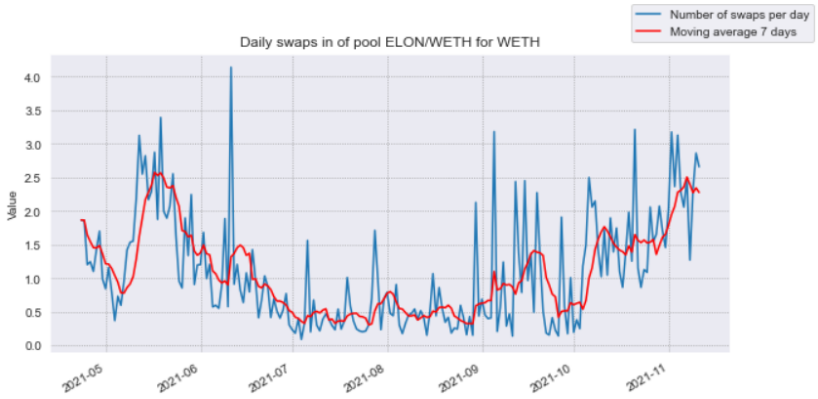
Picture 88: swap-based token price change rates for DOGE/WETH pool

Conform presented charts there were no anomalous price changes that would demonstrate the MEV attack pattern. It does not mean that such an attack will not happen in the future. Small reserves, small transaction frequency and token popularity can cause attackers attention to this pool.

ELON/WETH (Meme-token) or how unstable memes can be

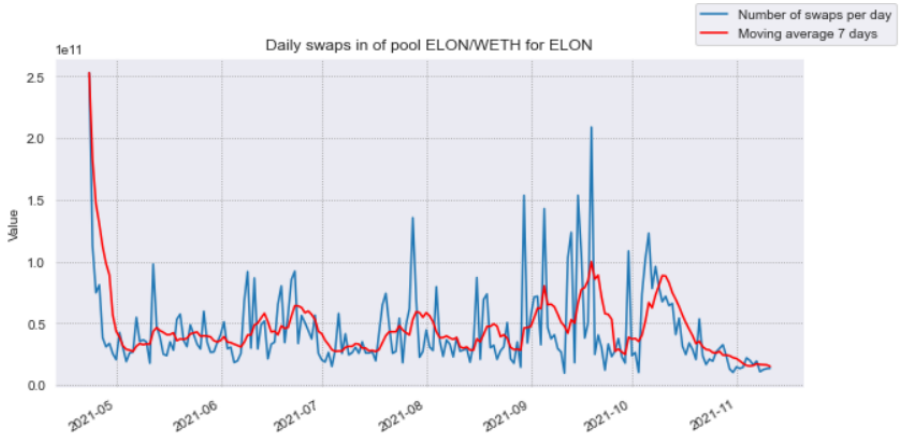
After multiple Dogecoin market changes caused by the Elon Musk tweets and activity there appeared a new token named Dogelon (ELON token), which is another meme-token. It appeared this year and its price is always changing. Considering that this is a relatively new token and its appearance right from the beginning in the Uniswap V2 platform as a part of ELON/WETH pool it was decided to dive deeper into its analysis.

Due to the low token price of ELON below is presented the WETH swap distribution over ELON/WETH pool, where it can be seen that the amount of operations happening per day is relatively small. Higher pool activity was registered between May-June 2021 and between September-November 2021 and it keeps rising up.



Picture 89: swap operations distribution of the ELON/WETH pool for WETH

ELON swap distributions keep on almost the same level for entire registered token history and rolling week average demonstrates wave-like distribution of the swap operations.



Picture 90: swap operations distribution of the ELON/WETH pool for ELON

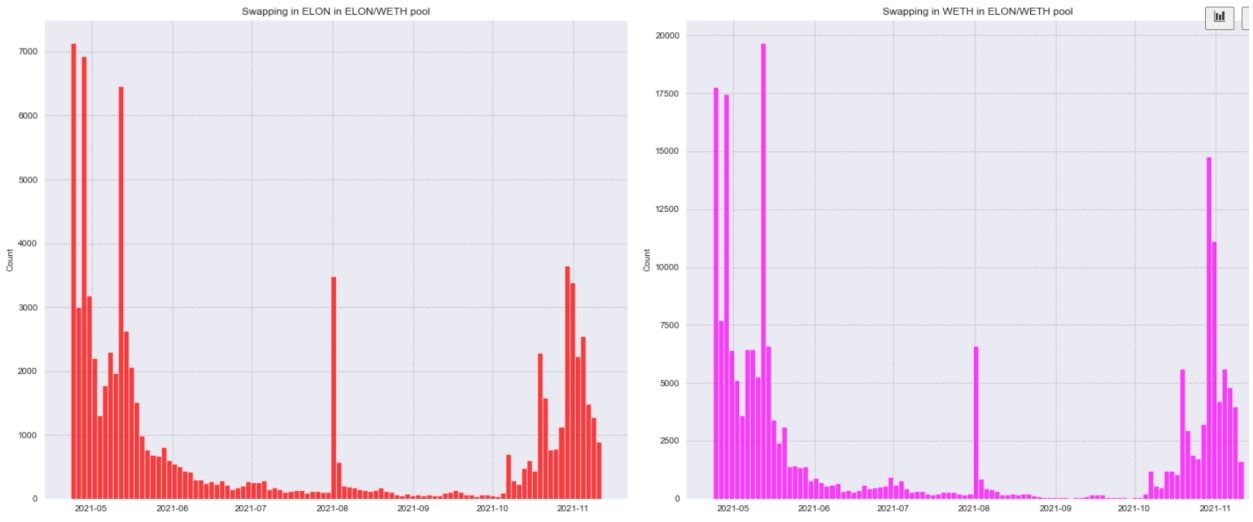
The interesting moment is that transaction count in the current pool has anomalous rises and drops that can be seen in the distributions presented below. There were registered 3 rises:

- Between end of April and middle of the May 2021;
- Start of August 2021;
- Between the start of October and the start of November 2021.

The same high activity periods were registered for the WETH side of the ELON/WETH pool. This distribution corresponds with real-market changes of the ELON token price meaning that each rise of the token price caused a rise of the swap activity. In the last period can be seen a drop of the swap activity related to token price decrease and stabilization.

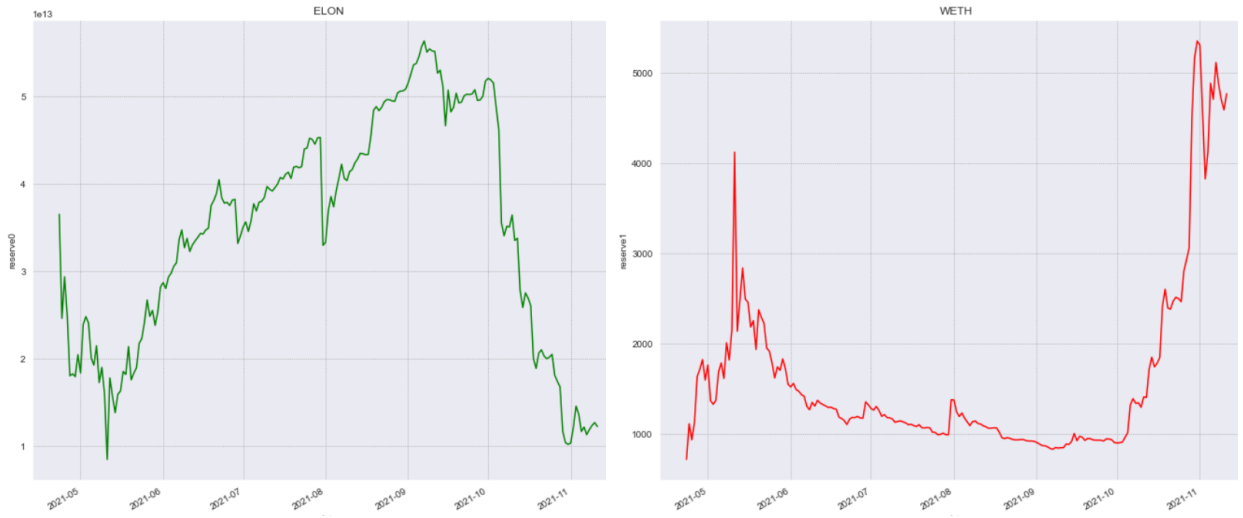
Picture 91: ELON token price evolution taken from Crypto.com

Transaction count distribution clearly demonstrates how popular meme-tokens can be and how many transactions can happen during high-activity phase.



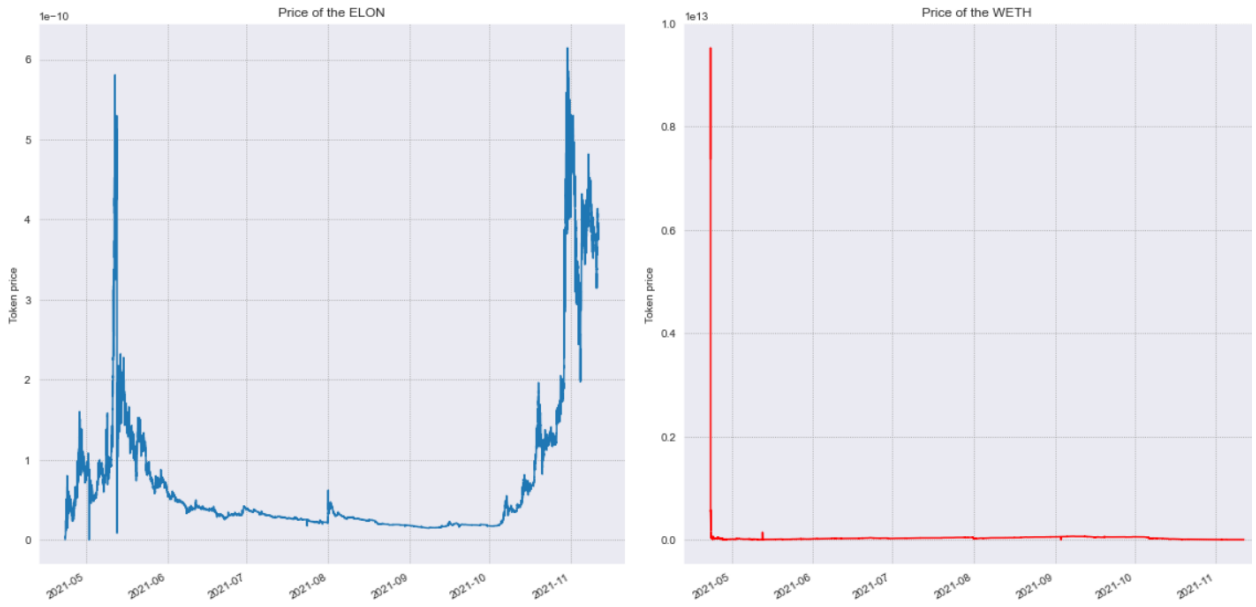
Picture 92: transaction count distribution for ELON/WETH pool

Transaction frequency during small activity periods show that there is an option of performing MEV attack. In order to check the possibility of performing such an attack it was decided to check pool reserves.



Picture 93: reserves distribution for ELON/WETH pool

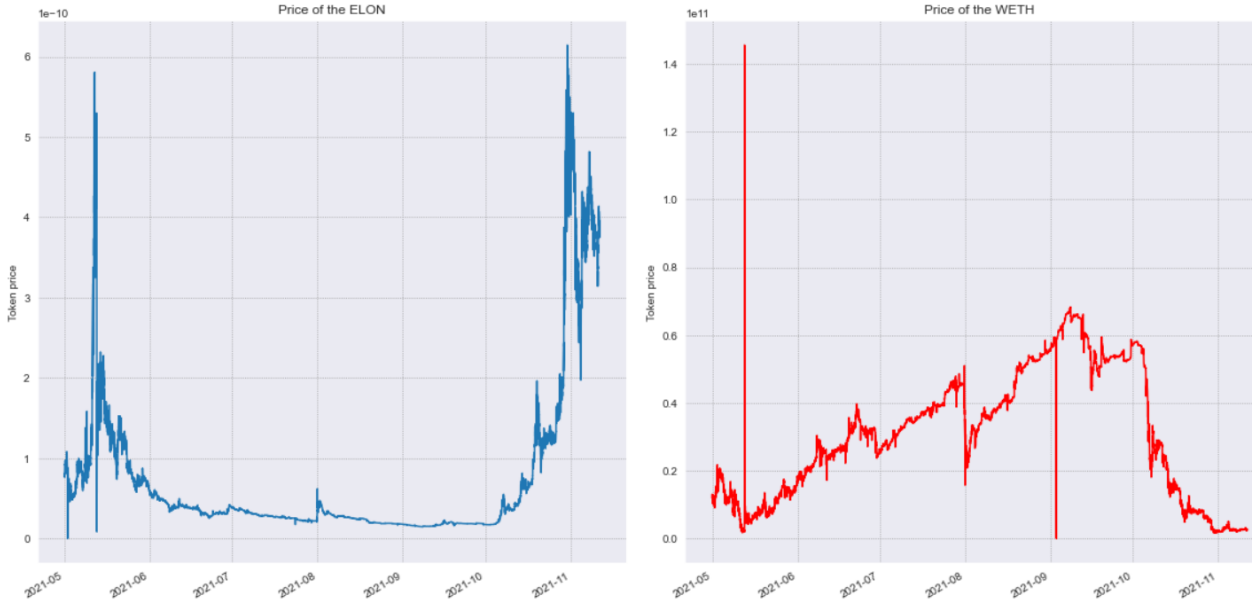
ELON reserves distribution shows slow increase of available tokens until last registered anomalous rise that caused big token burn. WETH reserve shows rise of liquidity during May 2021 after which comes a low reserves period, defining low trust to this token pair, after which comes anomalous rise of WETH tokens in the pool, defining great rise of traders interest to the token. Due to big changes in reserves and big transaction frequency rise and drops it is required to check swap price distribution for the current pool.



Picture 94: swap-based token price for ELON/WETH pool

The presented charts demonstrate how big the rise of the ELON token price is. Considering that the distribution of the WETH token in this pool has too much value at the

beginning, making the remaining chart barely readable below is presented a more detailed WETH price chart excluding beginning of the pool lifecycle.



Picture 95: swap-based price distribution for ELON/WETH pool

Distribution of the swap-based price starting from May 2021 shows that ELON token price had two giant rises during May 2021 and starting from October 2021. There are two anomalous changes in the token price from the WETH token price side, that look like MEV attacks. After deep pool history analysis was the only one strange transaction, price for which greatly increased, while there was no registered reserves drop or any big changes.

	token_in	token_out	amount_in	amount_out	amount_usd	timestamp	first_to_second_price	price_change_rate
201473	WETH	ELON	1.322041e-02	7.811944e+08	4.939528e+01	2021-09-03 01:08:31	5.909002e+10	-3.443978e-02
201474	WETH	ELON	9.000268e-03	5.318127e+08	3.362562e+01	2021-09-03 01:11:34	5.908854e+10	-2.502673e-03
201475	ELON	WETH	5.457151e+09	9.179362e-02	3.427337e+02	2021-09-03 01:19:07	1.682079e-11	5.973902e-02
201476	ELON	WETH	3.569799e+10	6.000000e-01	2.238869e+03	2021-09-03 01:53:39	1.680767e-11	-7.804131e-02
201477	ELON	WETH	1.933268e+09	3.247048e-02	1.221740e+02	2021-09-03 02:50:43	1.679564e-11	-7.153145e-02
201478	WETH	ELON	1.000000e-18	1.000000e-18	3.771929e-15	2021-09-03 03:17:31	1.000000e+00	-1.000000e+02
201479	WETH	ELON	2.200650e+00	1.299231e+11	8.360580e+03	2021-09-03 04:07:53	5.903853e+10	5.903853e+12
201480	ELON	WETH	5.027630e+09	8.485039e-02	3.237747e+02	2021-09-03 04:37:52	1.687682e-11	4.832956e-01
201481	WETH	ELON	4.700149e-01	2.767094e+10	1.791605e+03	2021-09-03 04:57:30	5.887248e+10	-2.812665e-01
201482	WETH	ELON	7.000000e-01	4.115662e+10	2.669034e+03	2021-09-03 05:00:46	5.879516e+10	-1.313210e-01

Picture 96: transaction history fragment with strange transaction, where was registered anomalous price change

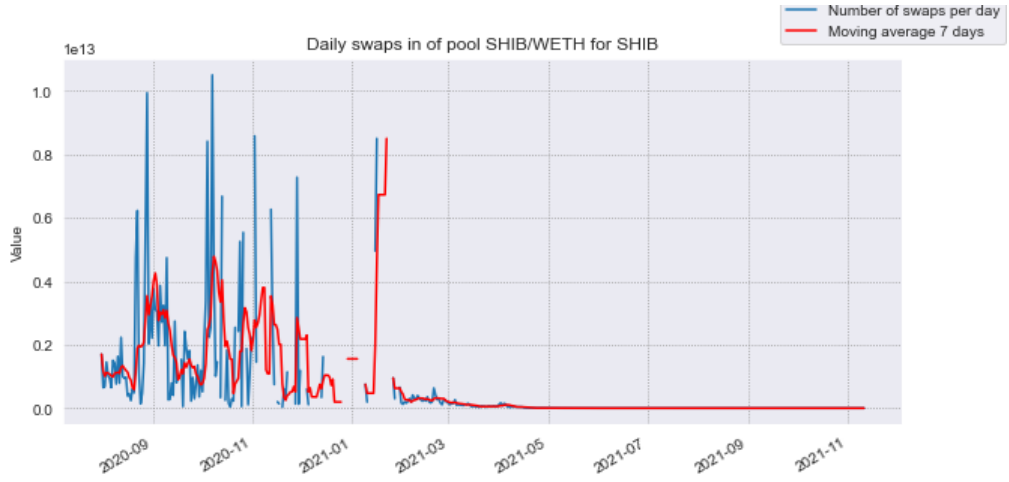
There was no MEV attack detected during the pool analysis. While transaction frequency opens an option for performing a MEV attack, reserves values are relatively high compared to

previous pools, meaning that an attacker must obtain a large financial power to perform an attack, meaning that there is a very small chance of performing such an attack. Still, considering small token lifecycle and that this is a meme-token, distribution of which much depends on the news related to this token, this pool may be unstable and there can be multiple token changes in the future, causing distribution drops and rises.

SHIB/WETH (Meme-token) or unstable token case

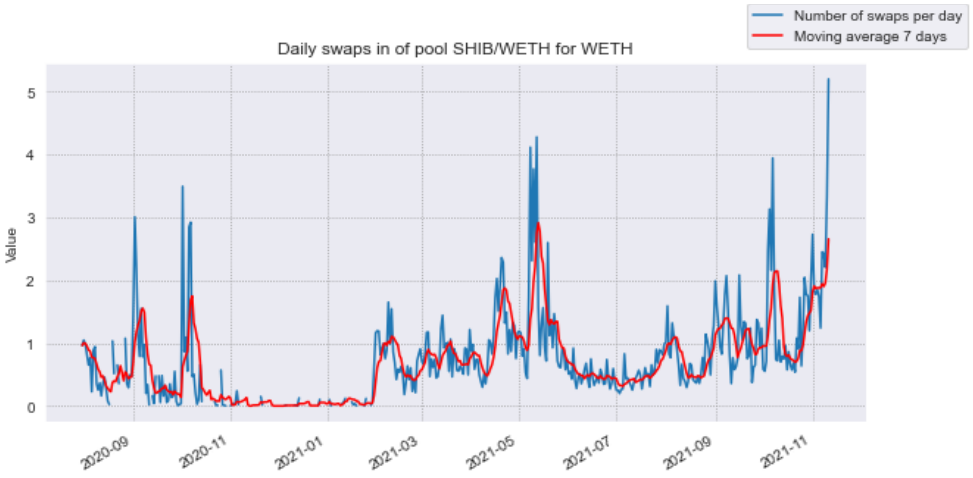
How one token phenomenon can cause appearance of another one

The Dogecoin phenomenon caused higher interest to the meme-tokens, increasing community interest in the meme-coins. Those changes caused the appearance of some coins like ELON (Dogelon), but the current case is a little bit different. Shibu Inu token is a token that appeared at the August 2020 as a "Dogecoin killer" making this token an unique case of the token launched as another token killer. There is one strange moment about this token - the goal of the token is to beat a Dogecoin capitalization without crossing the 0.01 USD dollar threshold price. One of the inspirations for creating this project was the case of the WallStreetBets group that raised GameStop share price. On the 4-th October 2021 there was a token price rise that happened due to the tweet from Elon Musk about this token. Another interesting moment is that this token almost reached the desired capitalization value (to overcome Dogecoin capitalization, links: 1, 2, 3).



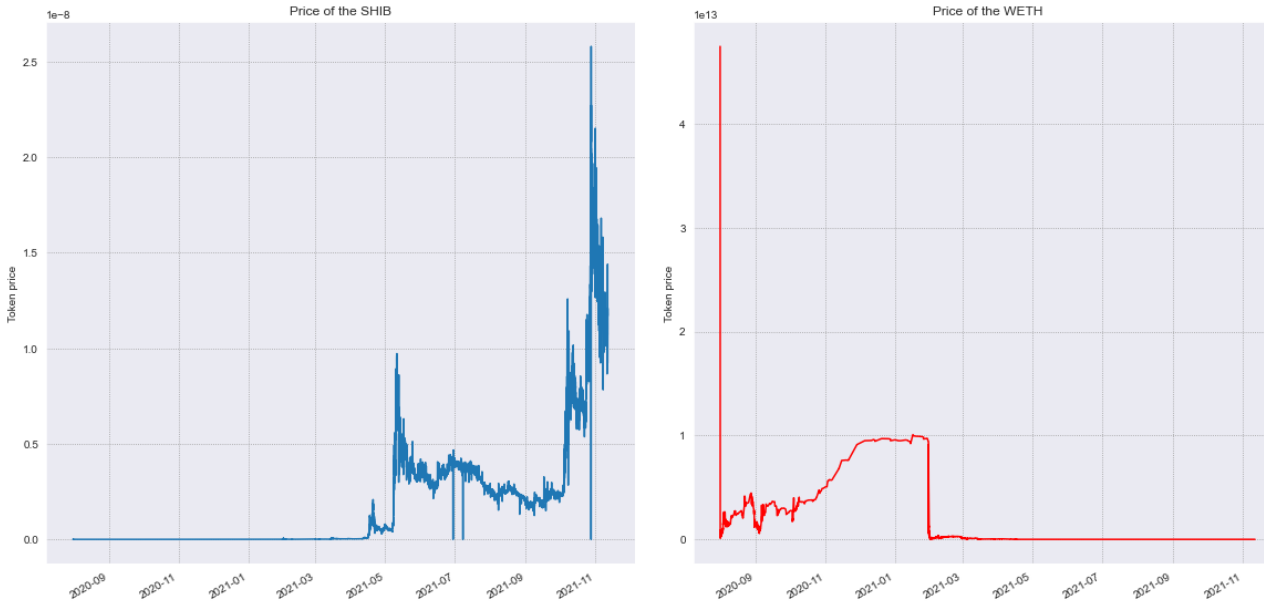
Picture 97: Swap operations distribution of the SHIB/WETH pool for SHIB token

Swap operations distribution looks unstable until February 2021, after which happened a distribution stabilization with smaller transaction values for current token. This could happen due to the Shibu Inu token price rise and this moment will be reviewed later.



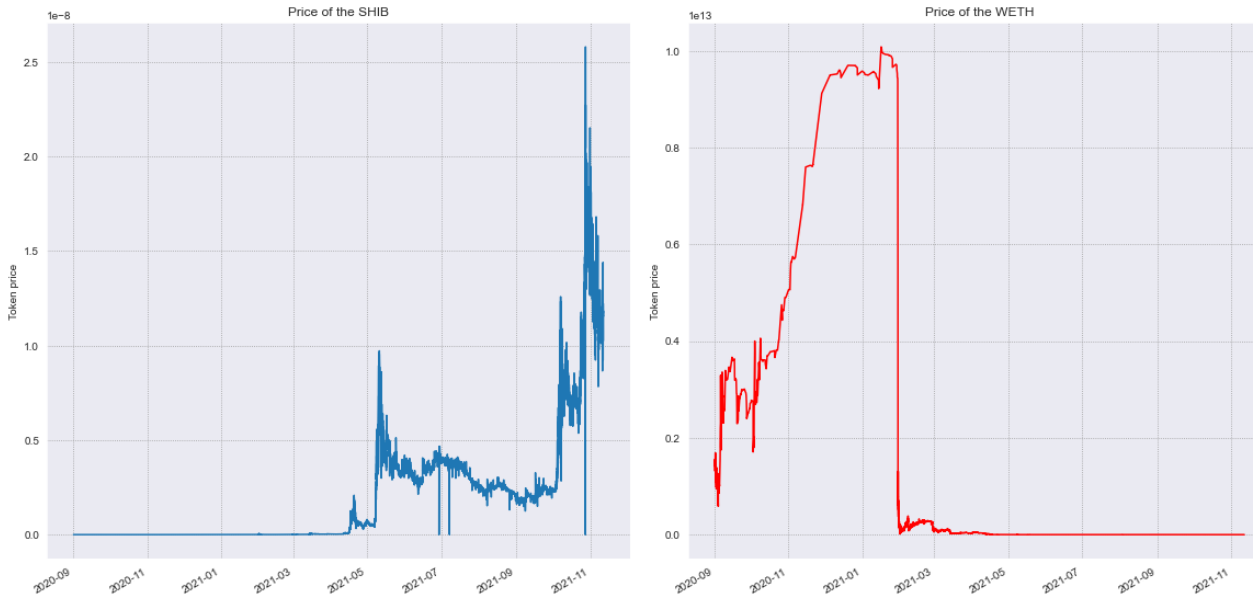
Picture 98: swap operations distribution of the SHIB/WETH pool for WETH

Pool swapping operations distribution from the WETH side looks more representative considering the rise of the transaction values starting from February 2021. To ensure that such a swapping activity is related to the token price below are presented swap-based price distributions and real-market based ones.



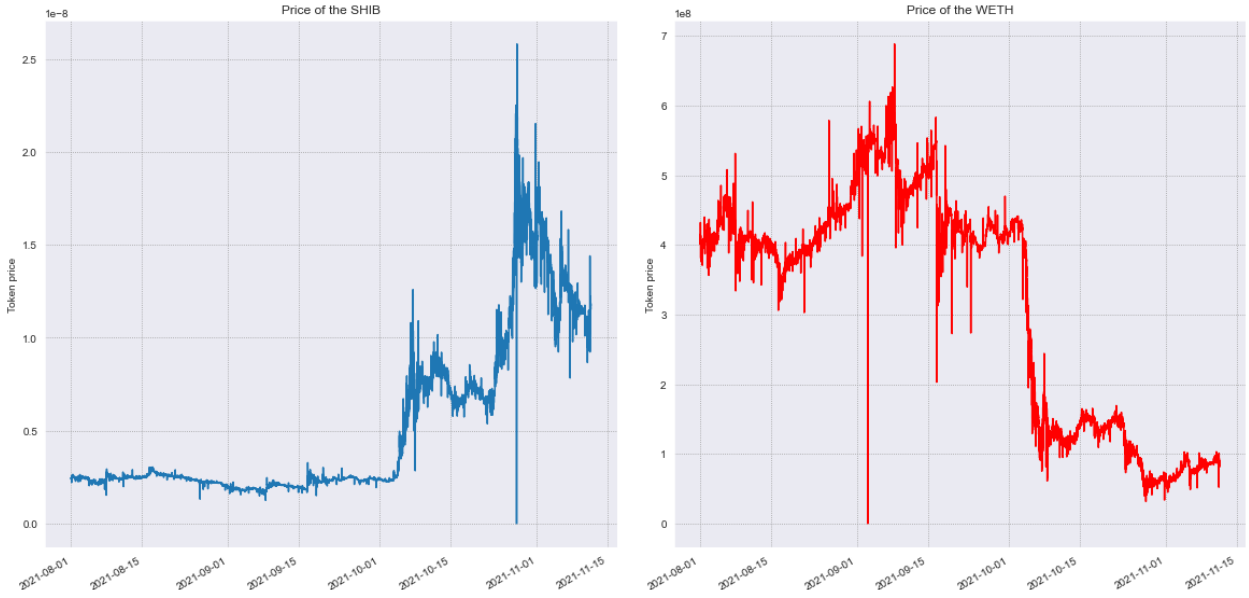
Picture 99: swap-based token price distributions for SHIB/WETH pool

Conform presented swap-based prices Shibu Inu token price had a great rise. Considering that first transactions have anomalous changes in prices distributions it was decided to move chart periods starting from September 2020 and distributions have become more readable.



Picture 100: swap-based price distributions for the SHIB/WETH pool starting from the September 2020

Until the middle of April 2021 the SHIB price was keeping on very low values after which started anomalous token price rises. During those high activity periods token price deviations were high and there were some strange token price falls. Considering such a big token price rise it was decided to look for the last 3 months price distribution.



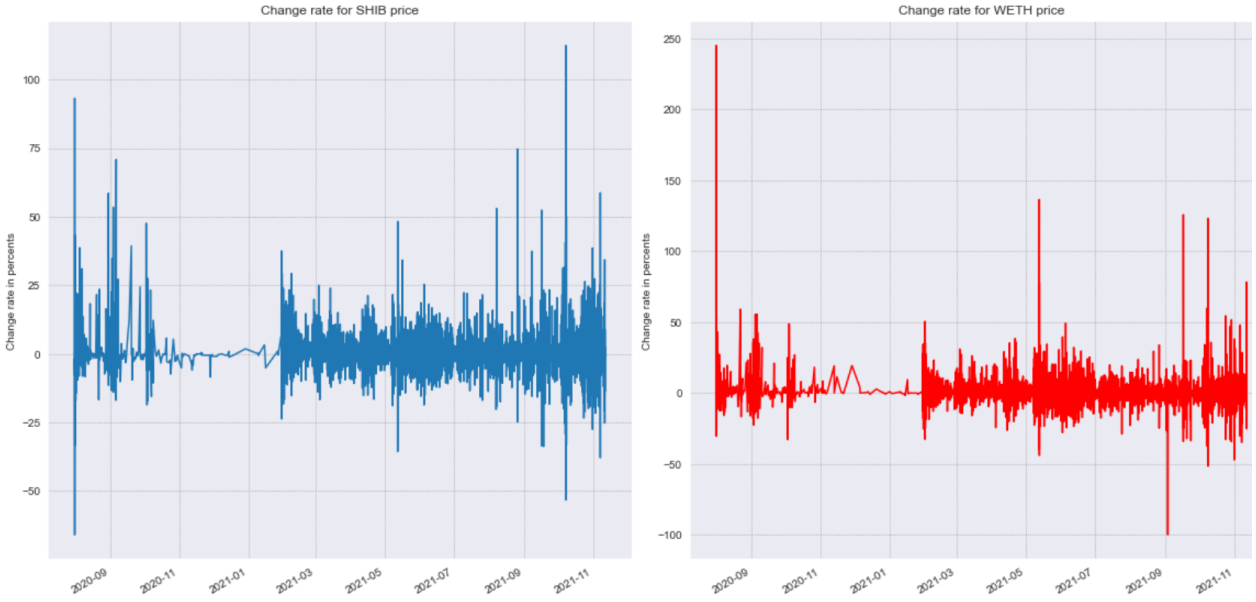
Picture 101: swap-based token price distributions for the SHIB/WETH pool starting from the August 2021

The reason of some strange transaction prices present in the distribution are still strange transactions where token_in is converted to the 0 value of token_out.

1159303	WETH	SHIB	2.508196e-01	1.217386e+07	990.276540	2021-10-27 23:40:37	4.853633e+07	-0.089877
1159304	WETH	SHIB	9.912500e-01	4.810640e+07	3913.007422	2021-10-27 23:40:37	4.853104e+07	-0.010902
1159305	WETH	SHIB	7.523578e-03	3.650677e+05	29.704308	2021-10-27 23:40:37	4.852316e+07	-0.016252
1159306	WETH	SHIB	4.956250e-02	2.411494e+06	195.650371	2021-10-27 23:40:37	4.865561e+07	0.272971
1159307	WETH	SHIB	1.003144e-01	4.869960e+06	396.057434	2021-10-27 23:40:37	4.854699e+07	-0.223250
1159308	SHIB	WETH	4.522284e+06	0.000000e+00	97.825186	2021-10-27 23:40:37	0.000000e+00	-100.000000
1159309	SHIB	WETH	2.711460e+07	5.548228e-01	2190.530748	2021-10-27 23:40:37	2.046214e-08	inf
1159310	SHIB	WETH	3.058607e+07	6.263206e-01	2472.815350	2021-10-27 23:40:37	2.047731e-08	0.074133
1159311	SHIB	WETH	1.424226e+07	2.909101e-01	1148.381766	2021-10-27 23:40:37	2.042584e-08	-0.251369
1159312	WETH	SHIB	1.630327e-01	7.916052e+06	643.679751	2021-10-27 23:40:37	4.855499e+07	0.016478
1159313	WETH	SHIB	1.931311e-01	9.399173e+06	762.394339	2021-10-27 23:41:09	4.866732e+07	0.231355
1159314	WETH	SHIB	1.632544e+00	7.936093e+07	6446.318684	2021-10-27 23:41:09	4.861181e+07	-0.114055

Picture 102: transaction history fragment containing strange transaction for SHIB/WETH pool

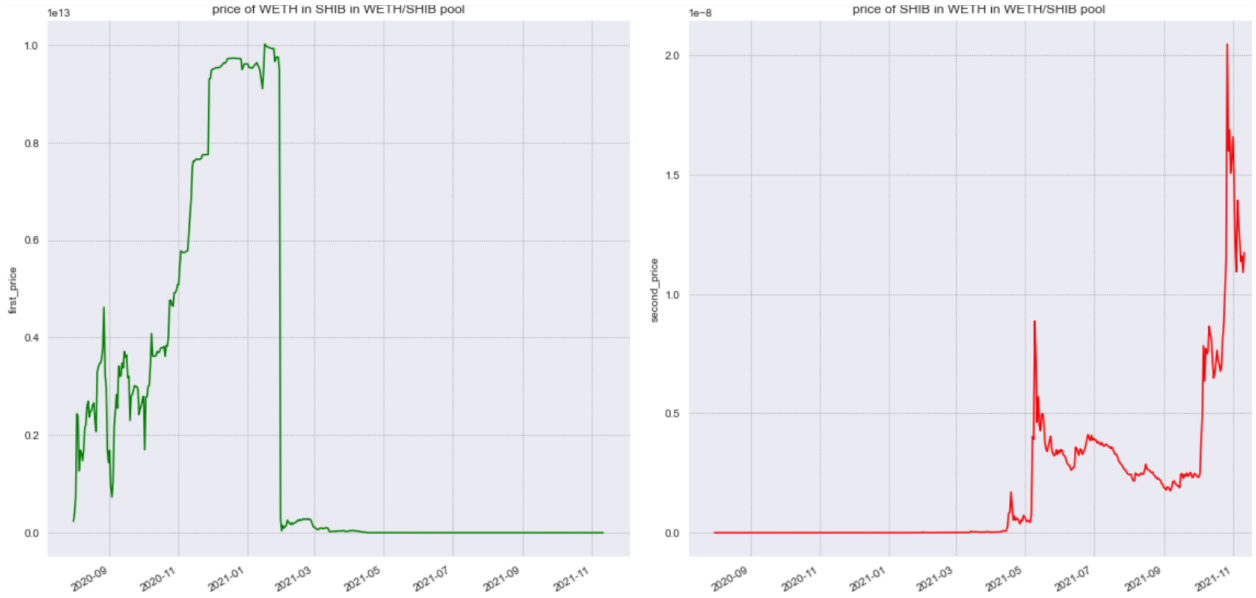
Considering those strange transactions and present swap changes below is presented the price change rates distribution.



Picture 103: swap-based price change rates distributions for SHIB/WETH pool

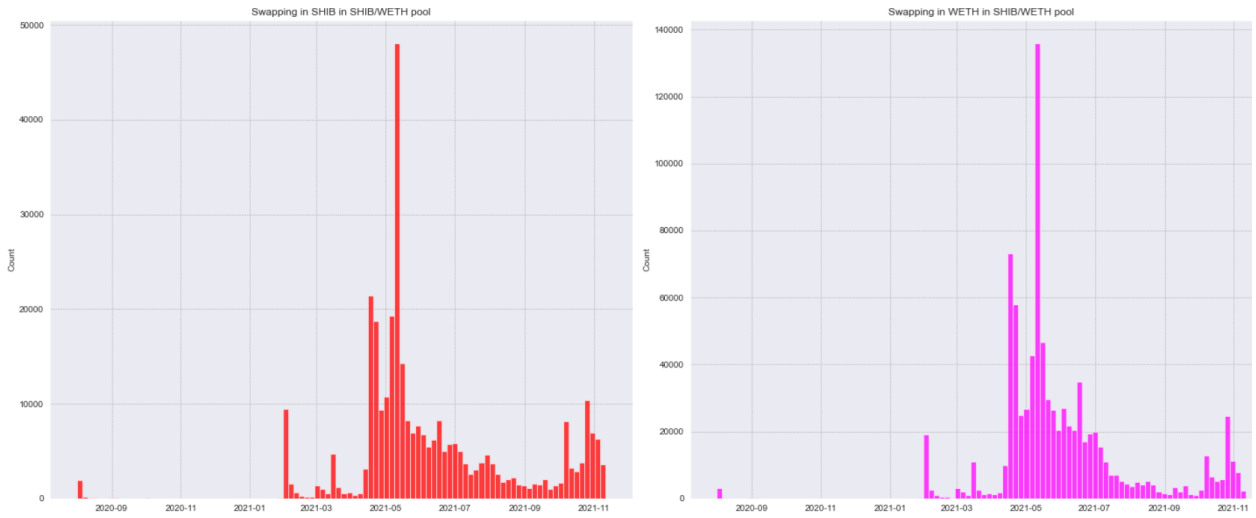
Conform presented distributions can be seen that the pool is unstable, prices for SHIB have high deviation and it is hard to predict which price value will token have in the future. The same unstable picture can be seen in reserve-based prices.

When reserves are weak, but transaction frequency is high



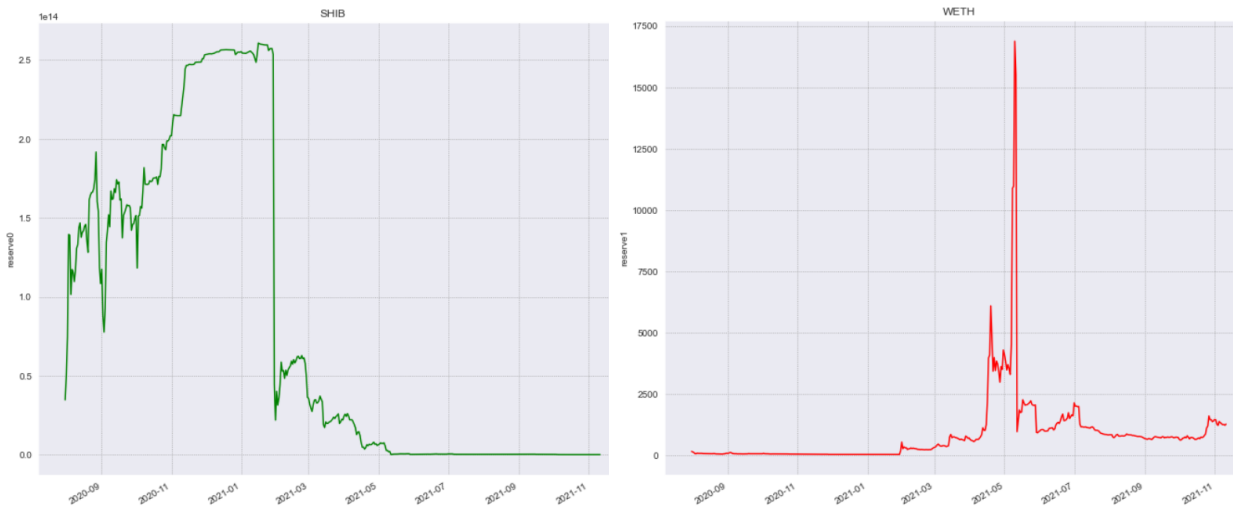
Picture 104: reserve-based price changes in the SHIB/WETH pool

Price distribution is unstable even from reserves perspective. Considering those high price deviations it is required to check for possibility of performing MEV attacks.



Picture 105: swap transactions count distribution for SHIB/WETH pool

Conform presented distribution pool activity was almost around 0 between September 2020 and February 2021, but after that pool activity had an anomalous rise of pool activity and high transaction frequency is keeping through the entire remaining time of 2021. There are multiple drops, but considering present values frequency is still relatively high.



Picture 106: reserves in the SHIB/WETH pool

Presented values in reserves of the SHIB/WETH pool were relatively high in the time interval between April 2021 and June 2021 making possible MEV attacks hard to implement. But in other periods the amount of required financial power to perform attacks is much lower and the only factor protecting the current pool from performing such an attack is TWAP mitigation mechanism.

SQUID/WETH or how fraud with one token influences another one

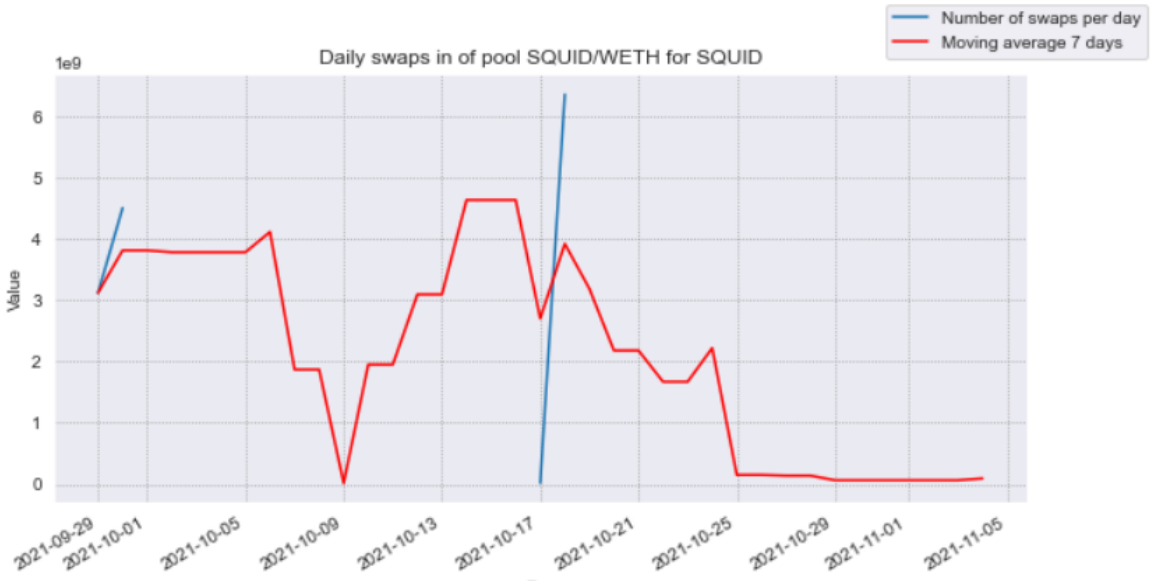
Why is this an interesting case?

Authors decided to take a look at an interesting case that happened with one of the new tokens, that was dedicated to the new TV-series made by Netflix called the “Squid Game”. The token was named SQUID and it was launched on the 20-th October 2021. After getting to the high price (around 3 000 USD dollars), the token was massively sold. Conform original concept, the principle behind the token was to have access to buying the token and winning selling option via web-games dedicated to this specific token (founders web-games). Trader was able to sell the token only after winning any “SQUID” game, but at the moment of token launch there was no web-page available for mentioned games. Conform transaction history that can be found on the Etherscan founders of the SQUID token changed several times the contract for the token (they left a specific window in the original contract in order to be able to change its behavior) and before selling the tokens massively founders changed the contract, opening selling option for the founders.

This led to the massive price drop from around 3 000 USD dollars to less than 1 USD dollar. This token is currently considered as a “scam” token (there were predictions from several sources about the “scam” scheme of this token) and founders extracted around 3 million USD dollars (sources: 1, 2, 3, 4).

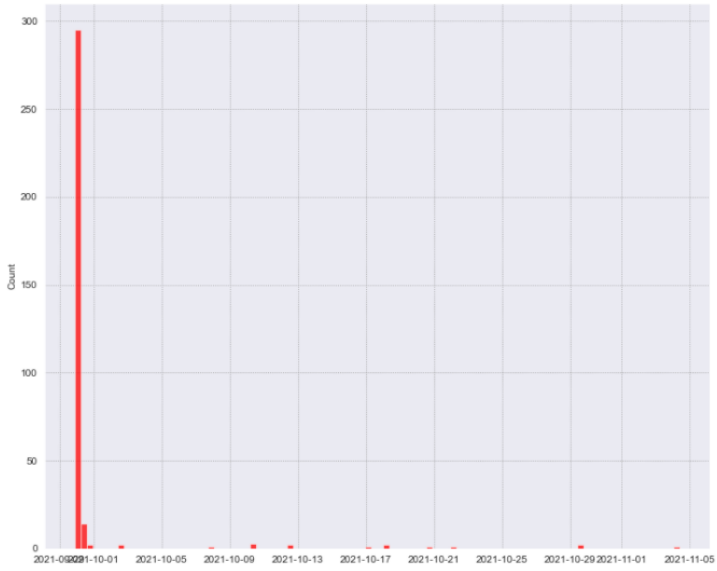
What connection can be between SQUID from SQUID/ETH pool and the “scam” one?

There was a token registered in the Uniswap V2 starting from the end of September 2021, which means that SQUID token reviewed in this section is not the “scam” based one, but reputational damage that was received by all the “Squid Game” theme may sign a soon end of the SQUID/ETH lifecycle.



Picture 107: Swaps transaction history of SQUID/ETH pool for SQUID

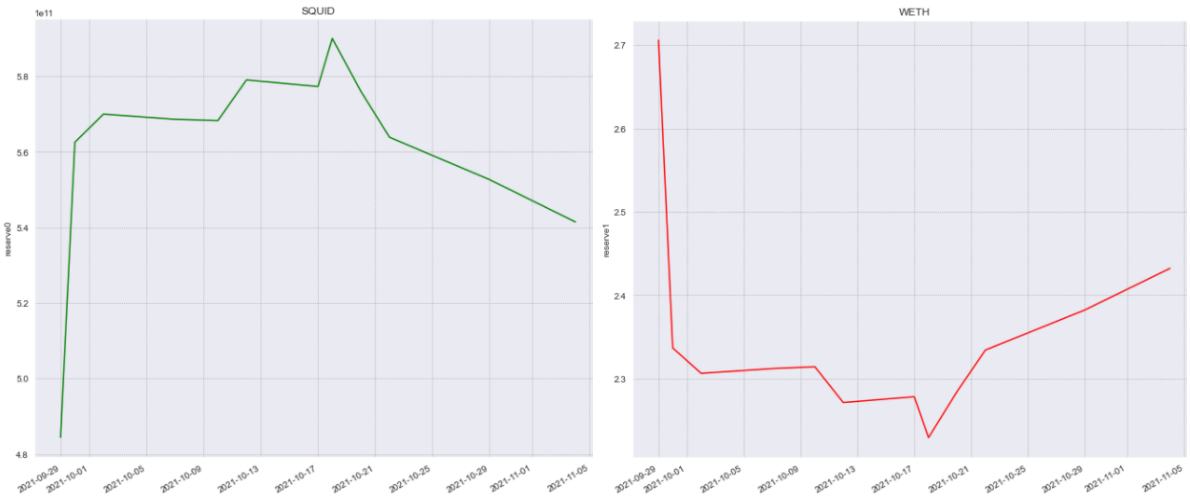
During even such a small lifecycle the pool activity is extremely low and distribution shows small transaction frequency.



Picture 108: SQUID/ETH swap transactions count

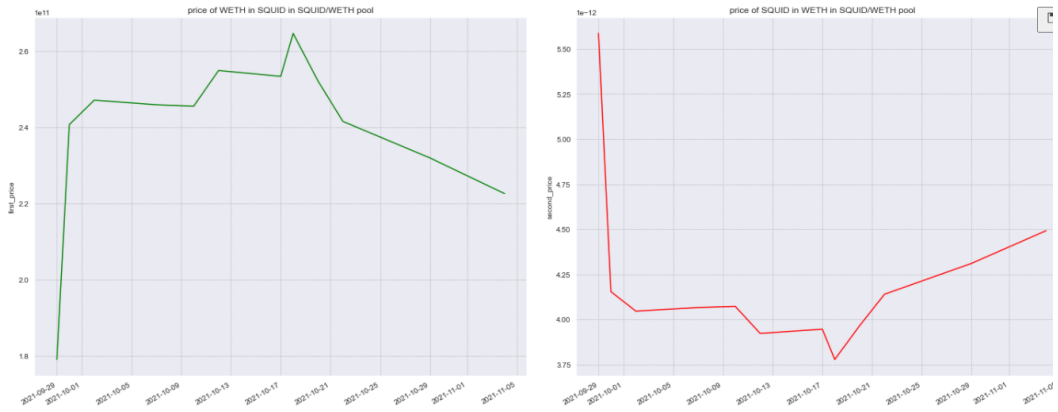
Why is the weak pool not always a target for MEV attack?

Here it can be clearly seen that SQUID token is not a popular one and there is a small activity period during the start of the pool lifecycle. This pool can be an easy target for any attack, but the problem of the pool is in its low attractiveness, that can be seen through reserves amount and prices.



Picture 109: SQUID/ETH pool reserves

While the SQUID reserve has a weak positive trend, WETH reserve has a negative trend, defining decrease of user interest in the current pool. The WETH token is a popular one and its distribution better establishes the current situation on the market with this pool.



Picture 110: SQUID/ETH pool reserve-based prices

Conform price distributions the SQUID token is dropping from the initial moment, when the price is raised at pool initialization stage. There is no attention to the market, reducing the option of performing MEV attacks.

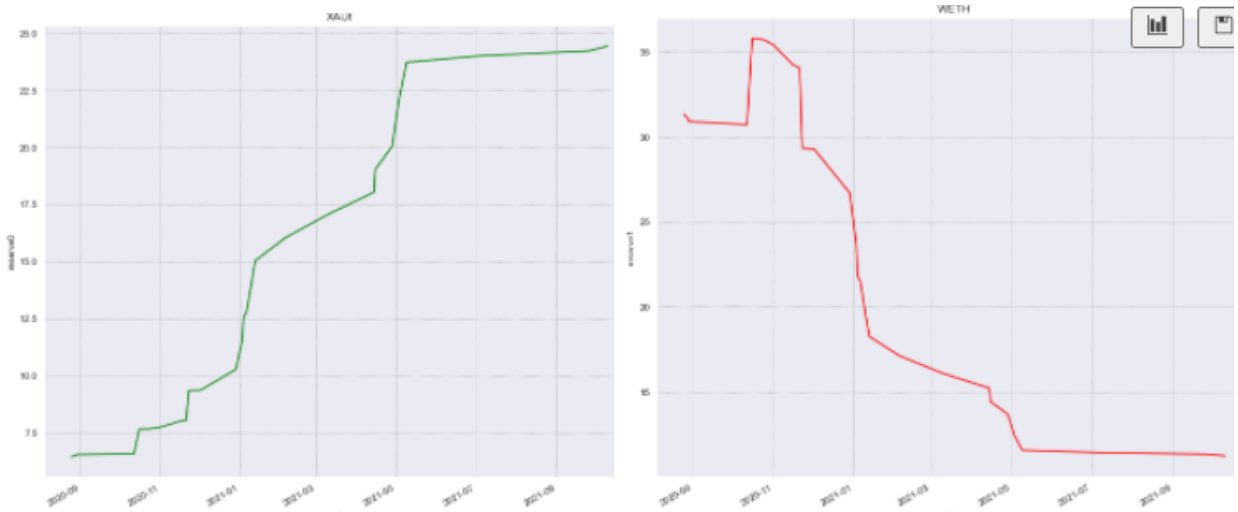
The important moment that requires mentioning is that the “scam” SQUID token used a scheme conform which no trader was able to perform sell operation over the token, causing only a price increase of the token. If the market wants to protect participants it would be required to consider such cases and pay attention to the behavior of such tokens.

XAUt/WETH (STO) or how STO is used only to get access to altcoin

Tether gold is a digital asset that is offered by TG Commodities Limited. One full XAUt token represents one troy fine ounce of gold on a London Good Delivery bar. The principle behind the token is to have gold ownership avoiding drawbacks associated with physical gold, such as high storage costs and limited accessibility (links: 1, 2). Authors took Uniswap V2 history of this token and below is presented the token history.

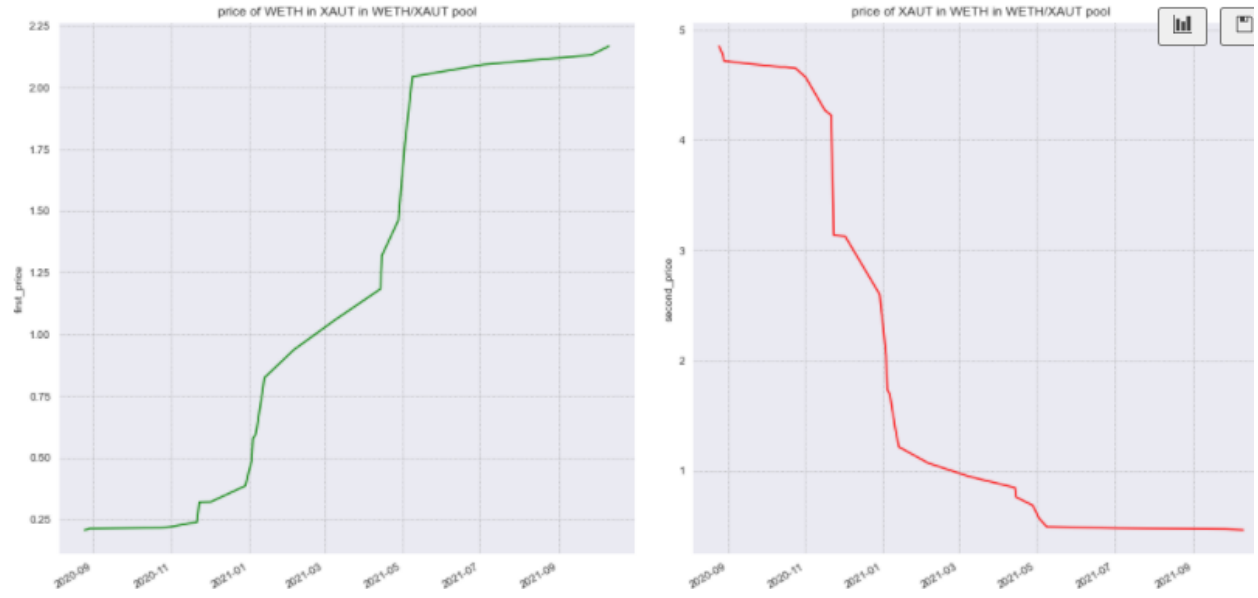
Picture 111: swap-based XAUt token price in the XAUt/WETH pool

There were no swap transactions from WETH to XAUt setting such a situation when XAUt token price is decreasing. Reserve-based XAUt token price distribution looks similar to the swap-based one.



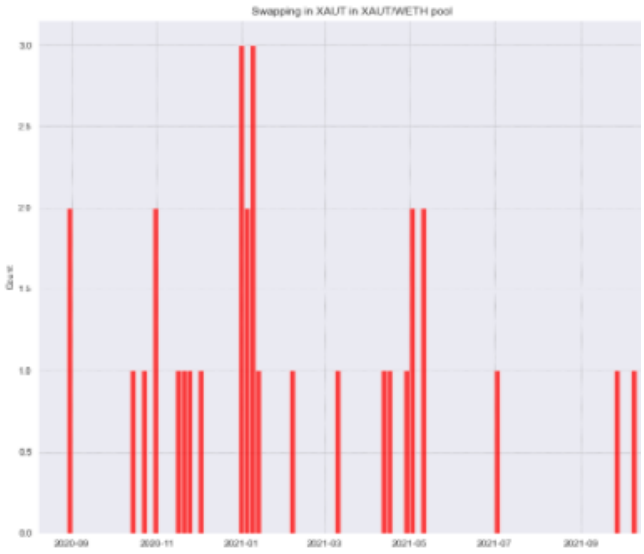
Picture 112: reserves distributions in the XAUt/WETH pool

Conform presented distributions can be seen that reserves of the pool are slowly increasing from the WETH side and decreasing from XAUt one.



Picture 113: reserve-based price distributions of the XAUt/WETH pool

The problem behind this pool is in its small reserves and relatively high transaction values, decreasing price so much that reserves increase in the current case just cause a smaller decrease of the XAUt token price.



Picture 114: swaps transaction count for XAUt in the XAUt/WETH pool

The situation in the current pool is relatively bad, considering that reserves are small, transaction rate is small and therefore MEV attack can be easily performed. Additional factor about possible MEV attacks is that both tokens in the pool are popular, meaning that their attractiveness is higher for attackers compared to the other pools.

The last important observation about this pool is that the price taken from the start of the pool lifecycle is not matching the real one. At the start of pool lifecycle the price set for one XAUt was around 5 WETH. WETH token price was around 420-430 USD dollars while XAUt price was around 1900 USD dollars. Ethereum price was rising through the entire time taken. This pool looks like a good source of getting Ethereum at a smaller price compared to the real-market one. Therefore, this pool does not have at all swaps of WETH to XAUt due to the bad price.

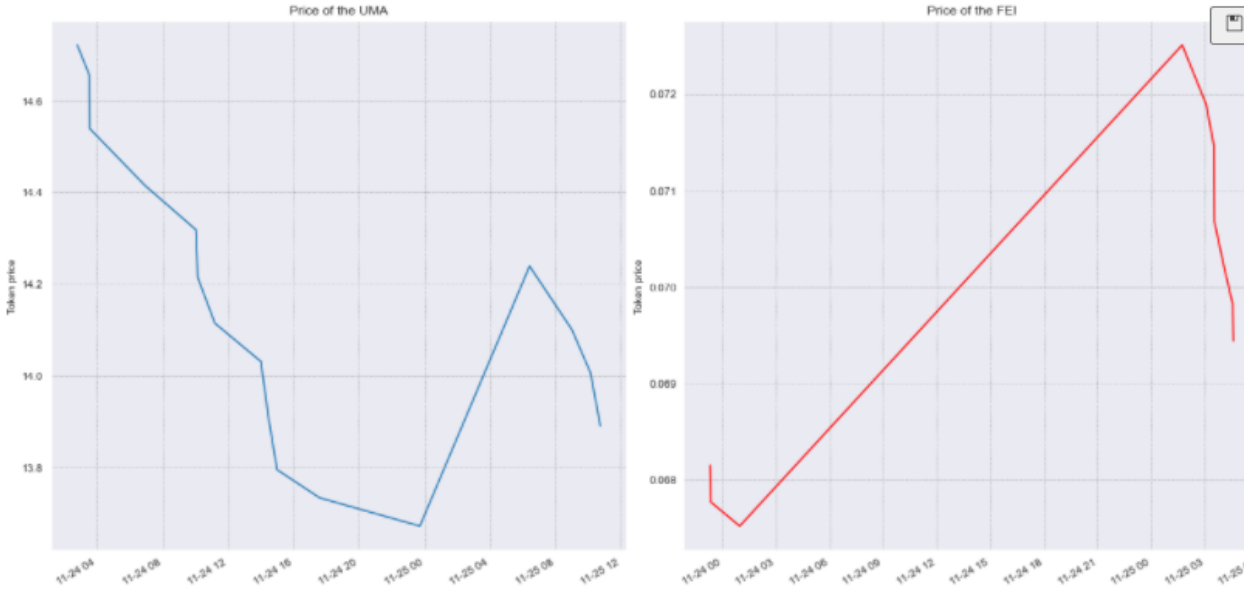
Picture 115: XAUt token price for the last year distribution taken between end of November 2020 till end of November 2021

Considering that this pool became a good source of getting Ethereum at a smaller price it is hard to say if this pool further will become a complete one with exchanges on both sides.

UMA/FEI (STO)

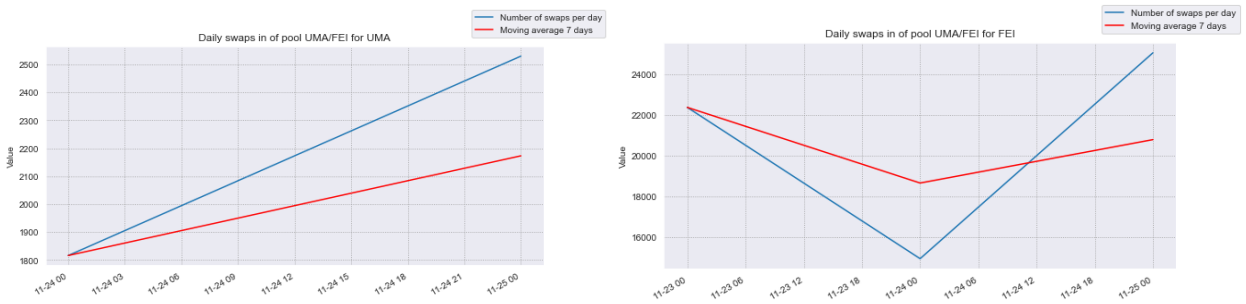
UMA is an Universal Market Access token that was launched in December 2018. UMA gives the option of digitizing any real-world derivatives like futures, contracts for difference, swaps and so on. The reason why this idea appeared was that there are limitations and high financial barriers present on the financial market and authors of the UMA wanted to give an option for any person to become a part of this market (Link: 1).

UMA/FEI is a relatively new pool on the Uniswap V2 that has a history of only several days and therefore charts will not represent a clear distribution picture. For better understanding it is required to have a bigger picture, but even basing on the current time interval something can be estimated.



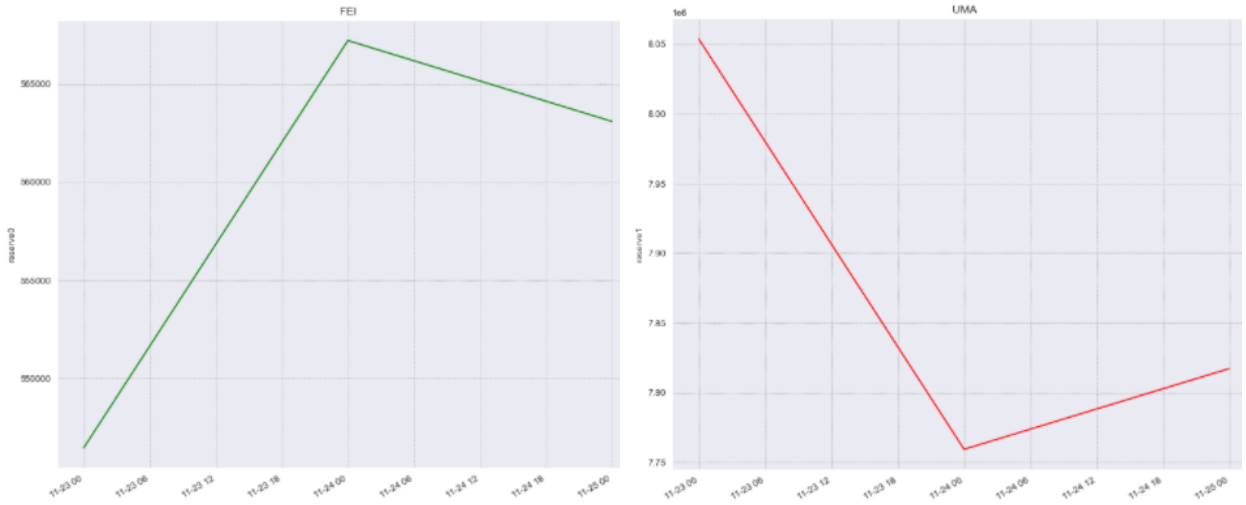
Picture 115: swap-based prices distributions of the UMA/FEI pool

Conform presented distributions can be seen that the time window is relatively small and UMA token was slowly decreasing during the first day and had a small rise during the second day. The FEI token price is increasing but during the second day this token was decreasing. Those distributions show people's interest in changing the UMA token to the stablecoin one.



Picture 116: swaps activity distributions in the UMA/FEI pool

Conform present charts can be seen that there is a relatively small activity, but with further pool evolution it can become a popular and reliable pool.



Picture 117: reserves distributions of the UMA/FEI pool

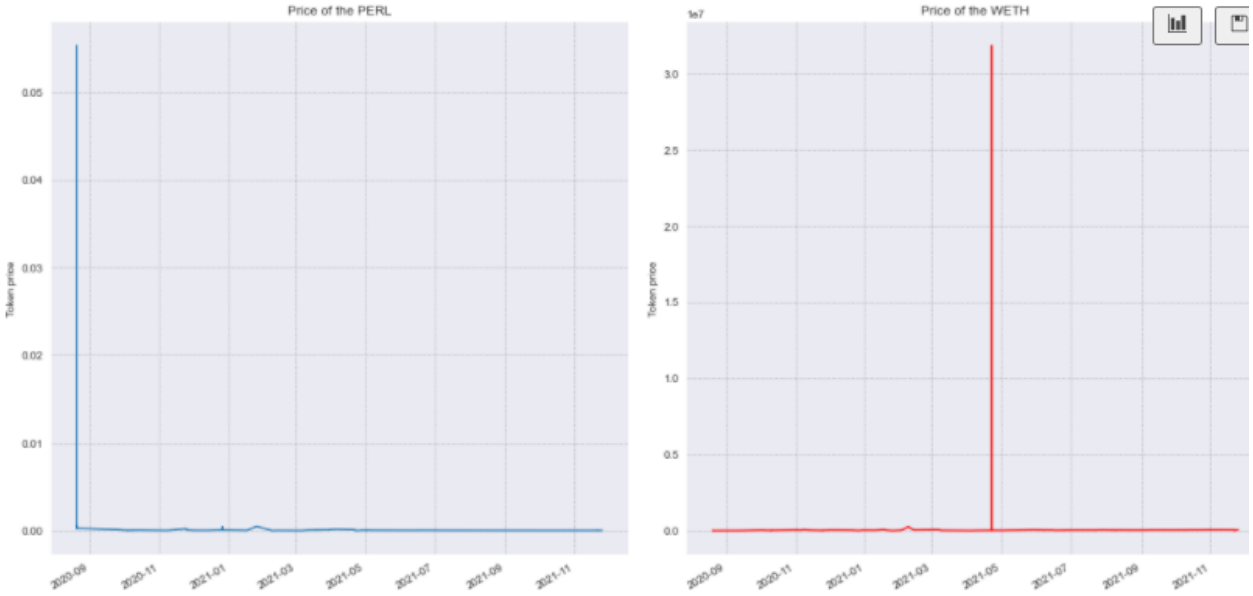
Conform presented pool reserves can be seen that the pool is relatively stable and attackers would require a high financial power to perform this attack and transaction frequency (even for such a small time window) is relatively high. Therefore, it would be difficult to perform a MEV attack on that pool.

To perform a more efficient and better overview of the pool distributions, to find patterns in the data and find general trends it would be useful to get a bigger time window and therefore to get a better history.

PERL/WETH (STO) or how mint transactions could save a pool

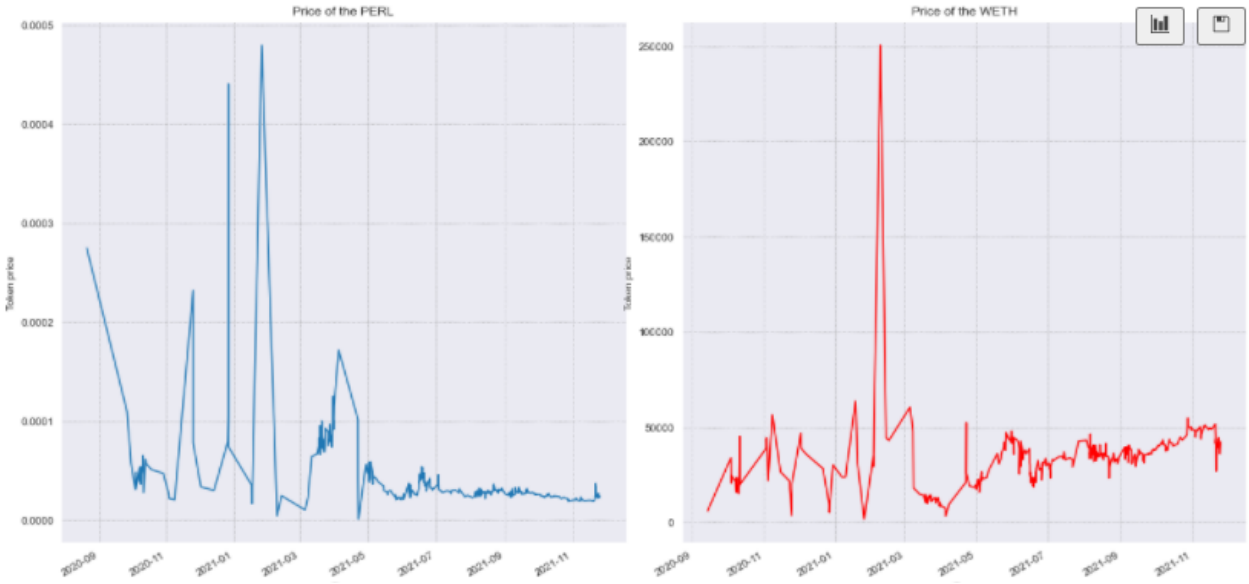
PerlinX is a decentralized finance interface platform that allows users to trade assets of any kind with each other through incentivized liquidity mining and synthetic asset generation. Pools on that platform are powered by the Balancer protocol and use UMA protocol to generate

synthetic assets (link: 1). This token was found inside the PERL/WETH pool on the Uniswap V2.



Picture 118: swap-based price distributions of the PERL/WETH pool

Presented distributions are unclear considering that there is a big drop of the token price from the PERL side and a great token price rise from the WETH side. Eliminating those prices from distributions is required to see a better picture.



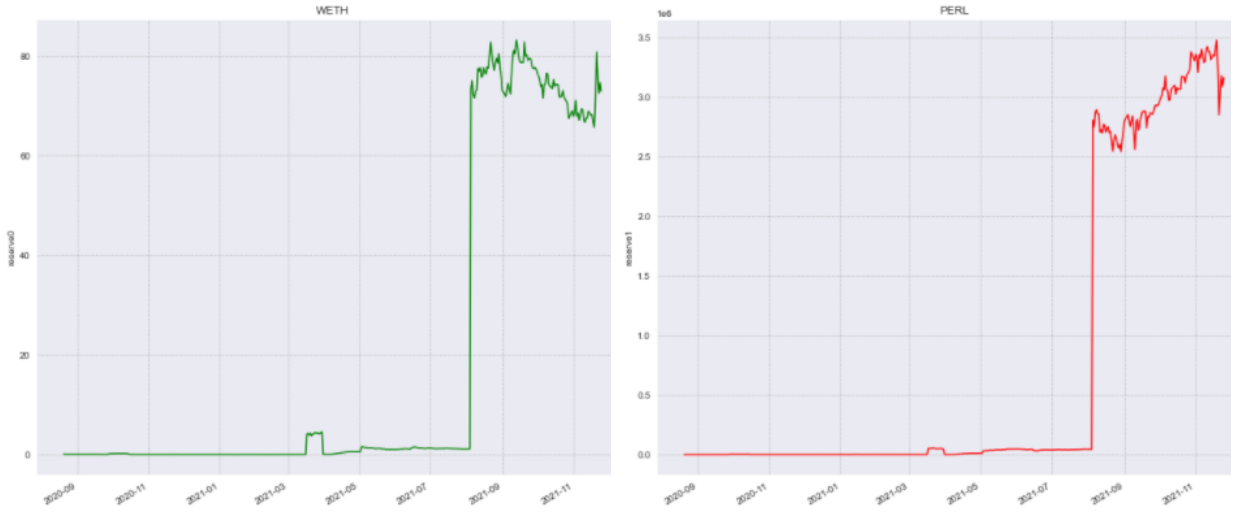
Picture 119: swap-based price distributions of the PERL/WETH pool

Swap-based prices distributions show better overview with removed strange behaviors. Even with removed anomalous rises in the price there are strange rises that should be analyzed closely.

	token_in	token_out	amount_in	amount_out	amount_usd	timestamp	first_to_second_price	price_change_rate
7	PERL	WETH	408.979034	1.546745	312.551851	2020-08-20 07:44:09	3.781967e-03	1528.124912
8	WETH	PERL	0.010000	39.812766	2.020848	2020-08-20 07:53:39	3.981277e+03	22180.594590
69	PERL	WETH	901.362451	0.209247	63.801716	2020-11-24 20:25:34	2.321456e-04	1020.592464
102	PERL	WETH	1316.251394	0.631761	450.743442	2021-01-25 12:17:45	4.799698e-04	2734.041390
104	WETH	PERL	0.001461	50.000000	1.000974	2021-02-02 03:04:53	3.423146e+04	1852.842586
213	WETH	PERL	0.277616	424153.138076	357.593123	2021-04-22 13:25:58	1.527841e+06	7099.831468
214	WETH	PERL	0.001372	43680.787426	1.766648	2021-04-22 13:25:58	3.184822e+07	1984.523861
218	PERL	WETH	600.370614	0.030088	38.991787	2021-04-28 09:44:12	5.011490e-05	4547.285878

Picture 120: transactions with biggest price change rates

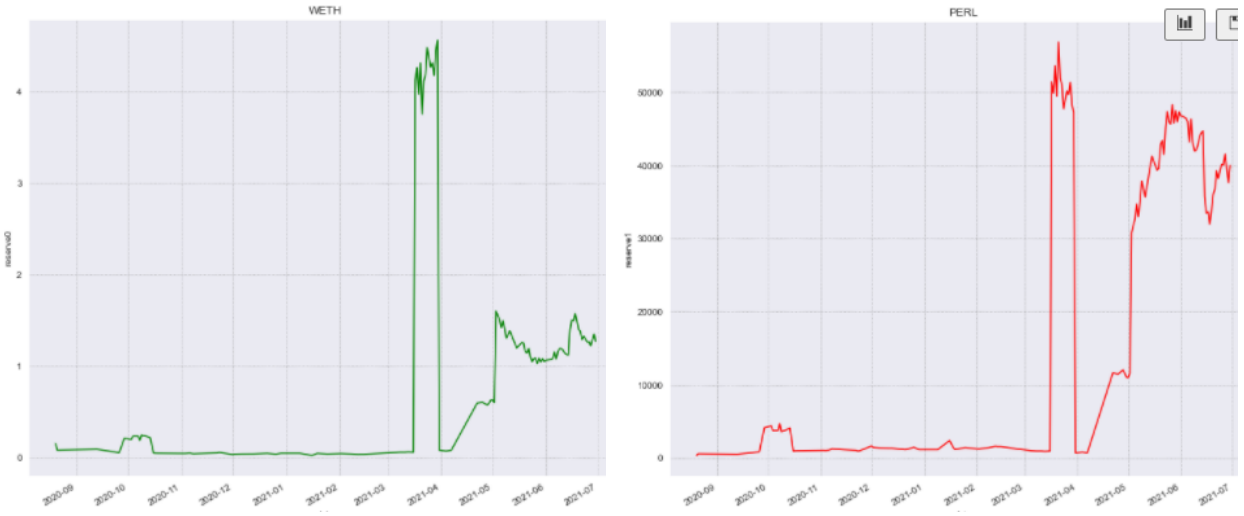
Some transactions have anomalously high transaction price change rates, meaning that there are either MEV attacks, or there were some extreme changes in the reserves.



Picture 121: reserves distributions for the PERL/WETH pool

Conform presented reserves distributions there were very small reserves amount until middle of August 2021, meaning that even relatively small transactions would cause big price changes. After the middle of August 2021 there is an anomalous rise of pool reserves. In order to ensure that price change rates were caused by small reserves it was decided to look into transaction history.

Below can be seen a mints transaction history, conform which first reserves inserted in the pool are around 450 of PERL and around 0.1 of WETH.



	amount0	amount1	timestamp
0	0.100000	4.500000e+02	2020-08-20 07:31:20
1	0.184215	2.819900e+03	2020-09-29 17:26:24
2	0.002946	6.350000e+01	2020-11-06 17:48:44

	token_in	token_out	amount_in	amount_out	amount_usd	timestamp	first_to_second_price	price_change_rate
3	WETH	PERL	0.111533	2.000000	22.576193	2020-08-20 07:37:55	17.931936	-12.868540
4	PERL	WETH	2.058032	0.113905	23.020060	2020-08-20 07:41:29	0.055346	NaN
5	WETH	PERL	0.122975	2.197419	24.871883	2020-08-20 07:43:44	17.868808	-0.352045
6	PERL	WETH	9.435072	0.002192	0.442872	2020-08-20 07:44:09	0.000232	-99.580298
7	PERL	WETH	408.979034	1.546745	312.551851	2020-08-20 07:44:09	0.003782	1528.124912
8	WETH	PERL	0.010000	39.812766	2.020848	2020-08-20 07:53:39	3981.276636	22180.594590
9	WETH	PERL	0.010000	33.276398	2.018745	2020-08-20 07:55:58	3327.639778	-16.417770

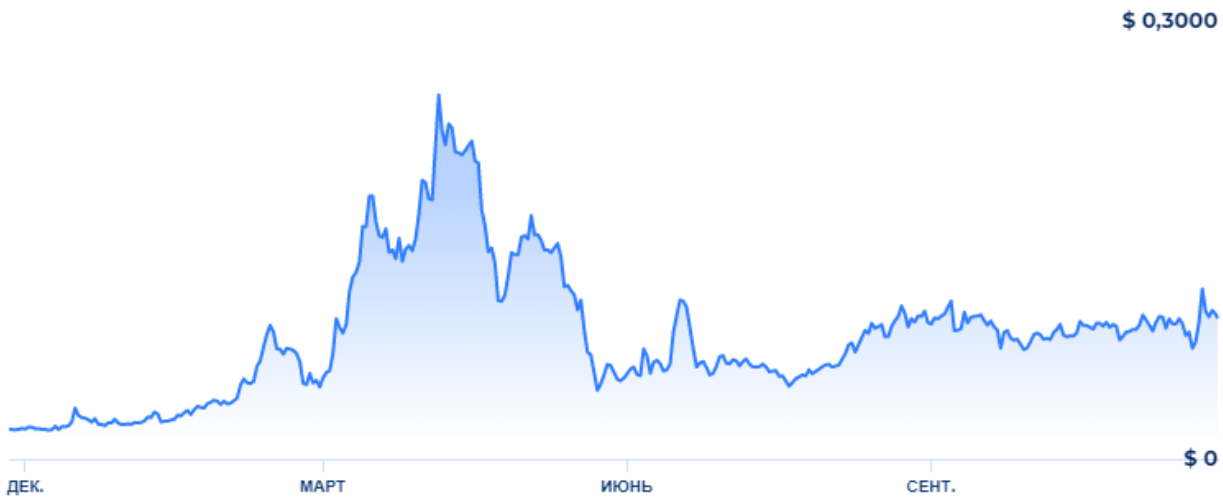
Picture 122: reserves distributions in the PERL/WETH pool with first three mints history and swap transactions history fragment, where anomalous price rise was registered

Presented transaction history demonstrates that anomalous price rise happened due to the small reserves values. Initial PERL reserves in the pool are around 295 PERL tokens and in the same date was registered a mint transaction that raised PERL token value by 450 PERL tokens having in result around 745 PERL tokens. As a result, swap of the 408 PERL tokens in the transaction nr. 7 causes drop of the 54.77% of pool reserves. Such a drop causes extreme change in the token price.

	reserve0	reserve1	reserveUSD	dailyVolumeToken0	dailyVolumeToken1	date	first_price	second_price
0	0.153498	2.958885e+02	62.347684	3.435517	1.087056e+03	2020-08-20	0.000519	1927.631252
1	0.081605	5.573478e+02	33.663391	0.071893	2.614593e+02	2020-08-21	0.000146	6829.813170
2	0.091605	4.966680e+02	33.233211	0.010000	6.067977e+01	2020-09-13	0.000184	5421.836328
3	0.054551	8.350475e+02	19.107331	0.037054	3.383795e+02	2020-09-26	0.000065	15307.637112

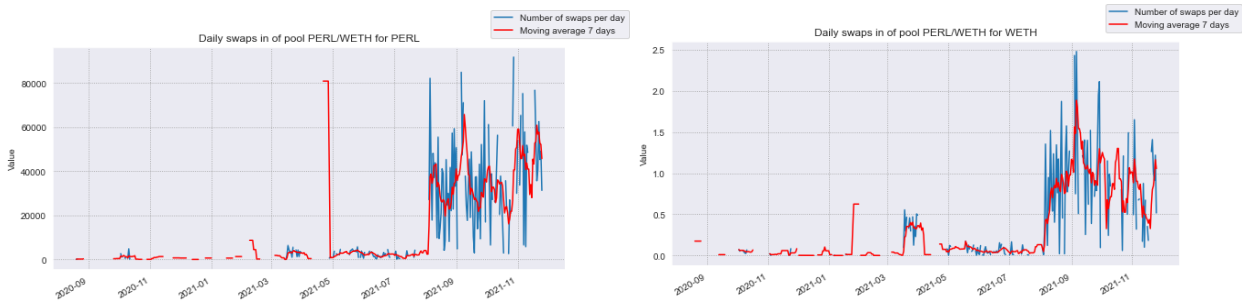
Picture 123: reserves distributions in the PERL/WETH pool

Another interesting observation is that all extreme price changes were registered before anomalous reserves mint. The strange thing about those mints is that in most of the cases they are happening with positive token price changes that signal to investors about possible further high activity of the pool.



Picture 124: PERL price in USD dollar changes taken from the coinranking.com for time interval between end of November 2020 till end of November 2021

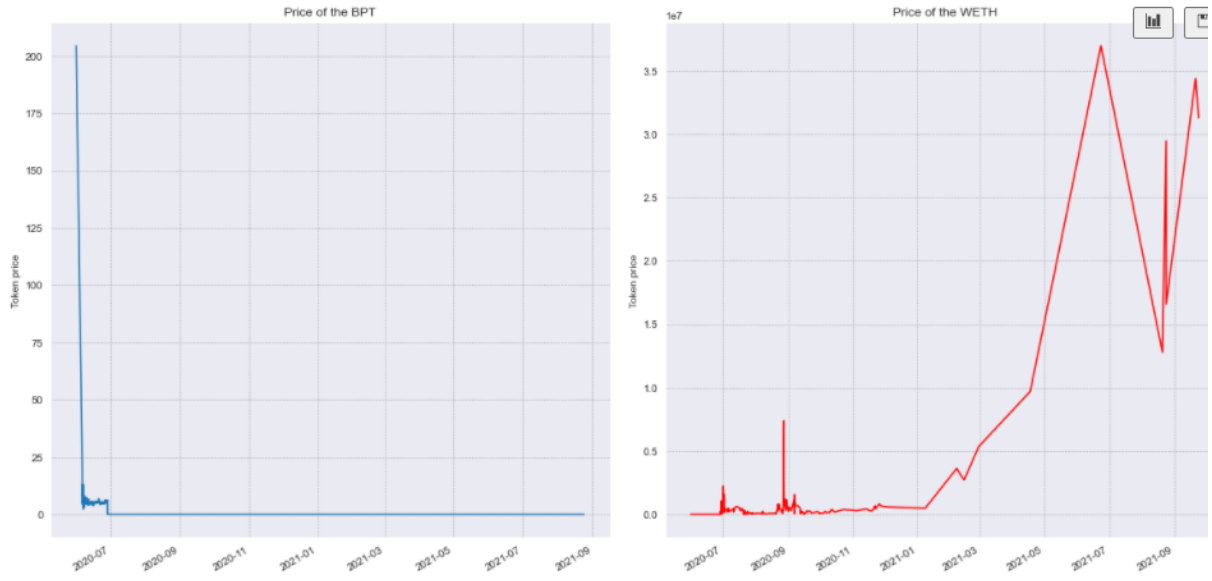
Conform presented distributions there should be mints transactions (either with high values or many of them) while anomalous mints were registered in the first half of August 2021. Authors suggest that anomalous mints were caused by the desire of token founders to save the presented pool. Another strange moment is that transaction count before anomalous mints is only ⅓ of transaction history, while after reserves mints transaction count is ⅔ of transaction history. More than 1000 of the 1500 transactions happened during the last 3 months while before that only 500 transactions happened in 8.5 months. This can be seen even on the swap activity charts.



Picture 125: swaps activity charts for PERL/WETH pool

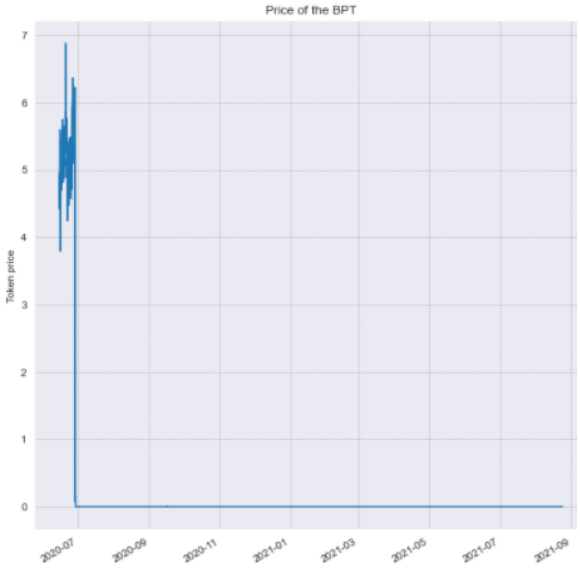
BPT/WETH (STO) or how incorrect pool prices can lead to pool death

BPT tokens are Balancer Pool tokens created for Balancer Platform. This is a community-driven protocol, automated portfolio manager, liquidity provider, and price sensor. The tokens are representing a share of a specific pool and in case of losing BPT token, the person loses its share of mints in the invested pool (links: 1, 2).



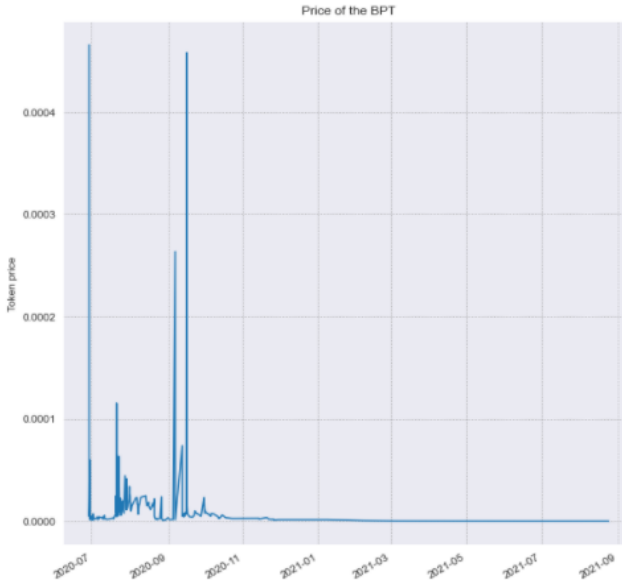
Picture 126: swap-based price distributions in the BPT/WETH pool

Anomalous price change in the beginning of the pool lifecycle makes a BPT token distribution hard-to-read. In order to see the overall picture it is required to check price distribution excluding anomalous price drop segments.



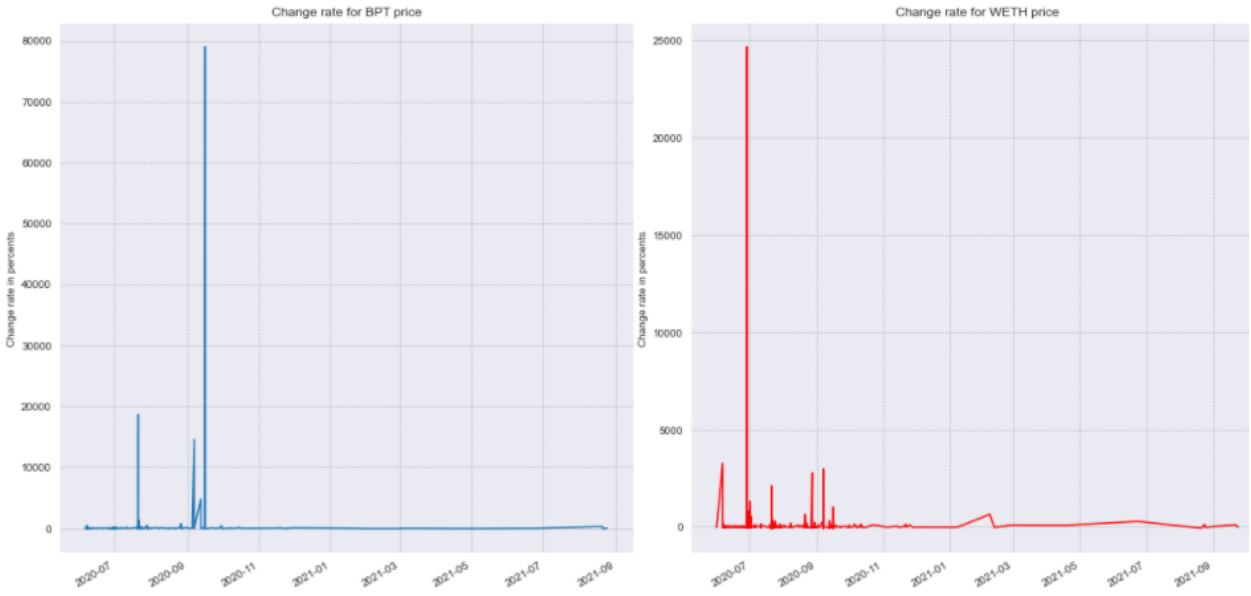
Picture 127: swap-based price distribution of the BPT token in the BPT/WETH pool after 15th June 2020

Presented flat line in the distribution may be a much smaller price that due to the small prices it looks as a flat line on the distribution. The distribution was taken from July 2020, but distribution was still flatlined and it was decided to take all transactions whose price was smaller than 0.002.



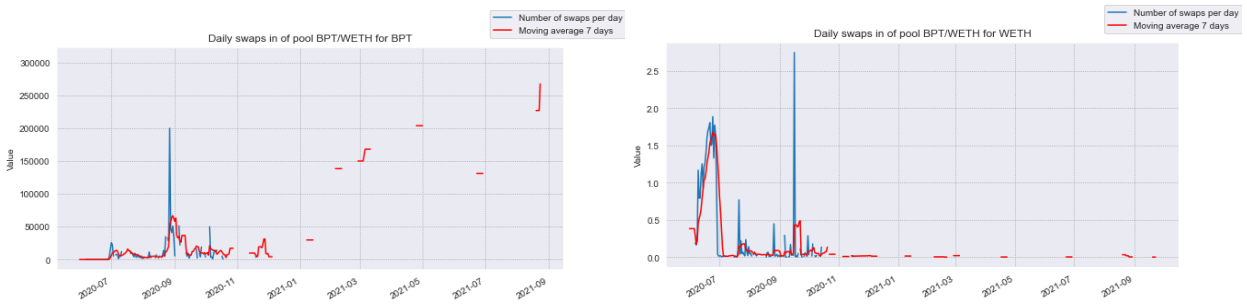
Picture 128: swap-based token price in the BPT/WETH pool where token price is smaller than 0.002

The price changes are too high. Therefore it was decided to find price change rates distributions in the BPT/WETH pool.



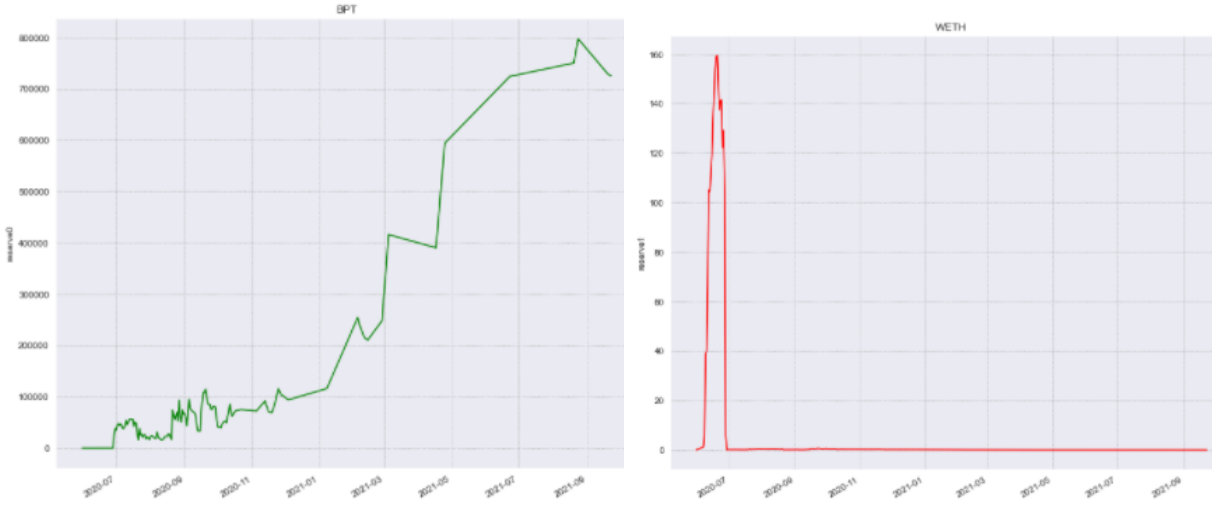
Picture 129: swap-based price change rates in the BPT/WETH pool

The strange moment about both of the presented distributions is that there are many changes present in the time interval between June 2020 till middle of October 2020. It means that the high swap activity period was in the same time period. This can be seen on the distributions shown below.



Picture 130: swap activity in the BPT/WETH pool

In order to check why price changes dropped it was decided to check pool reserves presented below.



Picture 131: BPT/WETH pool reserves distributions

Conform presented distributions another reason why price changes have stabilized is due to the reserves increase over the time. Price could stabilize with increase of reserves, but while BPT reserves greatly increased the WETH reserves came to almost zero. Therefore it is important to check distributions closely.

Looking at the swaps operations tokens movement it was decided to check what was the WETH token movement during 28th June 2020, after which pool started to lose almost all WETH tokens.

```
print(bpt_weth_df[(bpt_weth_df.index > 1679) & (bpt_weth_df.index < 1977) & (bpt_weth_df.token_in == 'BPT')]['amount_out'].sum())
print(bpt_weth_df[(bpt_weth_df.index > 1679) & (bpt_weth_df.index < 1977) & (bpt_weth_df.token_in == 'WETH')]['amount_in'].sum())
```

✓ 0.4s

```
227.1167151118571
138.73205975724926
```

Picture 132: WETH token movement inside BPT/WETH pool where first number represents token moving out of the pool and the second one represents token moving into the pool

During transactions between numbers 1700 and 1850 there was removed around 80.12 WETH token. Conform reserves records for the start of 27th June there were around 105 WETH token reserve. It means that using swap operations there was removed around 76.3% of WETH token pool reserves.

	amount0	amount1	amountUSD	liquidity	timestamp
0	0.038184	5.250594	2461.568018	0.447214	2020-05-31 21:06:15
1	0.417425	2.000000	945.674491	0.887479	2020-06-13 10:07:00
2	0.119339	0.582595	275.554580	0.256009	2020-06-13 16:50:17
3	3.280877	16.797741	7885.957027	7.204152	2020-06-14 10:14:07
4	2.659988	11.818349	5190.763404	5.436221	2020-06-15 06:32:10
5	2.575563	13.775960	6217.870796	5.772561	2020-06-15 17:54:35
6	0.007609	0.038823	17.953201	0.016500	2020-06-22 02:10:53
7	2.714016	13.339686	6494.472194	5.771805	2020-06-22 18:27:18
8	0.228369	1.126151	543.369184	0.485606	2020-06-23 16:38:16
9	4.187742	20.707012	9628.537045	8.880001	2020-06-25 16:48:59
10	2.254845	12.293817	5621.547012	5.000000	2020-06-27 06:19:54
11	1.890473	10.326405	4735.810114	4.195795	2020-06-27 08:04:21
12	2.249246	12.730518	5563.581778	5.074951	2020-06-28 06:24:14
13	19926.757513	0.107702	23.803892	39.372188	2020-06-29 14:26:50
14	813.791060	0.002403	0.539017	1.078611	2020-07-03 01:26:21

Picture 133: Burns transactions in the BPT/WETH pool

Considering that person removed 80.12 tokens out of the pool and that after that there were burns on the total sum of around 23.06 tokens, meaning that at the end of 28 of June there remained only around 2 WETH tokens.

1721	BPT	WETH	0.004215	0.024040	5.424104	2020-06-28 15:58:01	0x7a250d5630b4cf539739df2c5dacb4c659f2488d	0xe644ae0d7640ed2838e97a3a0689e9bf50627eab	0xba5acdb334e420ed9dbaa469fbbb226ef2bdaeee98e8...	5.704031
1722	BPT	WETH	0.267191	1.500000	335.551931	2020-06-28 16:08:49	0x7a250d5630b4cf539739df2c5dacb4c659f2488d	0x7a250d5630b4cf539739df2c5dacb4c659f2488d	0x22e6869b5d7a895bcaa6b75d6b00378699ef9ea5ec54...	5.613970
1725	BPT	WETH	0.121490	0.680867	153.222975	2020-06-28 17:11:22	0x0000000000025d4386f7fb58984cbe110aee3a4c4	0x0000000000025d4386f7fb58984cbe110aee3a4c4	0x43a7469912b079520f99f8699866bcb03145a2c37d16...	5.604305
1726	BPT	WETH	0.157132	0.866407	194.780662	2020-06-28 17:12:07	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x1c387372410b4226910b5bac6a9bf5ccbf613990a562...	5.513875
1729	BPT	WETH	0.474830	2.845818	634.537659	2020-06-28 17:57:22	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x9e5b29aee88011c038cdd0c23f2ce8b3913816af555a...	5.993346
1730	BPT	WETH	0.301881	1.711233	383.648371	2020-06-28 17:57:45	0xf164fc0ec4e93095b804a4795bbe1e041497b92a	0xf164fc0ec4e93095b804a4795bbe1e041497b92a	0x0b5ca2ad19858642b2e5712cd52b97d61602c1524c1b...	5.668570
1731	BPT	WETH	0.076169	0.441519	99.642952	2020-06-28 17:57:45	0x693c188e40f760ecf00d2946ef45260b84fbc43e	0x693c188e40f760ecf00d2946ef45260b84fbc43e	0x91b907040b92a61c3b5065dbbe935129faf4f402477f...	5.796583
1733	BPT	WETH	494.784081	92.193342	10763.617011	2020-06-28 18:03:14	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0xe71b7ec874808805f1fd39106ebba7acc6b7533151c9...	0.186330
1735	BPT	WETH	30.867565	2.265044	464.643724	2020-06-28 18:03:23	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0xe739f130dd8c0e3a86fdc966a6adbb0688319f101992...	0.073379
1739	BPT	WETH	15.656916	1.572610	335.606901	2020-06-28 18:03:43	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x1a572ef61d8cd249ec7e020d6f6282b7987a9e737db2...	0.100442
1743	BPT	WETH	26.152808	2.648828	544.493173	2020-06-28 18:04:23	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0xe9e36815602bcb36cb7823d0d3913fd8e93a722cd123...	0.101283
1746	BPT	WETH	14.735481	1.534026	327.869574	2020-06-28 18:05:09	0xf1ad4bfdf8829d55ec0ce7900ef9d122b2610673	0xf1ad4bfdf8829d55ec0ce7900ef9d122b2610673	0x0376d703ea15409a14927ef51715241a2671f32ff71e...	0.104104
1749	BPT	WETH	16.235134	2.150065	453.345085	2020-06-28 18:05:23	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0xb1085e37d2d3c347c6d36242058c4112c1ed5413311d...	0.132433
1750	BPT	WETH	24.636451	3.677403	744.456818	2020-06-28 18:05:52	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x860bd2dba9cd475a61e6d1b45e16c365f6d78f66	0x3d99bc68155084f53d746522ec892915adc00f22875e...	0.149267

Picture 134: transaction history catching 4 transactions during which one person extracted almost all of the tokens in the BPT/WETH pool

Considering this extraction of all tokens out of the pool it is required to check pool-based token prices with real-market ones. Conform information on 28-th June 2020 taken from the coinmarketcap.com the BPT token price is around 12.03$, while WETH token price is around 231$. It means that one WETH token is equivalent to 19.2 BPT tokens (or BAL token).

Picture 135: BPT token price distribution for the last year taken from coinmarketcap.com

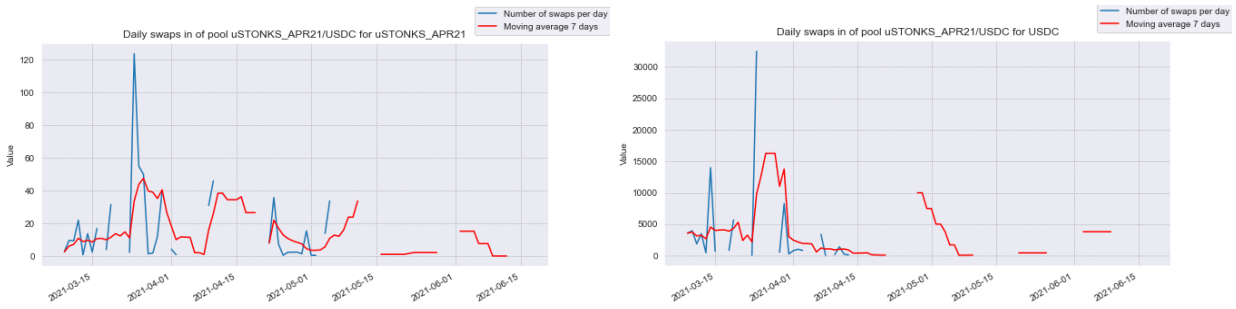
Transaction history shows that BPT token is equal to around 5.7 WETH tokens, which is not corresponding to the real-market price. Some attackers discovered that token prices are not corresponding to the real-market ones and there is a possibility of extracting all precious tokens using the less precious token. This is a perfect illustration of why token price should correspond or to be close to the real-market price. Otherwise some persons could try extracting all precious tokens using their less precious equivalents in the pool.

Another reason why this case is a unique one - for performing this attack a person used 567 BPT tokens that are equal to the 870$ which is a very small financial power required for performing this attack. Person extracted WETH token equal to the around 23 100$ meaning that person extracted and got around 22 230$ of profit from this situation.

After performing this attack on the pool there is almost no activity registered, meaning that pool died after extreme price changes and people see no reason for changing tokens inside this pool.

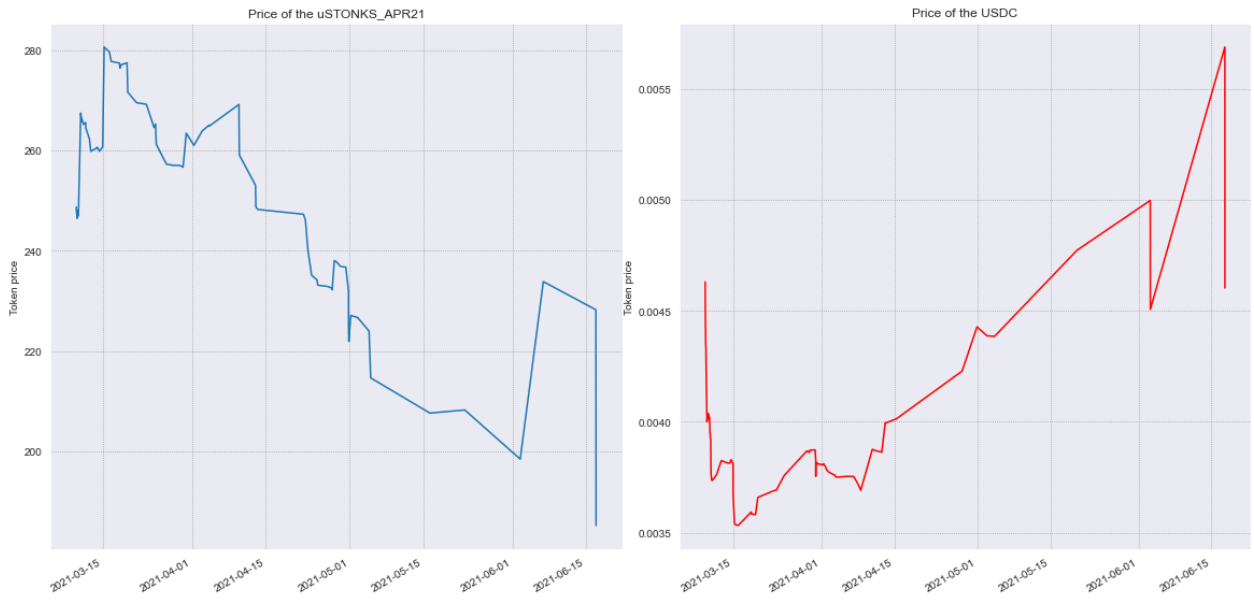
uSTONKS_APR21/USDC (STO) or small pool with bad activity

uSTONKS_APR21 token is a synthetic that tracks the ten most “bullish” Wall Street Bets stocks and captures sentiment of this community. This is a result of collaboration of the UMA project with YAM Finance to develop a suite of innovative DeFi derivatives (links: 1, 2). The problem about this token was that authors were not able to find token price distributions and therefore in the current chapter will be reviewed only information taken from Uniswap V2.



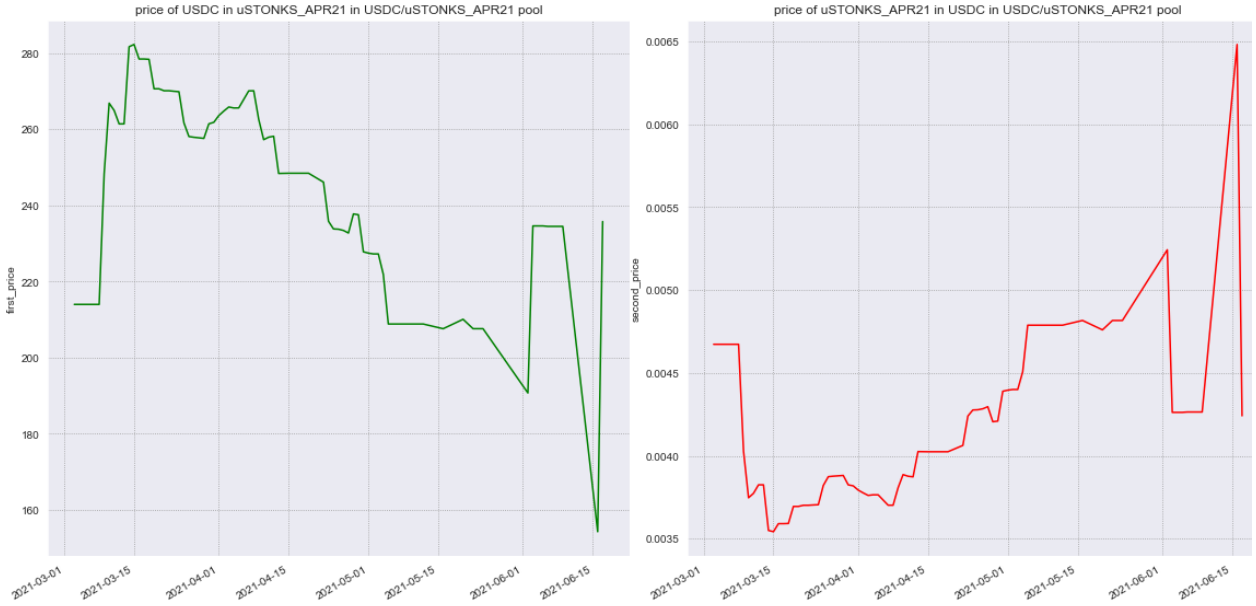
Picture 136: swap operations activity of the uSTONKS_APR21/USDC pool

Swap activity is relatively low and there were two periods of some present activity - during March 2021 and during the end of April 2021. The lack of price information makes it difficult to find out the reason for such activity drops and there is no option of checking if those changes were caused by bad token prices. Therefore it is required to dive deeper into the present data and compare swap-based prices and reserve-based ones.



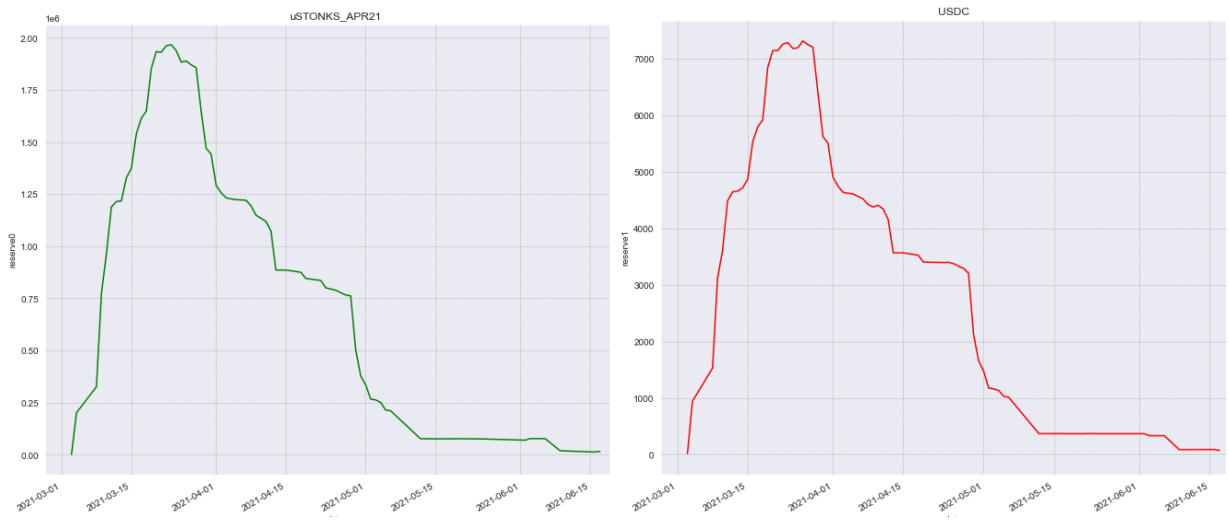
Picture 137: swap-based token price distributions of the uSTONKS_APR21/USDC pool

uSTONKS_APR21 price is slowly dropping with small local rises of token price, while USDC token price is slowly increasing. In the current case pool price changes are not caused by the both token prices changes due to use of stablecoin in pair with STO.



Picture 138: reserve-based token price distributions of the uSTONKS_APR21/USDC pool

General shapes of distributions look similar and swap-based prices are less stable compared to the reserve-based ones and the general price pattern is similar. The problem about the current pool is that there is a small overall transaction count, representing low pool activity and that pool data has multiple gaps.



Picture 139: reserves distributions of the uSTONKS_APR21/USDC pool

Presented distributions demonstrate that prices in the pool were more stable and close to the real ones during high-reserves values. Also transaction frequency during this period was higher compared to the period with smaller reserves. This change can be caused by the user's desire to exchange tokens in more stable and large pools than in ones that are less stable. Conform analyzed distributions there were no extreme changes that would represent frauds or some attackers activity while pool had both small reserves and small transactions frequency, meaning that presented tokens in the pool are not popular ones.

Current pool state is looking like a “dead” pool that has almost no present activity, where reserves are extremely low and where prices are unstable with negative trends.

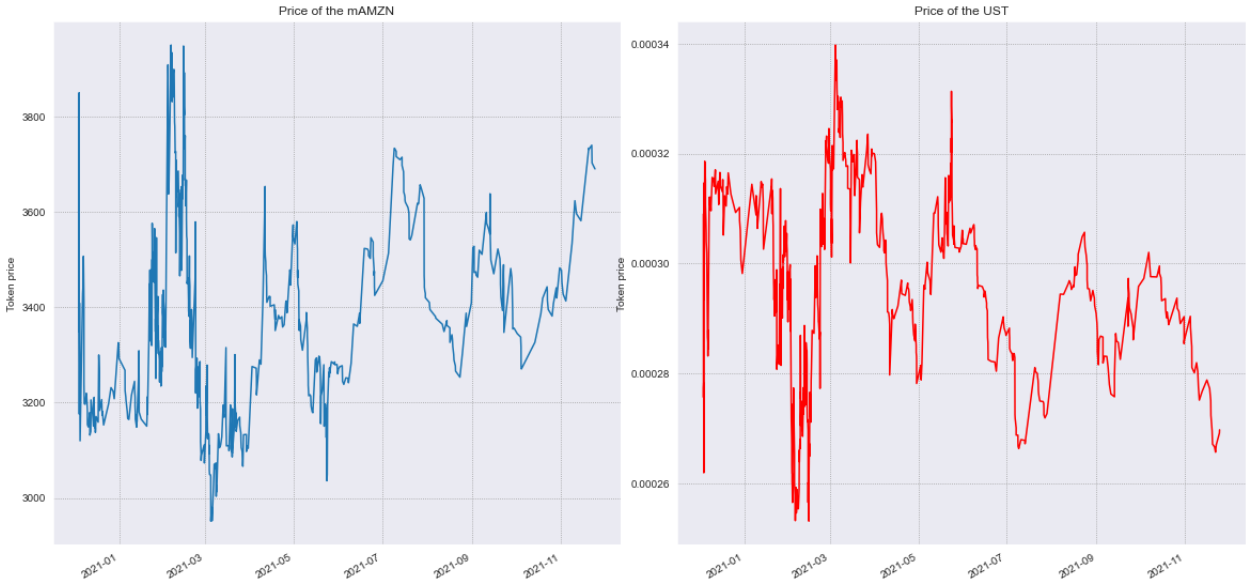
mAMZN/UST (STO)

mAMZN (or Mirrored Amazon) is a synthetic asset tracking the price of an Amazon stock. mAMZN exists as CW20 and ERC20 versions which can be traded on the Terraswap and Uniswap respectively (links: 1, 2). It can be minted on the Mirror protocol, which references on-chain prices provided by Band Protocol’s decentralized network or oracles.

This pool also contains TerraUSD token (shortly called UST) which is a decentralized and algorithmic stablecoin of the Terra blockchain. It is a scalable, yield-bearing coin that is value-pegged to the USD dollar. It was launched in September 2020 (link: 1).

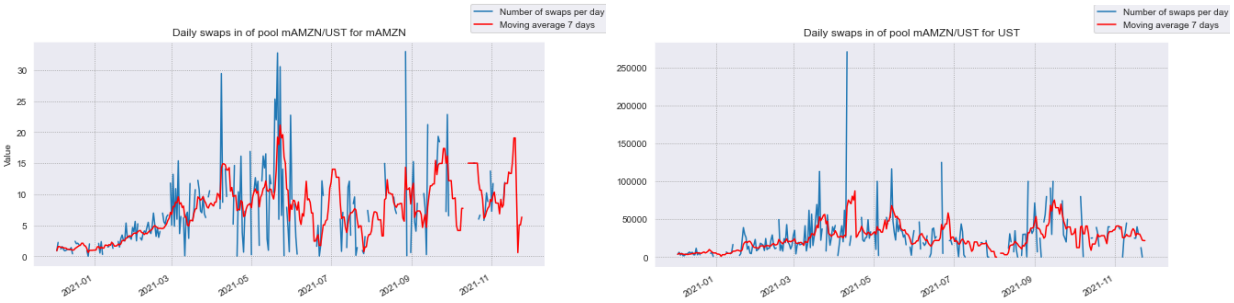
Picture 140: mAMZN token price from the left and UST token price from the right distribution for last year taken from CoinMarketCap.com

There were only two drops of the stablecoin price, meaning that price changes in the distribution could happen in the beginning of the 2021 and during the end of May 2021.



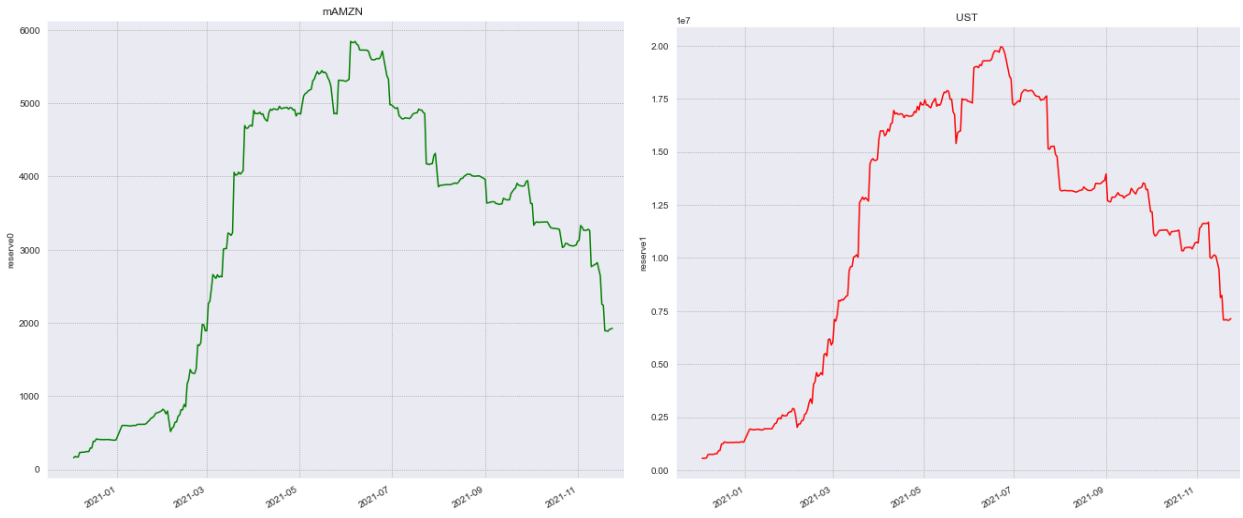
Picture 141: swap-based price distributions for the mAMZN/UST pool

During the start of the pool, the life cycle has “noisy” distribution, meaning that there is either small transaction frequency reducing “balancing” or small reserves in the pool.



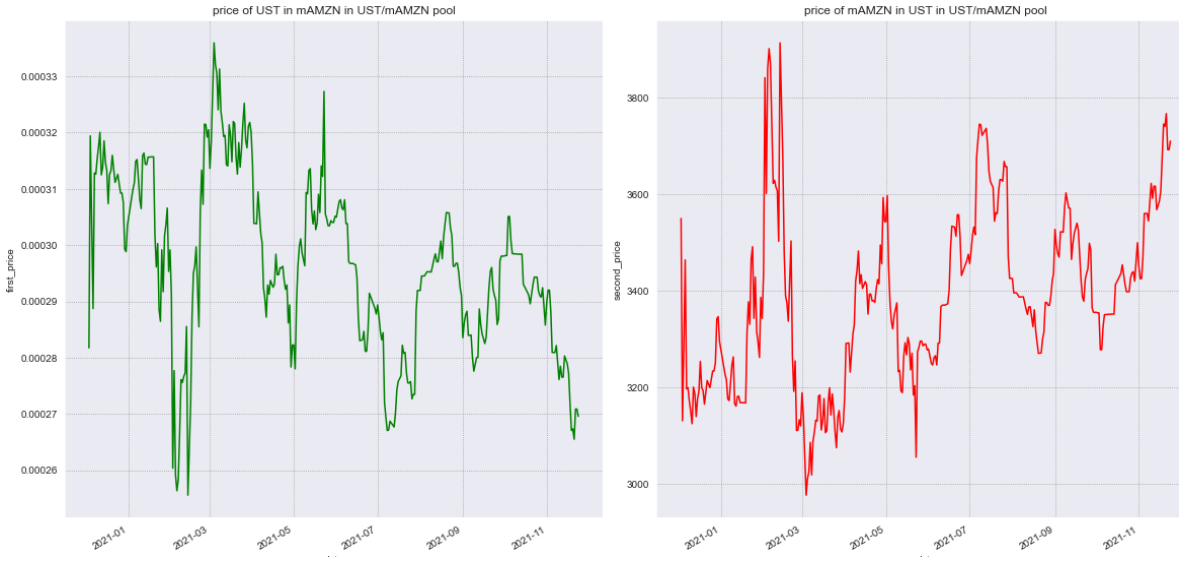
Picture 142: swap transaction activity in the mAMZN/UST pool

There were drops in transaction frequency starting from July 2021. Till that moment transaction frequency is relatively high, meaning that “noisy” price distributions in the first half and clearer distributions in the second half are caused by drop of the transaction frequency and therefore it is required to check pool reserves distributions.



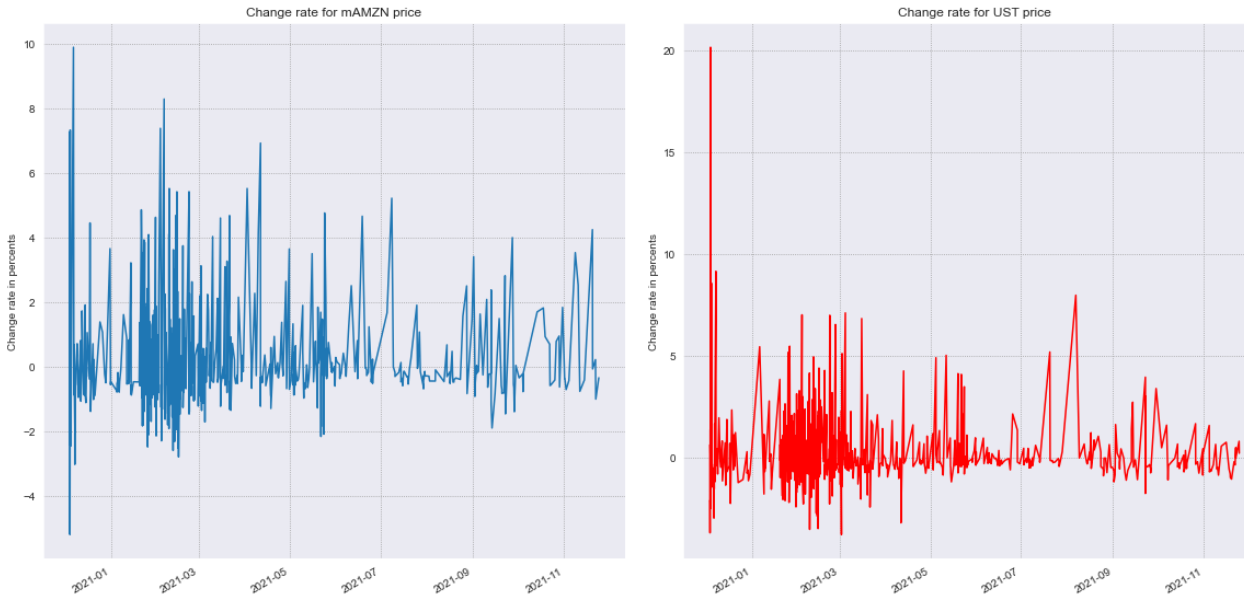
Picture 143: reserves distributions in the mAMZN/UST pool

Reserves in the pool were fastly increasing during the first half of the year and after that started a slow decrease of the token price. Transaction frequency had a great drop while pool reserves were increasing. This behavior is strange. Another strange moment is that mAMZN reserve-based token price has bigger rises and drops compared to the real market price distributions.



Picture 144: reserve-based price distributions in the mAMZN/UST pool

Considering that pool represents relatively popular tokens with big capitalization and high mAMZN token price it is important to dive deeper into pool price changes.



Picture 145: swap-based price change rates distributions in the mAMZN/UST pool

Swap-based price change rates look stable compared to the other ones, meaning that there were not registered extreme rises and drops in token prices. Conform distributions can be seen that there are higher change rates present during the beginning of the pool life cycle with smaller pool reserves and higher transaction frequency.

mBABA/UST (STO)

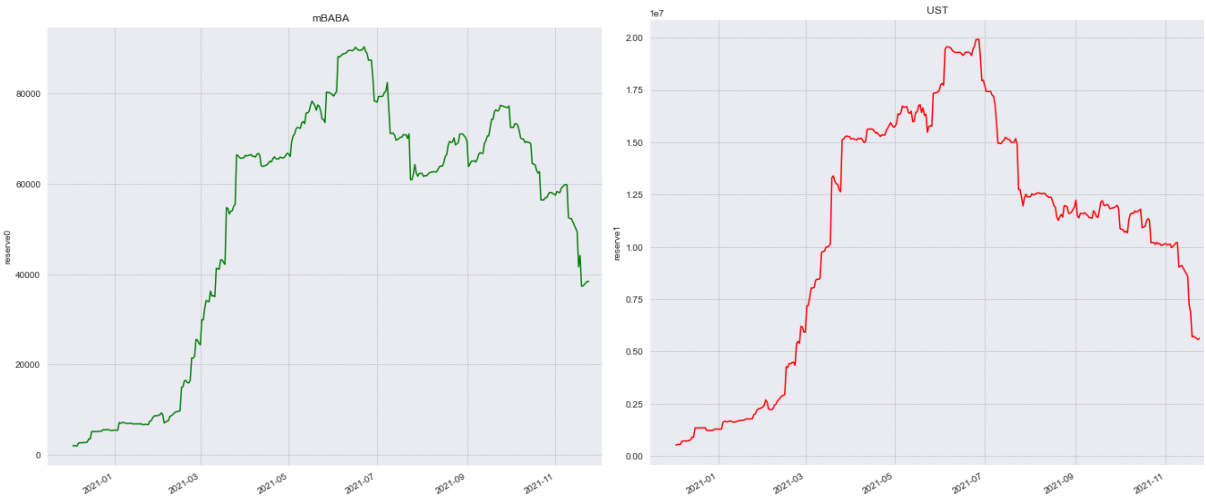
Mirrored Alibaba (or mBABA) is a token that works by the same principle as mAMZN token and represents Alibaba shares prices.

Picture 146: mBABA token price distribution taken from the CoinMarketCap.com

mBABA price is slowly decreasing and both swap-based and reserve-based token prices should correspond to the real-market price distribution.

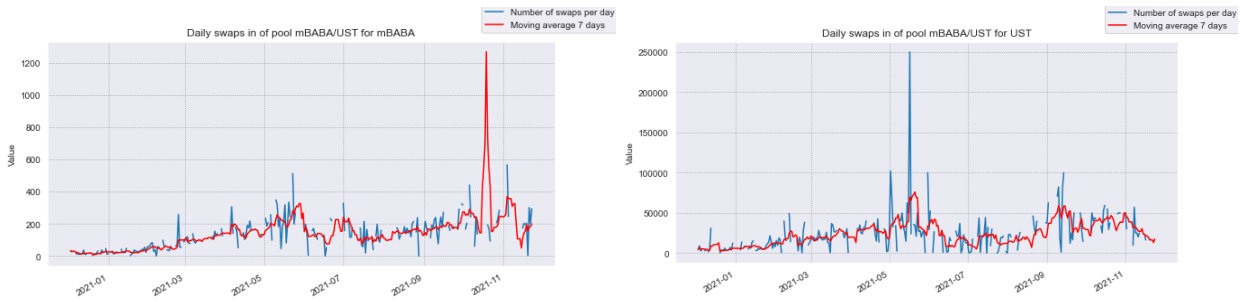
Picture 147: swap-based token prices distributions for the mBABA/UST pool

During the start of the pool life cycle there is a “noise” in distributions that represent either small transaction frequency or small reserves in the pool. After the first 3 months of pool activity distribution became more stable.



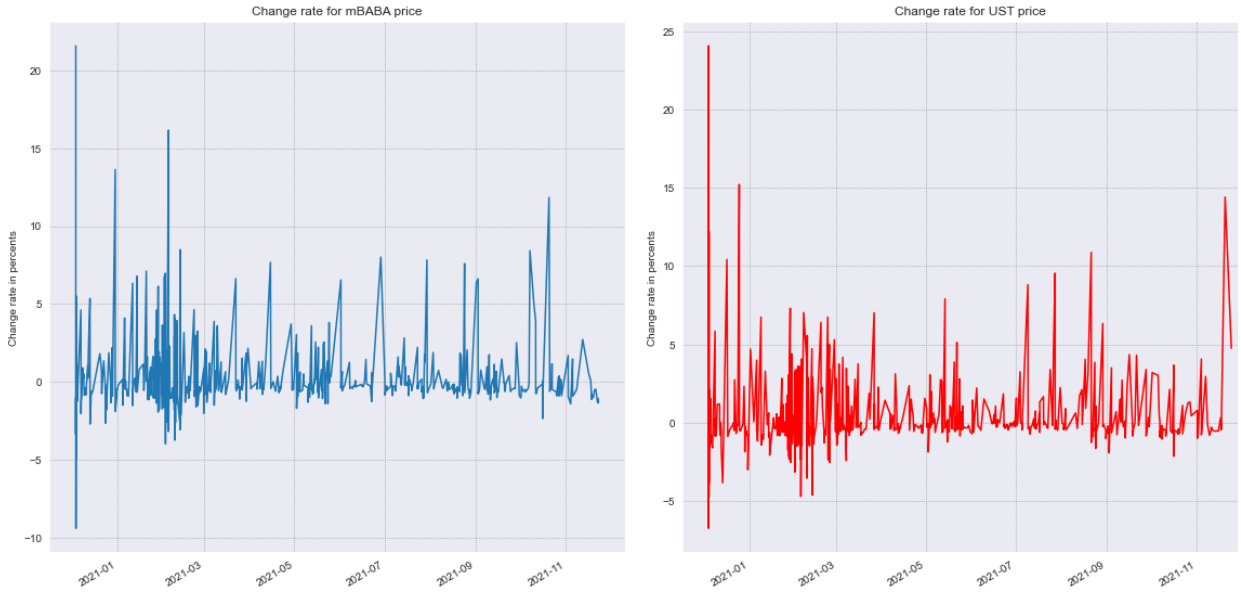
Picture 148: reserves distributions in the mBABA/UST pool

Reserves distributions show that during the first half of the pool life cycle “noise” present in the distributions is caused by small reserves present in the pool.



Picture 149: swap transactions activity in the mBABA/UST pool

Presented distributions show relatively stable activity with medium-level activity size. There should be no extreme drops and rises of the tokens prices, considering that pools are relatively big and transactions frequency is enough to hold prices from extreme changes.

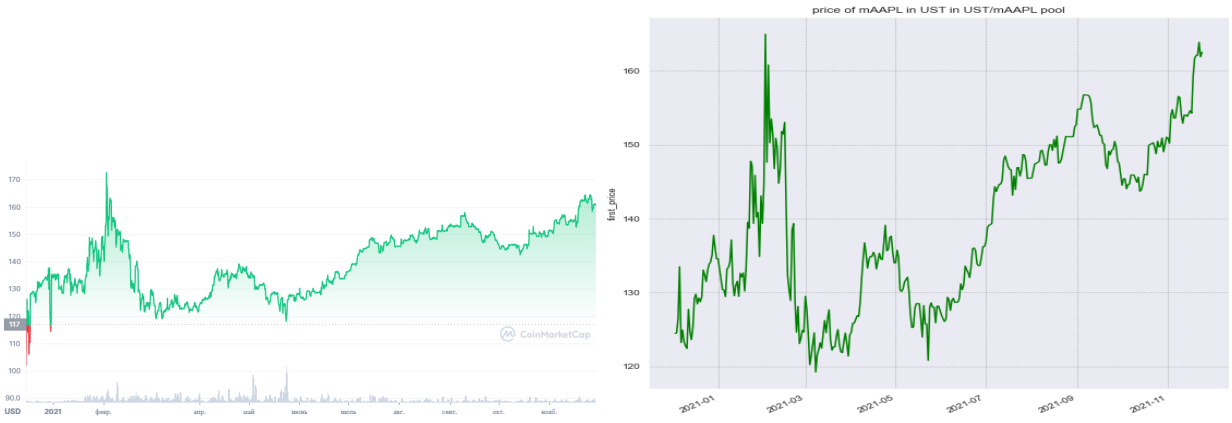


Picture 150: swap-based price change rates in the mBABA/UST pool

There are no extreme price changes present in the distribution meaning that there were no frauds or MEV attacks performed over the pool. Still, transaction frequency keeps an option for attackers with high financial power to perform such an attack.

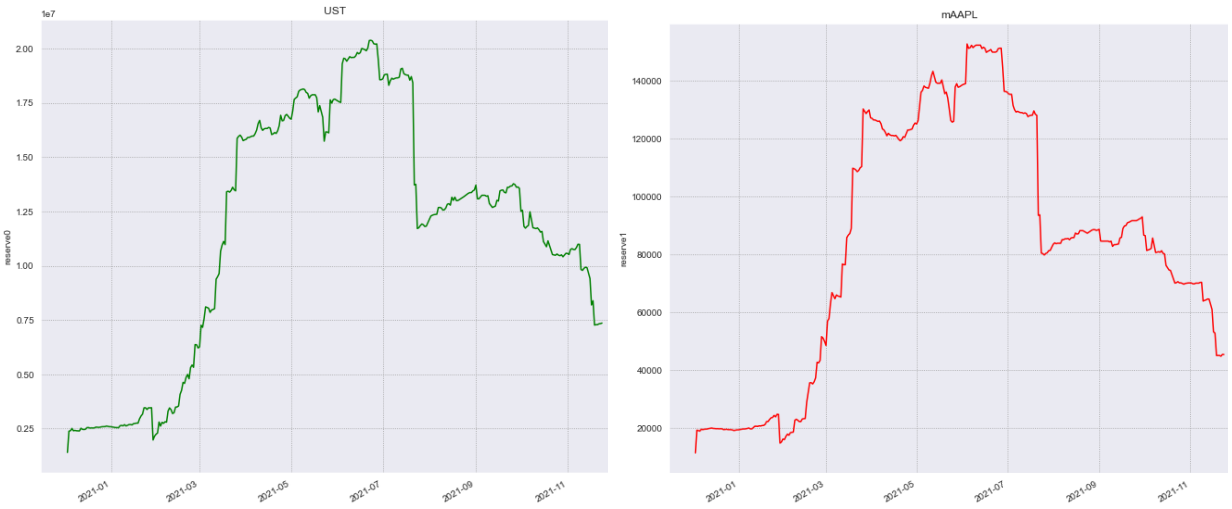
mAAPL/UST (STO)

mAAPL is working with the same principle as mBABA and mAMZN tokens and mirrors Apple company share price. Compared to the previous “mirrors” this pool has the biggest transaction history.



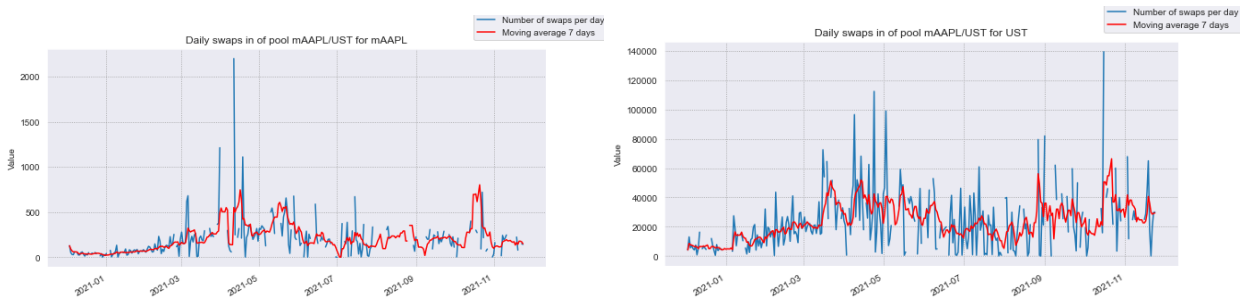
Picture 151: mAAPL token price distribution taken from the CoinMarketCap.com from the left and mAAPL swap-based token price from the right

Pool-based token price and real-market based one have similar distributions and therefore pool converges to the real market distributions. mAAPL token price is “noisy” meaning that pool reserves increased at the stage of smoothing the distribution. This can be seen on the distributions presented below.



Picture 152: reserves distribution for the mAAPL/UST pool

This pool is less likely to become a target for MEV attack or for extraction of all presented tokens, considering that there are high financial resources required for performing an attack and high transaction frequency.



Picture 153: swap transactions activity in the mAAPL/UST pool

The last important moment about this pool is that transaction frequency is relatively stable.

Simulations

To identify how the volatility mitigation mechanism impacts the overall state of the pool and the change of the price of tokens inside the pool, as well as identify under which circumstances the volatility mitigator kicks in, simulations using real transaction history have been conducted in 2 different modes: with and without the volatility mitigation mechanism.

WBTC / DAI

This is a pool with a relatively low frequency of transactions and capitalization value. At the moment of the analysis the total locked liquidity inside the pool is 1,313,930$, the median of the swaps count per day across the entire history being X.

Historical stats:

X swaps

Y mints

Z burns

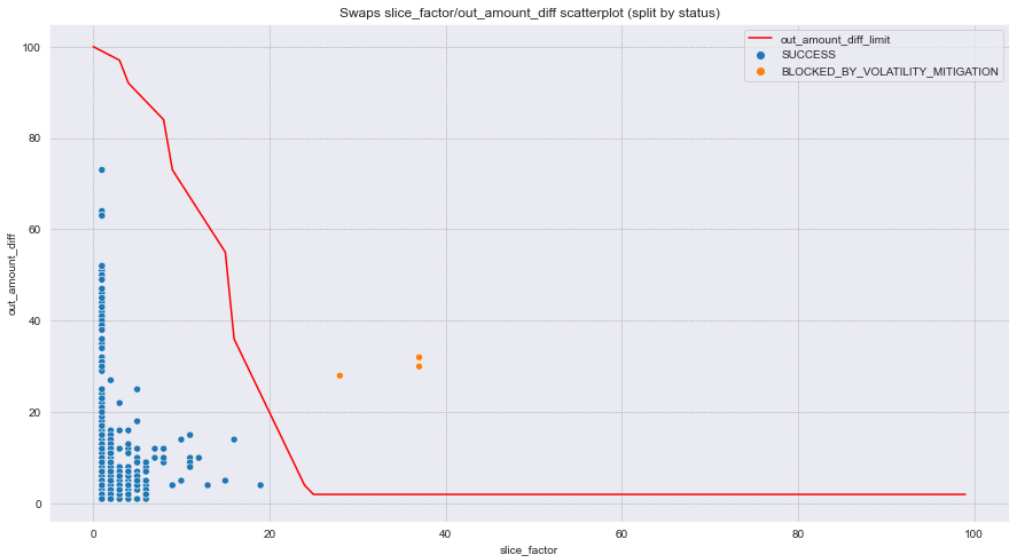
A more detailed overview of the pool can be found here.

After running the historical transactions from this pool through the synthetic AMM with the volatility mitigation mechanism enabled **3 out of 13 738** total swap-transactions have been **blocked**. During about **33.9%** of the cases the volatility mitigation mechanism didn't check the transaction because of the missing priceCummulative observation inside the DSW oracle. Below, is presented a table containing the information about each blocked transaction.

token_in	token_out	token_in_amount	token_out_amount	slice_factor	oracle_amount_out	out_amount_diff	reserve_Y_before	reserve_Y_before
DAI	WBTC	4000.000000	0.096655	37.0	0.134852	32.0	10782.468386	10782.468386
DAI	WBTC	152135.514321	2.855213	28.0	3.798328	28.0	546030.782612	546030.782612
WBTC	DAI	4.872345	143592.851237	37.0	195226.557181	30.0	540659.235042	540659.235042

Picture 162: Blocked by volatility mitigator transactions

todo: replace image, reserve_Y_before appears 2 times

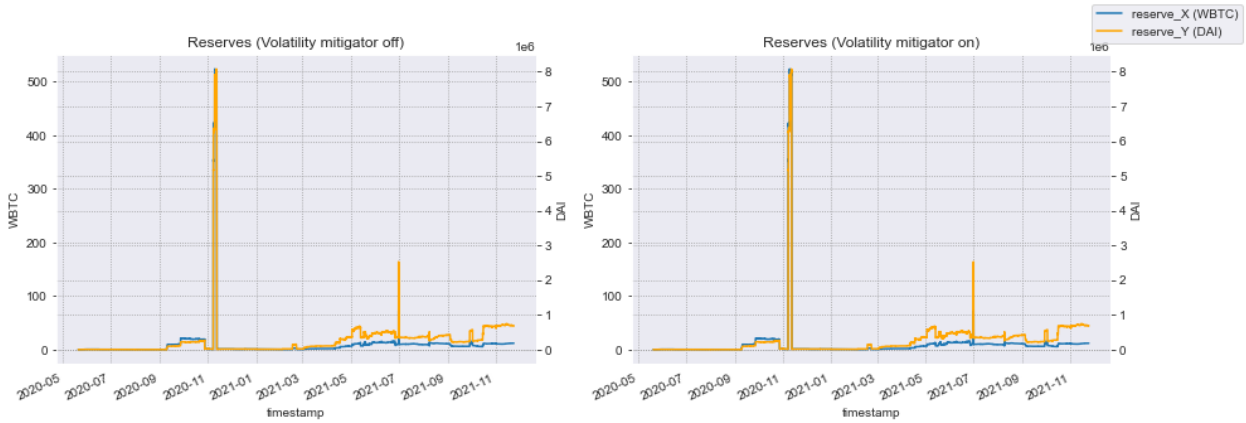


Picture 163: Swaps slice_factor/out_amount_diff scatter plot, split by status (with visualization of the out_amount_diff_limit)

Notes:

- in the plot above are not included the transactions for which TWAP couldn't be computed and which represent 33% from all of the transactions
- The out_amount_diff_limit border is not smooth, because the slice_factor_curve is computed according to the formula slice_factor * sqrt(slice_factor), where the sqrt(slice_factor) is rounded down in the original contract

The out_amount_diff limit separates the successful and blocked transactions visually very well. It can be observed that by varying the PRICE_TOLLERANCE_TRESHOLD by an amount of less than 20, no effect would be obtained. It would require to change this number by at least 20 in order to change the distribution of the successful/blocked transaction.



The reserves of the pool visually vary almost identically in the 2 distinct regimes. The second spike in the reserves (near 07.2021), which is not present in pool analysis section from the historical data, is caused by a large mint and burn during a single day (in the first section the extracted reserve values were daily, therefore the spike is not visible on the plot)

It can be seen from the variation of price that the volatility mitigation mechanism slightly decreases the price variation in several cases.

The sudden price increase in 02.03 is caused by a single transaction whose swap_in value is much bigger than the current reserves.

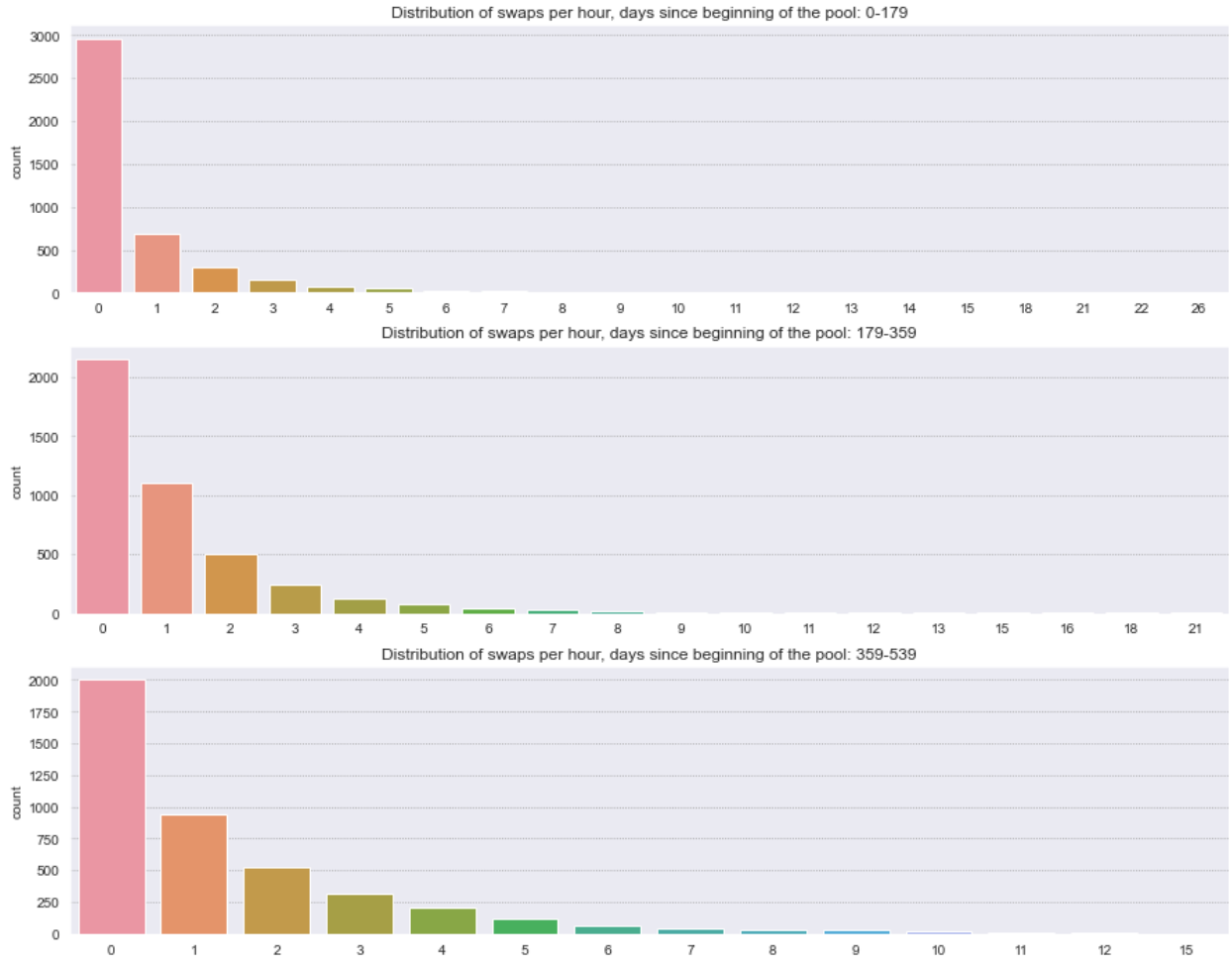
	token_in	token_out	token_in_amount	token_out_amount	mitigator_check_status	reserve_X_before	reserve_Y_before
4219	DAI	WBTC	10000.0	0.224279	CANT_CONSULT_ORACLE	0.440354	9537.874801

It can be seen that the volatility mitigator didn't check this transaction, as there were no swaps happening in the 1 hour window exactly 24 hours ago, even though during the entire 24 hour window_size period more than 10 swaps happened.

	token_in	token_in_amount	token_out_amount	mitigator_check_status	reserve_X_before	reserve_Y_before	transaction_timestamp	X_price
4208	DAI	23.169225	0.000725	CANT_CONSULT_ORACLE	0.360166	11365.037586	2021-02-02 21:20:12	31682.906432
4209	DAI	12.259807	0.000382	CANT_CONSULT_ORACLE	0.363637	11538.114135	2021-02-03 03:14:03	31796.775544
4210	DAI	101.080406	0.003120	CANT_CONSULT_ORACLE	0.363255	11550.324902	2021-02-03 04:26:15	32351.807538
4211	WBTC	0.000297	9.506241	CANT_CONSULT_ORACLE	0.360134	11651.000987	2021-02-03 04:36:03	32298.664654
4212	WBTC	0.001544	49.166394	CANT_CONSULT_ORACLE	0.360432	11641.456721	2021-02-03 04:39:35	32024.511635
4213	WBTC	0.000043	1.355833	CANT_CONSULT_ORACLE	0.361976	11592.093662	2021-02-03 09:50:32	32016.967973
4214	WBTC	0.000043	1.353929	CANT_CONSULT_ORACLE	0.362018	11590.732406	2021-02-03 10:55:02	32009.435793
4215	WBTC	0.000021	0.676528	CANT_CONSULT_ORACLE	0.362061	11589.373061	2021-02-03 10:58:20	32005.672464
4216	DAI	15.976918	0.000494	CHECKED	0.362082	11588.693827	2021-02-03 16:51:46	32093.364850
4217	DAI	16.363380	0.000504	CANT_CONSULT_ORACLE	0.361589	11604.606837	2021-02-03 18:13:00	32183.302391
4218	WBTC	0.079270	2074.731038	CANT_CONSULT_ORACLE	0.361085	11620.904763	2021-02-03 23:10:39	21659.537618
4219	DAI	10000.000000	0.224279	CANT_CONSULT_ORACLE	0.440354	9537.874801	2021-02-03 23:10:39	90236.450623

Picture 166: transaction frequency fragment around anomalous swap_in value

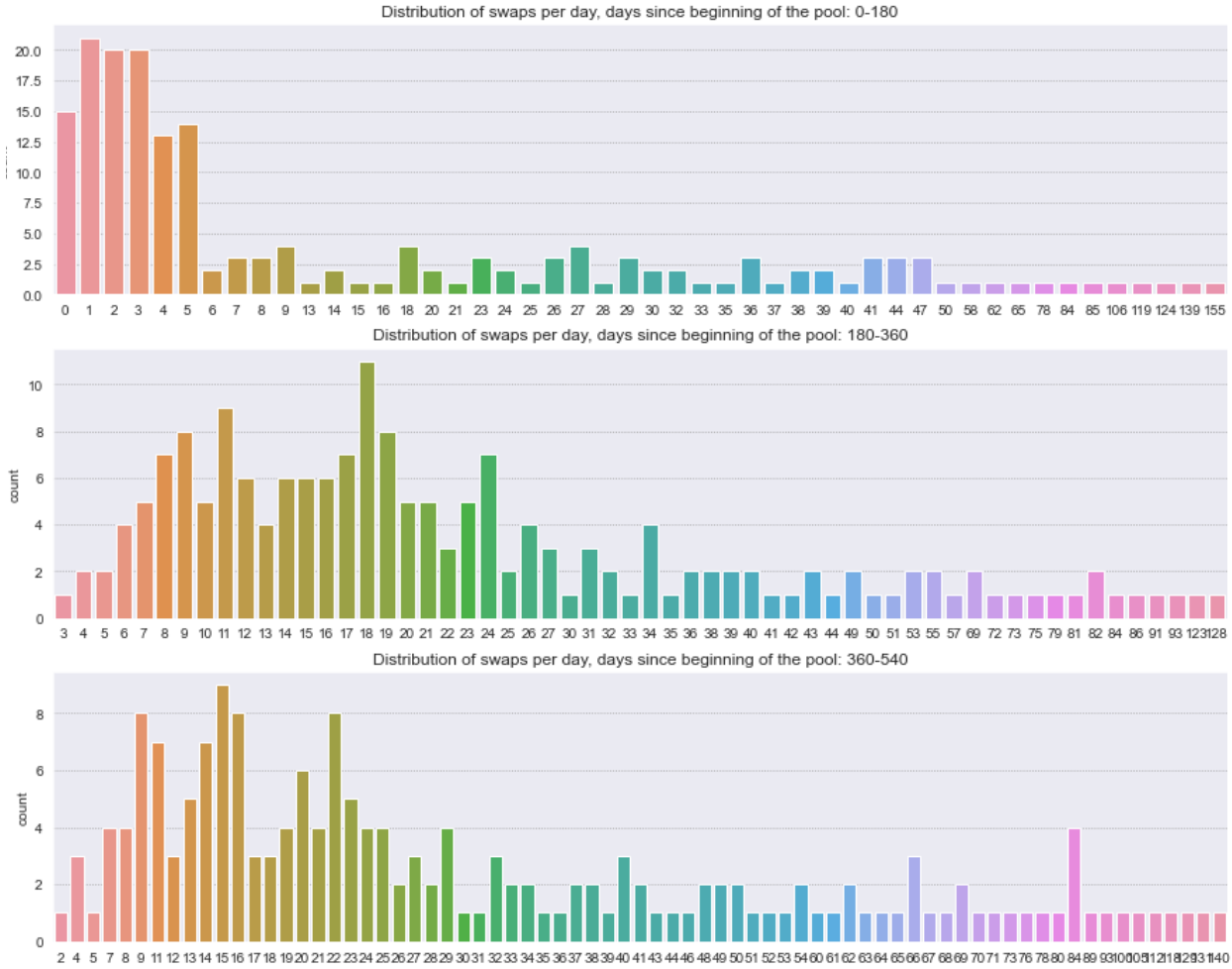
It was decided to analyze the distribution of swaps per hour during 3 stages of the pool (1st stage - initial period - days 0-179 since creation, 2nd stage - days 179-359 since pool creation, 3nd stage - days 359 till the end).



Picture 167: swaps per hour distributions

The count for x = 0 (no swaps per hour), shows how many missing windows for TWAP value exist. It can be seen that in the first period since creation, the highest number of missing TWAP values was registered (almost 3000).

Below, the distribution of the number of swaps per 24 hours is shown, similarly for the 3 stages in pool development.



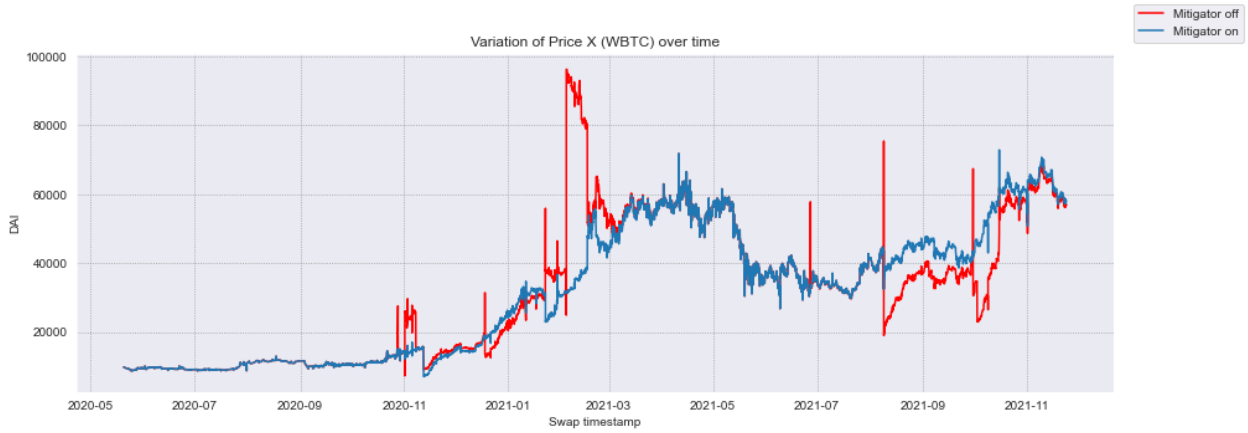
Picture 168: swaps per day distributions

It can be seen that in the second and last stage, there were no days with no swaps happening, the least number of swaps per day being 3 and 2 accordingly.

If the volatility mitigator mechanism would consider a more old recorded cumulative price for computing the TWAP value, in case the one that happened exactly 24 hours ago (in the period_size window) would be missing, it would allow to perform the volatility mitigator check for each swap in the 2nd and 3rd stage of the pool development.

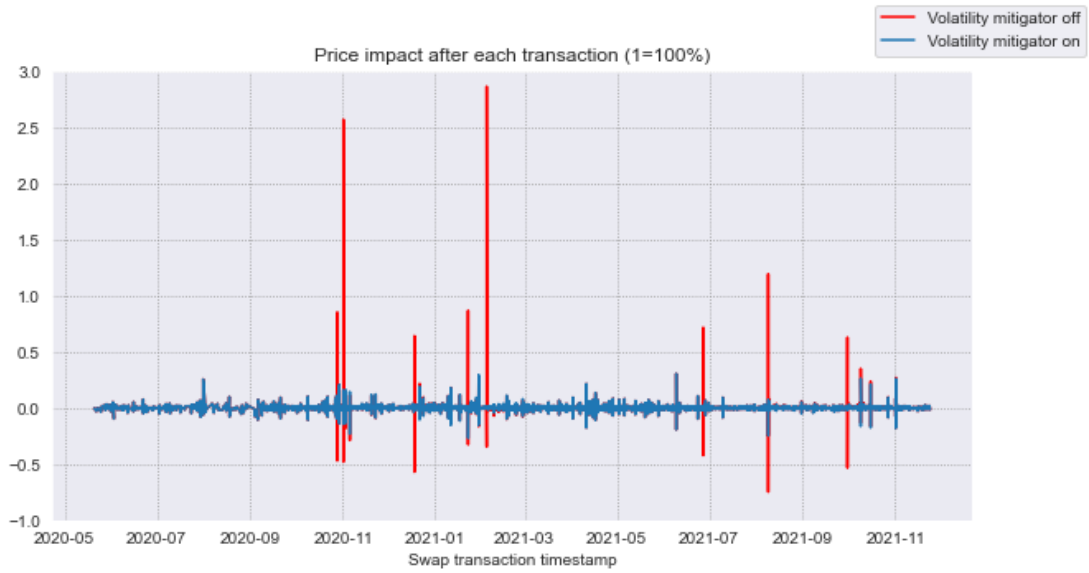
A modification was decided to be introduced in the pool: in case the cumulative price in the buffer for 24 hours ago index is not available, to take the oldest value from the buffer, which is not older than 48 hours ago (this number can be tweaked later).

By introducing the above mentioned modification in the simulator, the following plot for variation of X price across time is obtained:



Picture 169: price distribution over time with enabled/disabled mitigation mechanism, with 48 hour fallback_window_size

It can be seen that now almost all of the instantaneous price drops and increases are avoided. The price variation over time is much more smooth.



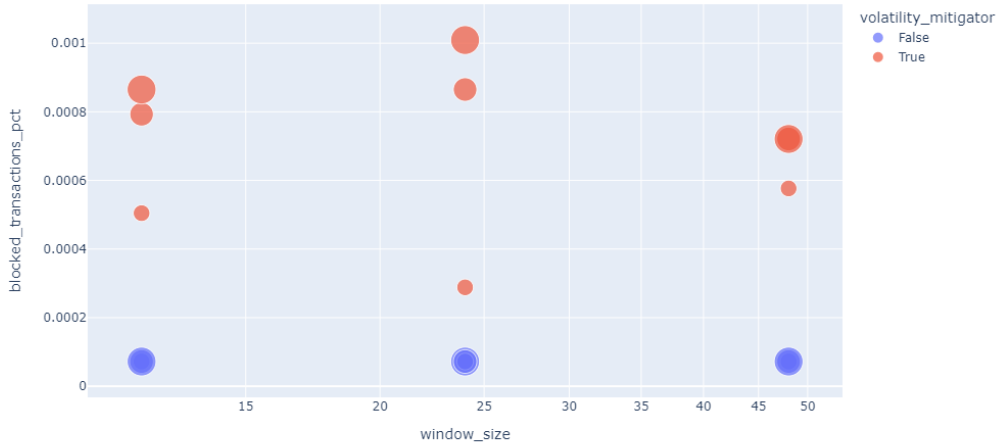
All of the swaps with a significant price impact are blocked by the volatility mitigation mechanism.

Simulations results for distinct VM related parameters

Below are analyzed the simulation results with different volatility mitigator related parameters set.

Examined parameters:

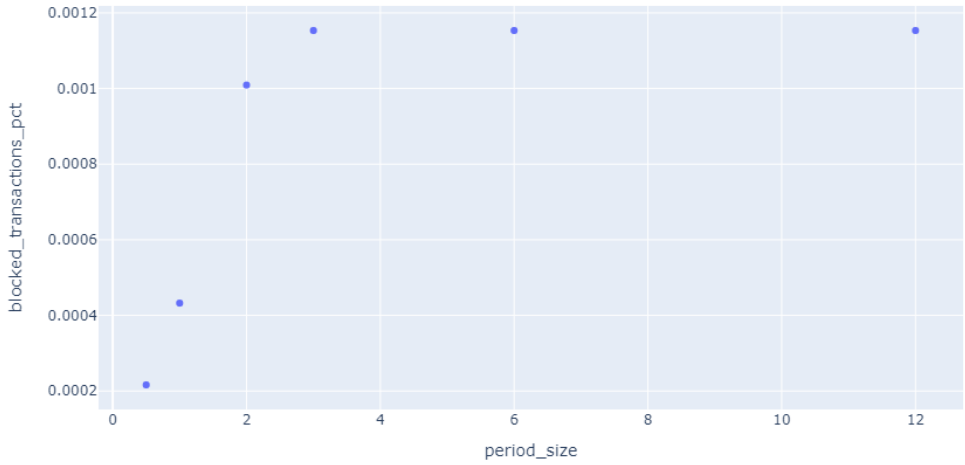
- `window_size: [12, 24, 48]`
- `period_size: [1, 3, 6]`
- `Units: hours`



Picture 170: correlation between blocked transactions, window sizes and volatility mitigation mechanisms

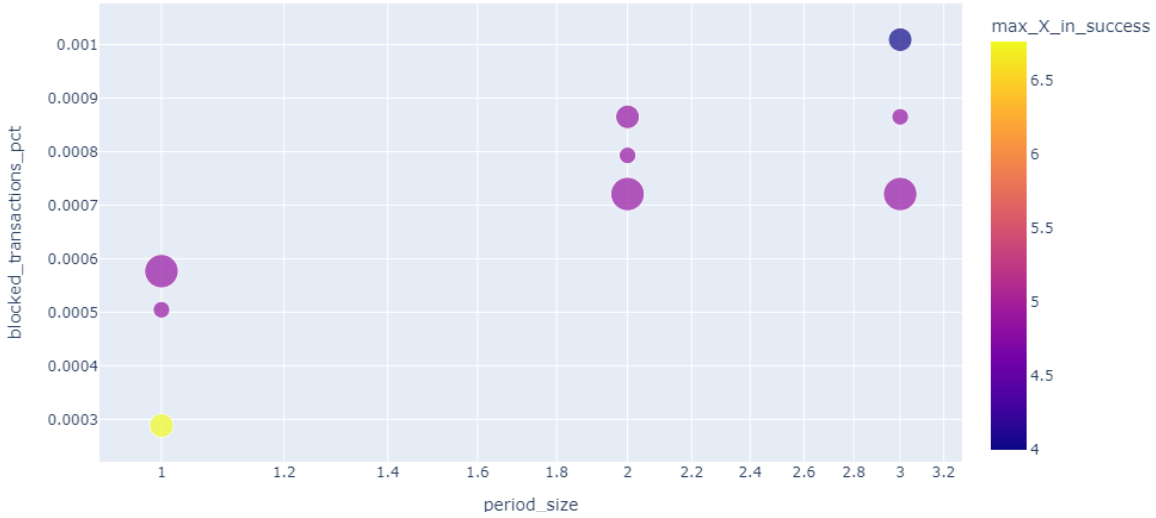
On the **x** axis is set up the window size and on the y - percentage of totally blocked transactions. Each point represents a simulation with different parameters. The size represents period_size.

It can be observed a consistent behaviour for all simulations with a fixed window_size value - the bigger the period_size - the more transactions are blocked.



Picture 171: period size correlation with blocked transactions in the WBTC/DAI pool history, `window_size` = 24h and enabled volatility mitigation

The number of blocked transactions increases as the period_size is being increased. This happens because of 2 reasons - the TWAP price is more up-to-date as the period number increases, and in law frequency pools there will be less windows of missing TWAP values, therefore the volatility mitigator check would be performed more often.

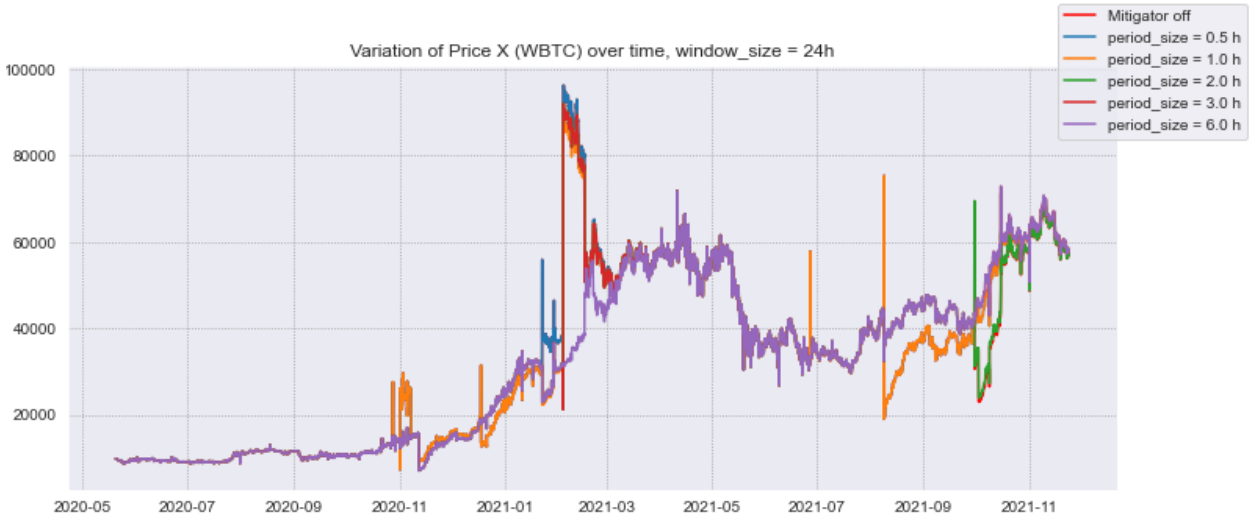


Picture 172: period size correlation with blocked transactions

In the above plot the maximal swap_in value in X token (WBTC) of a successful transaction is represented by color, and the size - window_size. The more transactions are blocked - the less is the maximal swap_in value.

Window size set to 24h

Comparison of price variations, for **different period_size** values, **window size = 24h**:



Picture 173: WBTC token price variation with different parameters

It can be seen that the price is much less volatile for bigger period_size values. At the same, the bigger the period_size, the less missing twap windows there will be, and therefore more transactions will be blocked:

period_size (h)	No TWAP available ratio	Swaps blocked by volatility mitigator
0.5	0.539	2
1.0	0.339	3
2.0	0.174	11
3.0	0.096	13
6.0	0.032	15

Picture 174: table of period sizes, TWAP ratios and amount of blocked transactions

If the volatility mitigator would use a more recent cumulative price for computing TWAP value in case the one exactly window_size hours ago would be missing, the presented below results would be obtained.

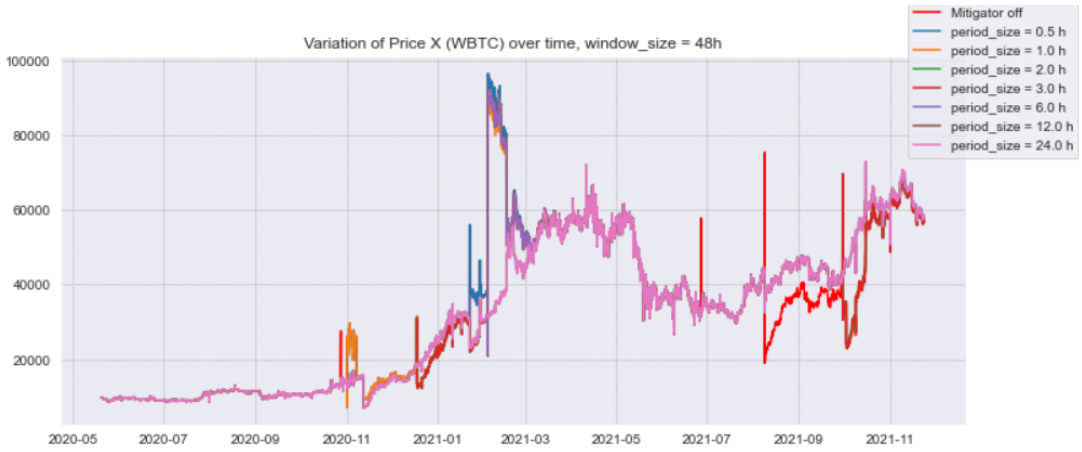
Picture 175: Variation of price for a slightly modified way of computing TWAP (in case the cumulative price for `window_size` hours is missing, but there were swaps in-between, a more recent observation is used for computing TWAP value), `window_size` = 24h.

It can be seen that the number of blocked transactions becomes the same for all distinct period_size parameters, and the number of no_twap_available windows decreases significantly, being relatively equal across simulations with different **period_size** parameter values.

period_size (h)	No TWAP available ratio	Swaps blocked by volatility mitigator
0.5	0.00022	15
1.0	0.00029	15
2.0	0.00029	15
3.0	0.00036	15
6.0	0.00050	15
12.0	0.00065	15

Picture 176: table of period sizes, TWAP ratio and amount of blocked transactions

Window size set to 48h

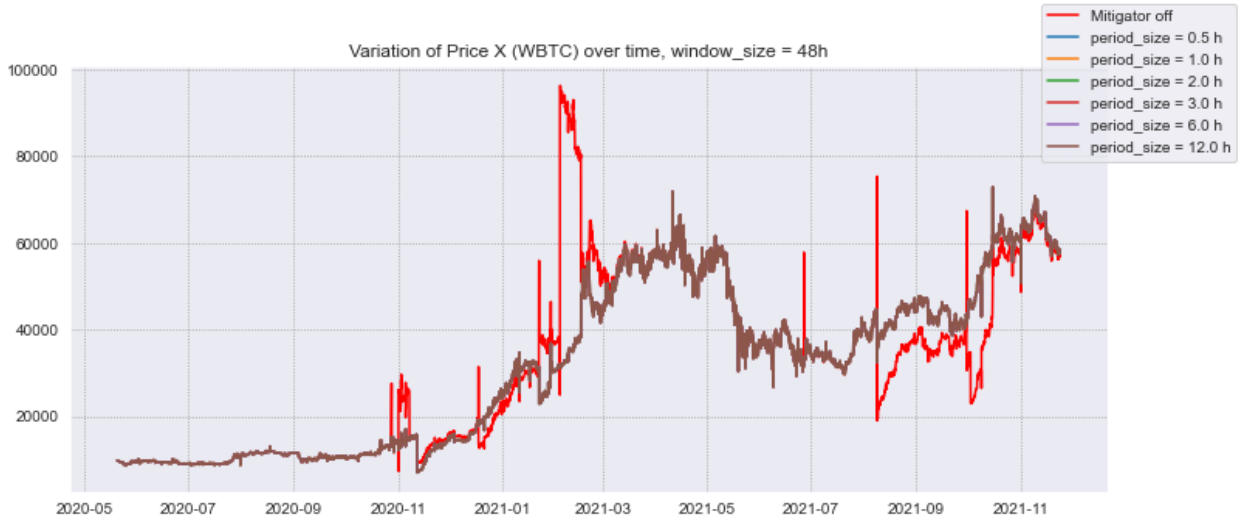


Picture 177: Variation of price for distinct `period_size` parameters and `window_size` = 48h

period_size (h)	No TWAP available ratio	Swaps blocked by volatility mitigator
0.5	0.55655	6
1.0	0.36092	7
2.0	0.18777	9
3.0	0.11403	9
6.0	0.03049	13
12.0	0.00865	15
24.0	0.00303	15

Picture 178. Distinct stats for simulations with different `period_size` parameters and `window_size` = 48

It can be observed that for smaller period_size values, there is a larger number of blocked swap transactions



Picture 179: Variation of price for a slightly modified way of computing TWAP (in case the cumulative price for `window_size` hours is missing, but there were swaps in-between, a more recent observation is used for computing TWAP value), `window_size`=48h.

WBTC/USDC

This is a pool with a medium frequency of transactions and capitalization value. At the moment of the analysis the total locked liquidity inside the pool is $136.56m, the median of the swaps count per day across the entire history being X.

Historical stats:

X swaps

Y mints

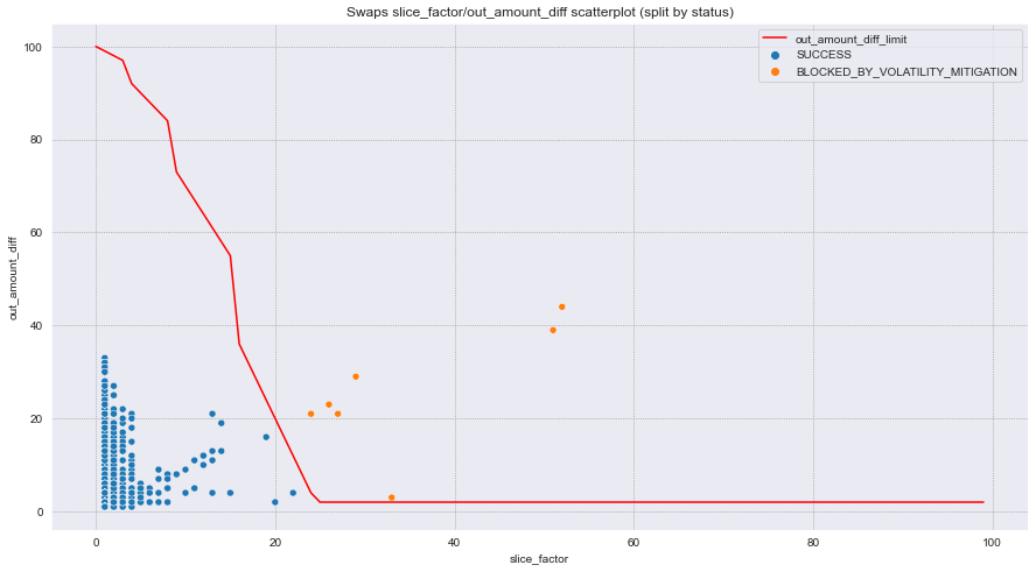
Z burns

A more detailed overview of the pool can be found here.

The volatility mitigation mechanism blocked **only 3 out of 68 189** transactions. In about **4%** of the cases the volatility mitigation mechanism didn't check the transaction because of the missing observations in the DSW oracle. By adding the above discussed modification in the dsw oracle, this number has been reduced to **0.02%** and the total number of blocked transactions is increased by 3.

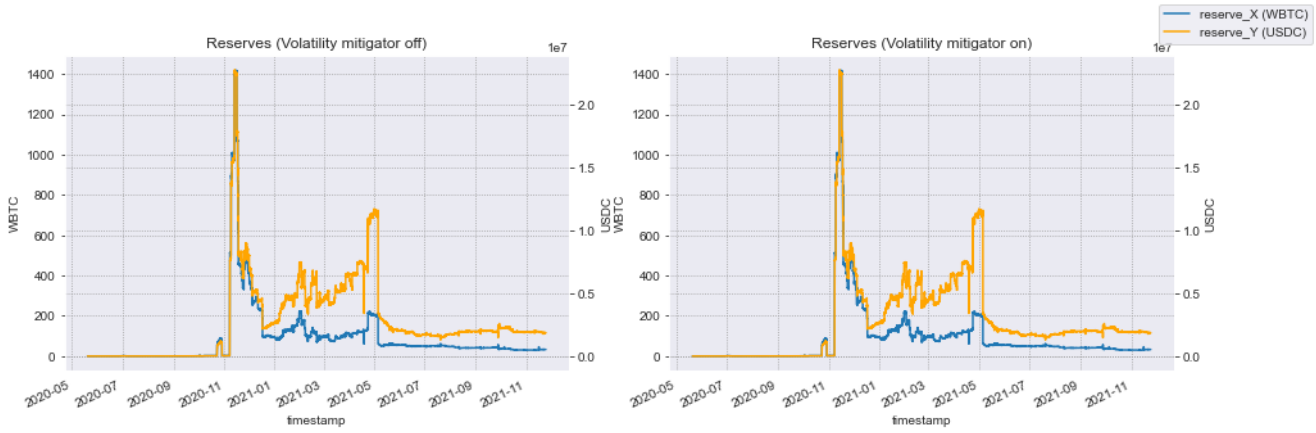
	token_in	token_out	token_in_amount	token_out_amount	slice_factor	out_amount_diff	reserve_Y_before	reserve_Y_before	transaction_timestamp
66	USDC	WBTC	31.840000	0.002410	24.0	21.0	1.368994e+02	1.368994e+02	2020-09-21 13:57:04
67	WBTC	USDC	0.003264	27.465270	26.0	23.0	1.368994e+02	1.368994e+02	2020-09-21 17:16:17
65608	WBTC	USDC	12.689636	415967.276382	29.0	29.0	1.888431e+06	1.888431e+06	2021-09-27 20:58:07
65610	USDC	WBTC	976323.861321	14.888663	51.0	39.0	1.901177e+06	1.901177e+06	2021-09-27 20:58:07
66006	USDC	WBTC	557057.298176	12.276771	33.0	3.0	1.706340e+06	1.706340e+06	2021-10-05 09:00:00
67843	WBTC	USDC	15.779159	644823.761426	52.0	44.0	1.905848e+06	1.905848e+06	2021-11-16 03:28:33
67844	USDC	WBTC	515070.490141	6.448343	27.0	21.0	1.905848e+06	1.905848e+06	2021-11-16 03:28:33

Picture X: Blocked by volatility mitigator transactions, with fallback_window_size = 48h



Picture X: Swaps slice_factor/out_amount_diff scatter plot, split by status (with visualization of the out_amount_diff_limit)

Overall, the border seems to separate the successful and blocked transactions pretty well, and the slice_factor_curve formula doesn't seem to require additional adjustments. There can be observed one swap, which would have been accepted if the price_tollerance_threshold would be a little bit higher.

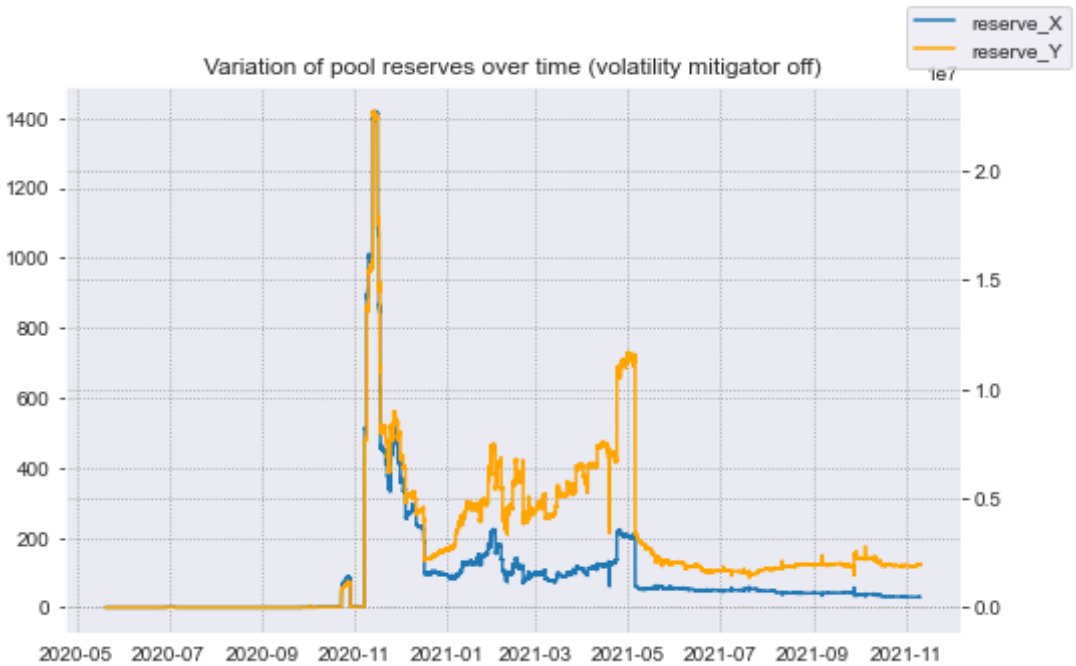


Picture 154: Distribution of the slice_factor (transaction amount from reserves) separated by transaction status

The reserves of the pool visually vary almost identically in the 2 distinct regimes. In the modification with added fallback_window_size, the reserves variation is also almost the same.

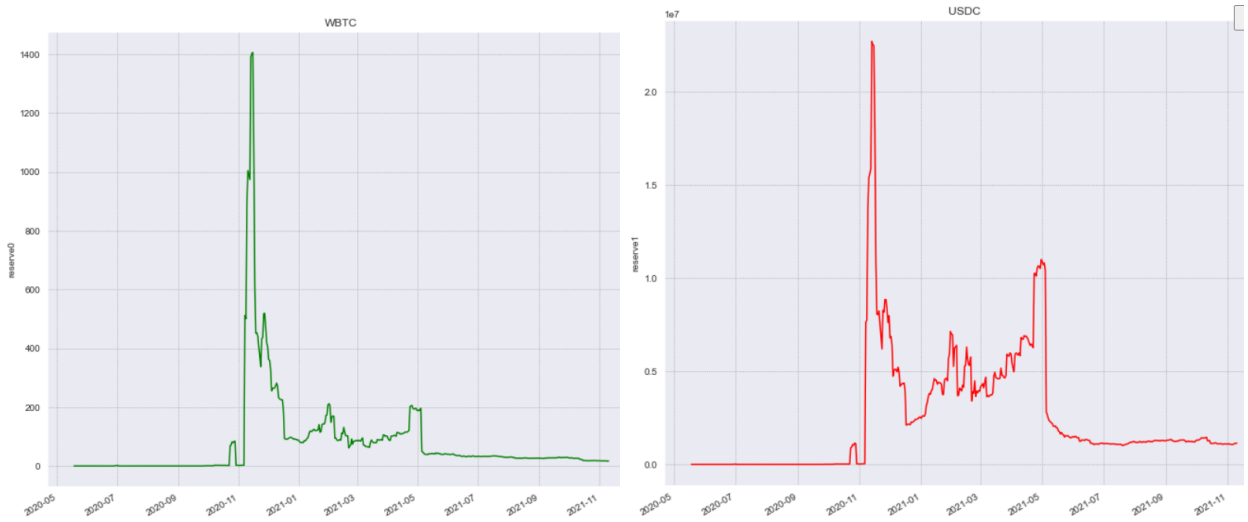
Picture 155: distribution of the difference with the price from DSW Oracle, separated by status

Again, in both cases the difference of the price with the one obtained from DSW oracle is pretty big (which is caused by the price impact of the swap - because of it's very large size).

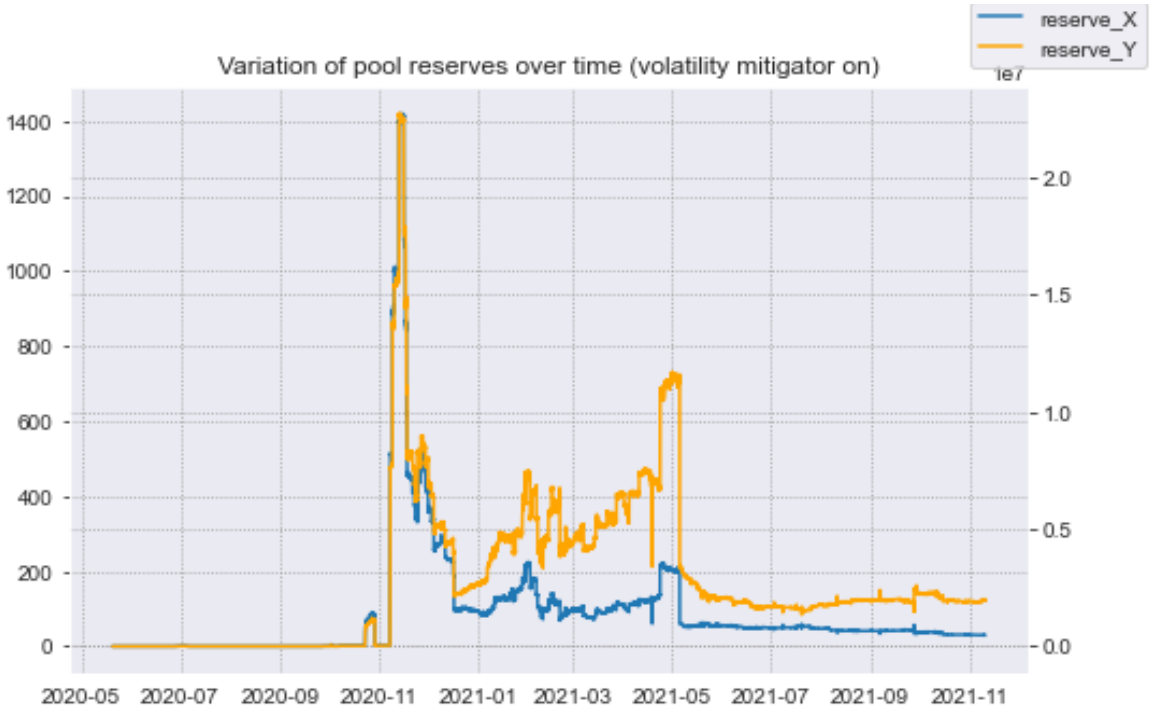


Picture 156: Pool reserves variation over time (volatility mitigator off)

The distribution of the simulation-based reserves is identical to the real ones that were present in the WBTC/USDC pool.

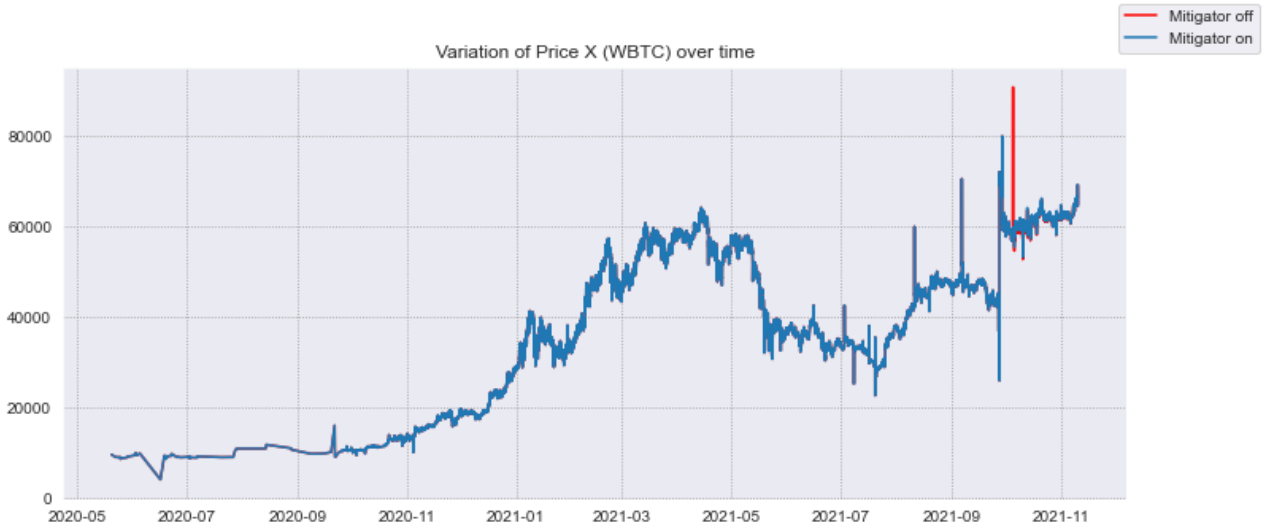


Picture 157: Pool reserves variation over time in the real WBTC/USDC pool



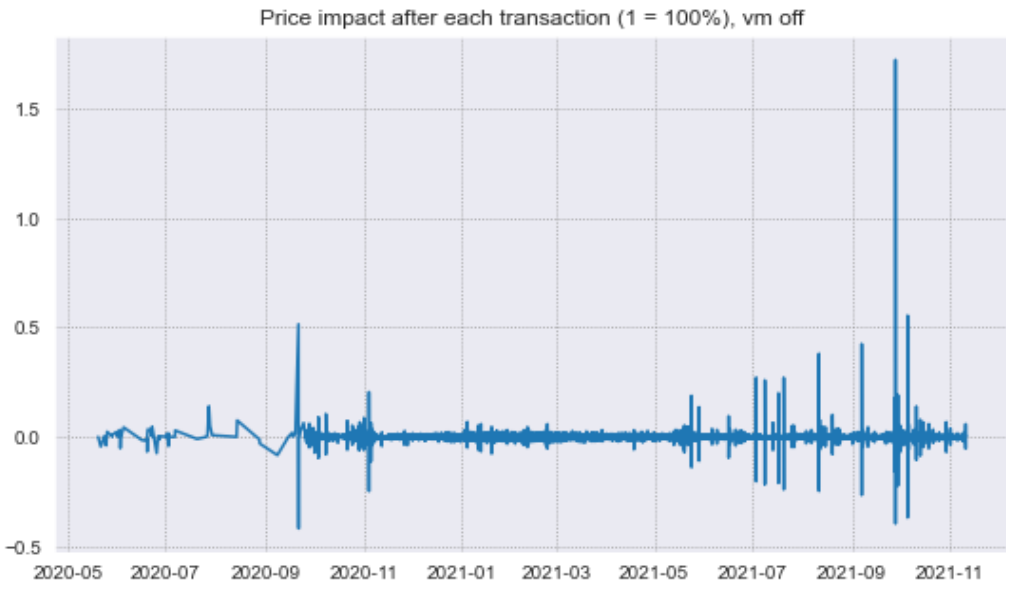
Picture 158: reserves variation over time with enabled volatility mitigation

The distribution of the reserves is almost identical in both cases of enabled and disabled volatility mitigation.



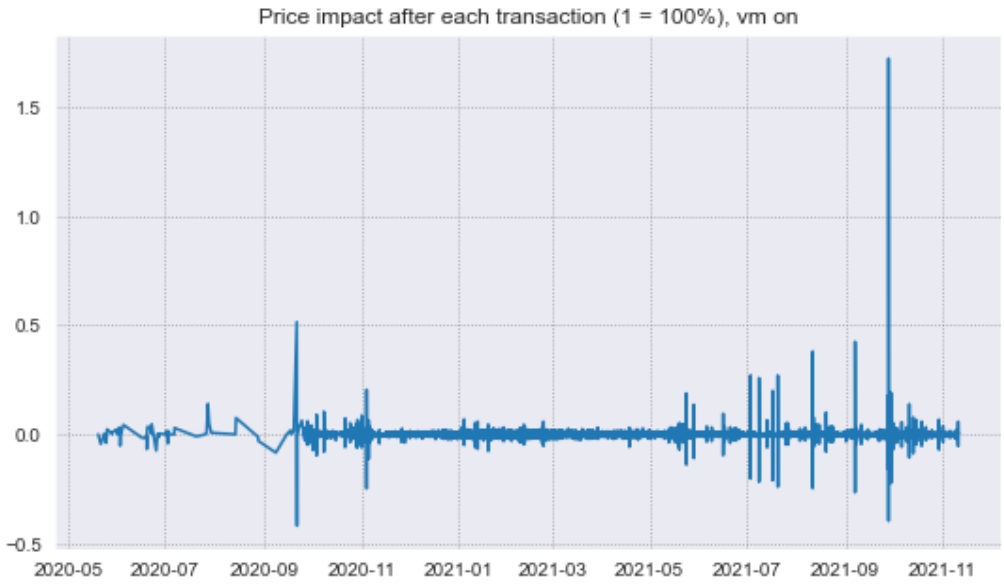
Picture 159: WBTC price variation over time

It can be seen that the only difference in the price of X token during 2 distinct modes (with/without volatility mitigator) is visible only during one spike. The volatility mitigator blocks a pair of consecutive transactions. Before and after that, the price stays almost the same.



Picture 160: Price impact after each transaction for X token (WBTC one)

Most of the spikes (consecutive increases/decreases of price), are caused by MEV-bot sandwich attacks.



Picture 161: Price impact after each transaction for X token (WBTC one) with enabled volatility mitigation

The volatility mitigator was able to block only one such transaction pair. The one with the highest price impact wasn't blocked as there was a several hours window with no swaps happening exactly 24 hours ago, therefore the cumulative price for this period wasn't computed and the volatility mitigator didn't check this transaction (as there was no price to compare to).

WETH / USDC

As this is a high capitalization pool with a very large amount of total transactions, it was expected to get a much more pronounced effect of the volatility mitigator mechanism inside this pool. Out of 2 927 355 total transactions number, only 17 were blocked by the volatility mitigator.

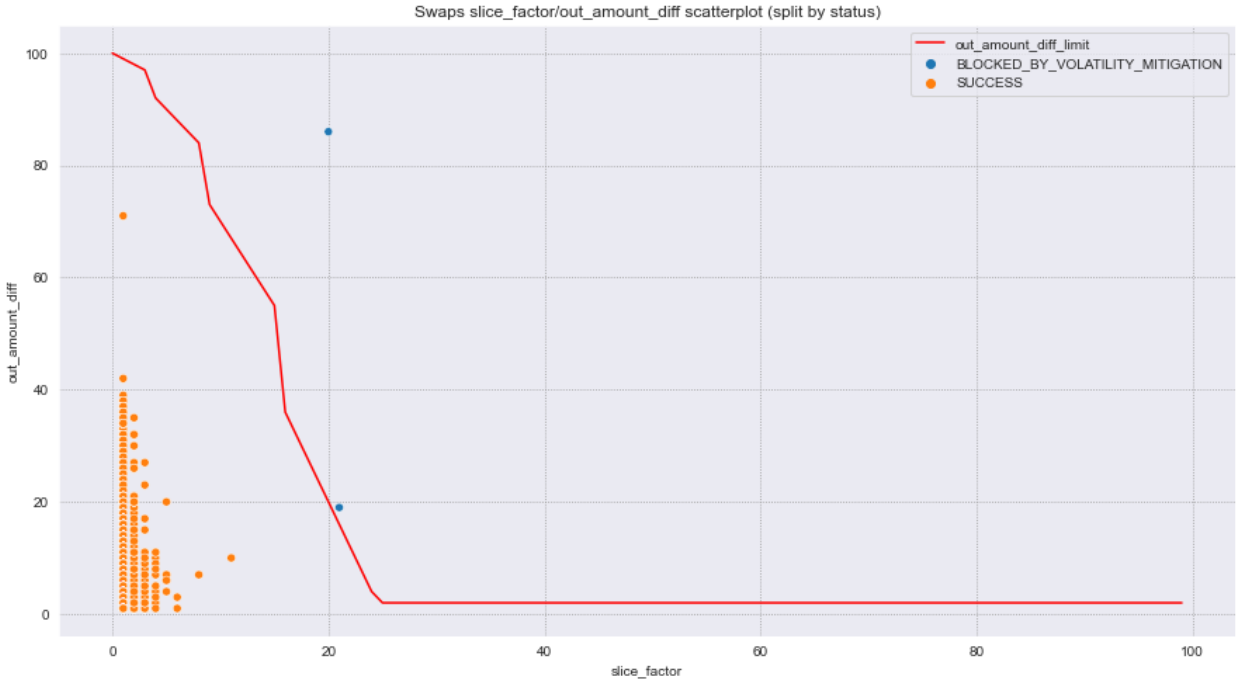
If checking for how many transactions it was able to obtain from the price from the daily sliding window oracle in order to compare the prices, it can be observed that only in 243 the price for 24 hours ago wasn't available.

```
sim1_df.mitigator_check_status.value_counts()
```

```
CHECKED                474831
CANT_CONSULT_ORACLE       243
```

Picture 180: results of running simulation with amount checked transactions and in how many cases TWAP was not found

If we skip the first 300 transactions from the beginning of the pool, the oracle price is always available, meaning that in high-capitalization markets the **volatility mitigator check should always happen**.



The analysis continuation of this pool analysis will be added later

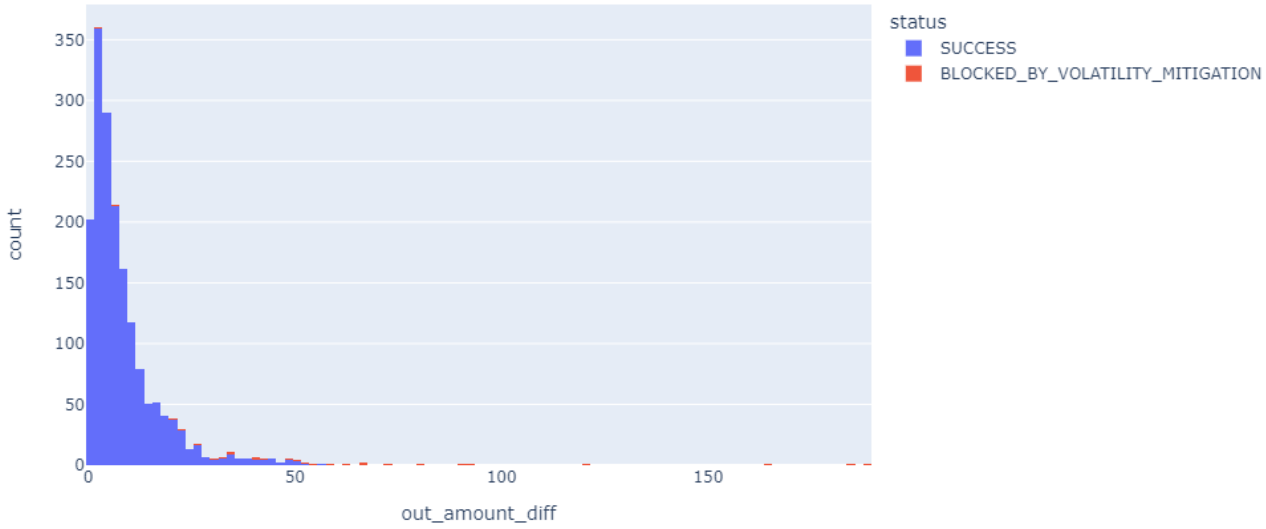
AXS / WETH

AXS/WETH is a pool with a law frequency of transactions. After the simulation, the volatility mitigator was able to mitigate 34 out of 4585 swaps.

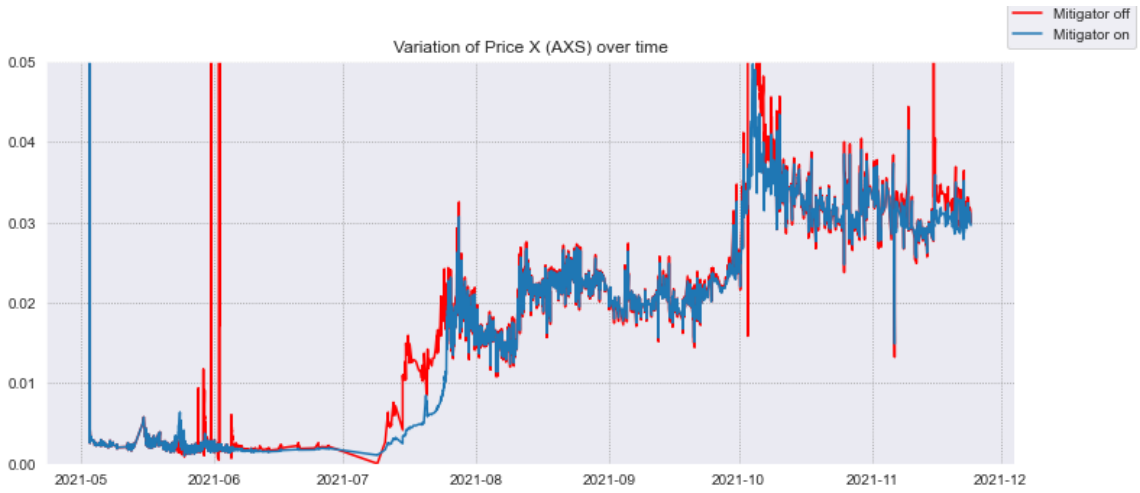
```
SUCCESS                          4551
BLOCKED_BY_VOLATILITY_MITIGATION   34
```

Picture 181: statistics of blocked and passed transactions in transaction history

Conform distribution presented below can be observed that the price difference with the oracle price for the blocked swaps is very large.

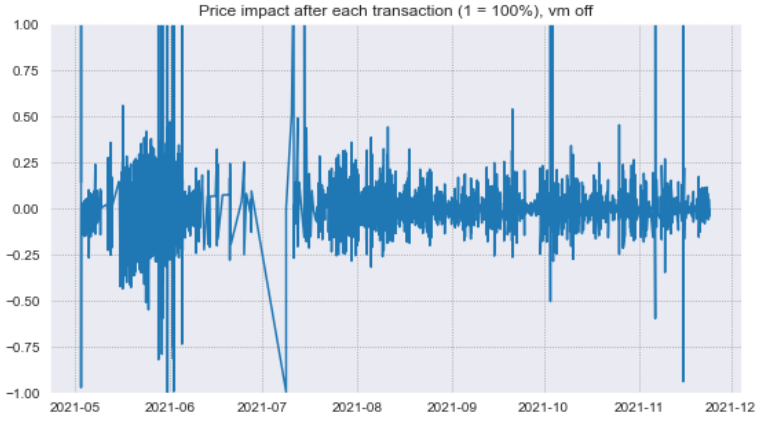


Picture 182: Distribution of difference with the price from DSW oracle, separated by status



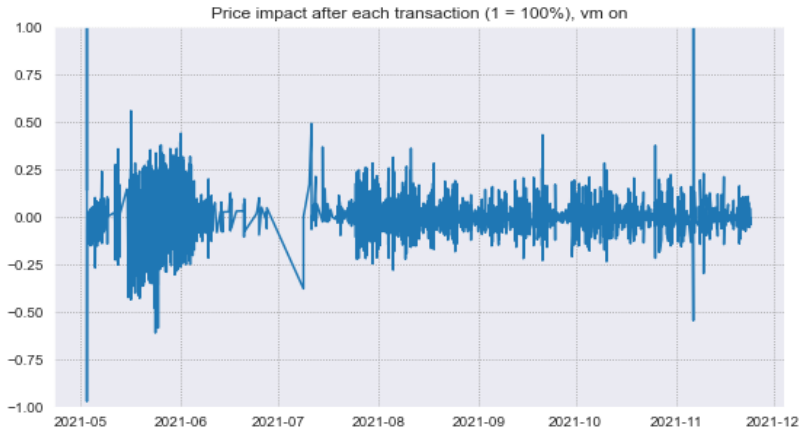
Picture 183: AXS price distribution over time with enabled and disabled mitigation mechanism

The variation of price becomes more smooth, even though there exist periods with sudden decreases/increases in price on the run with the mitigator turned on.



Picture 184: price change rates distribution with volatility mitigation off

The majority of the swaps with a high price impact are MEV-bot sandwich attacks.



Picture 185: price change rates distribution with enabled volatility mitigation

Many of them are blocked by the volatility mitigator.

Simulations results for distinct VM related parameters

Comparison of results for different period_size values (fixed window_size=24h):

Picture 186: Variation of price for distinct `period_size` parameters and `window_size` = 24h

period_size (h)	No TWAP available ratio	Swaps blocked by volatility mitigator
0.5	0.51886	30
1.0	0.36015	34
2.0	0.21169	51
3.0	0.14628	68
6.0	0.06039	151
12.0	0.01700	97

Picture 187: table of period size, TWAP ratio and amount of blocked transactions

Similarly to the case of the previous pool (which also has a law frequency of transitions), there are a lot of windows with missing TWAP value for small period_size values set. The number of blocked transactions generally increases for large period_size values.

Picture 188: Variation of price for a slightly modified way of computing TWAP (in case the cumulative price for `window_size` hours is missing, but there were swaps in-between, a more recent observation is used for computing TWAP value), `window_size`=24h.

period_size (h)	No TWAP available ratio	Swaps blocked by volatility mitigator
0.5	0.00698	122
1.0	0.00894	122
2.0	0.00959	121
3.0	0.01025	118
6.0	0.01090	118
12.0	0.01700	97

Picture 189: table of period size, TWAP ratio and amount of blocked transactions

Again, if the TWAP would be computed with a more recent cumulativePrice observation, in the case the one exactly window_size hours ago would be missing, the number of window with missing TWAP values would be reduced significantly, leading to a higher number of blocked transactions with a high price impact and reduced price volatility overall.

MANA / WETH

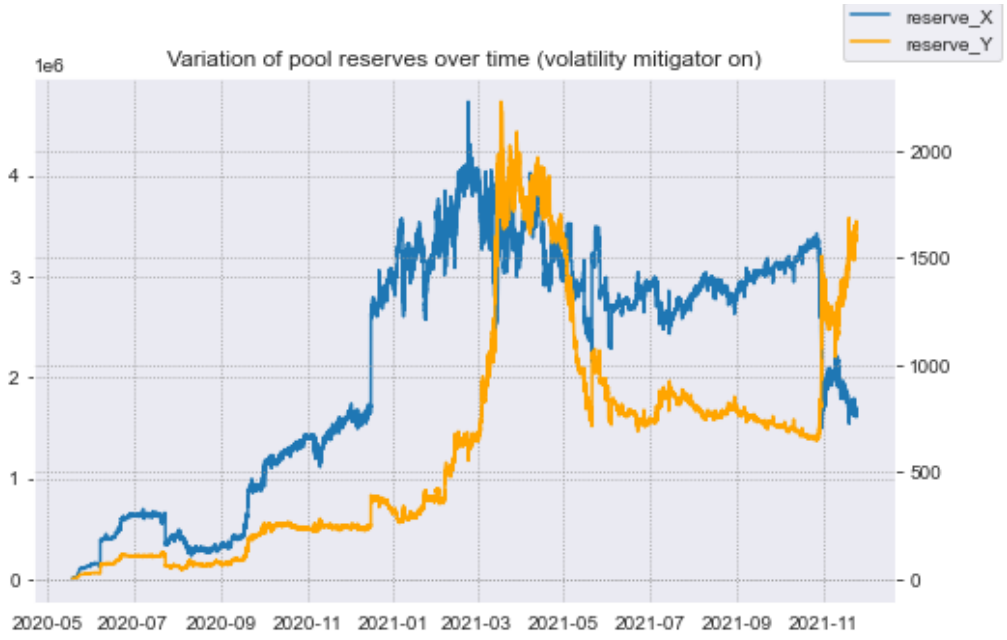
This is a medium capitalization pool with an NFT token. By running the simulations on the historical transactions from it, only 3 out of 72 981 swap-transactions were blocked.

Below, is shown the volatility mitigator check status for swap transactions:

CHECKED	69319
CANT_CONSULT_ORACLE	3662

Picture 190: amount of passed transactions and cases where TWAP was not calculated

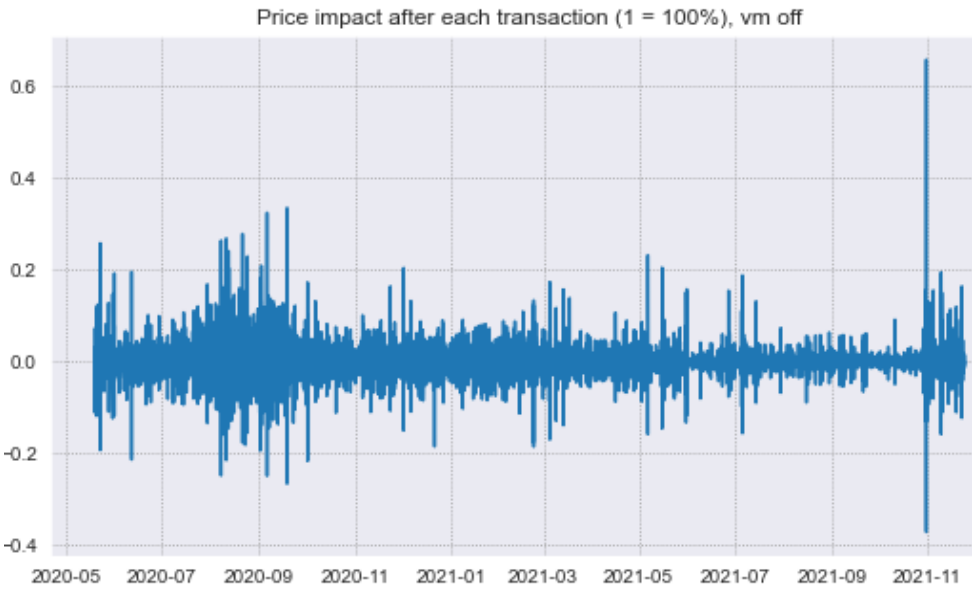
For 3662 it wasn't possible to compute the TWAP value, meaning that exactly 24 hours ago there was an hour gap with no transactions happening.



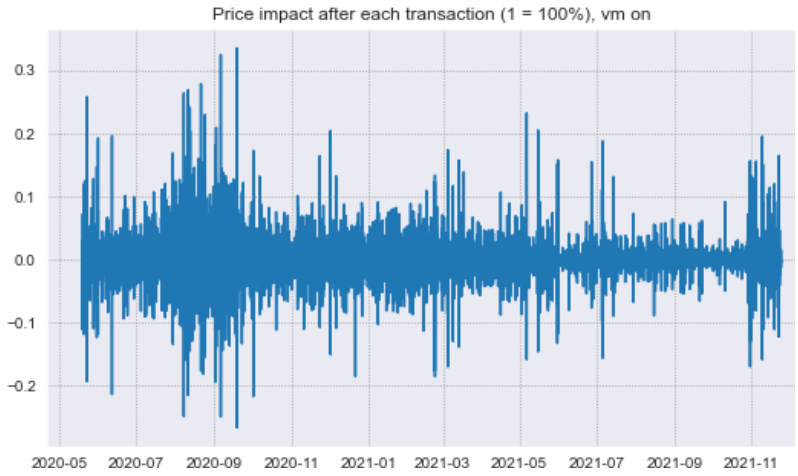
Picture 191: Variation of reserves. Pool MANA/WETH (volatility mitigator on)

Picture 192. Variation of price of X token over time for the MANA/WETH pool (volatility mitigator off/on)

The volatility mitigator blocks only one big transaction toward the end of the period. The transaction is a mev-bot sandwich attack. Besides this, the behaviour for different volatility mitigator regimes is the same.



Picture 193: price of X token change rates distribution for MANA/WETH pool, volatility mitigation off



Picture 194: price of X token change rates distribution for MANA/WETH pool, volatility mitigation on

It can be observed that the swap with the highest price impact is blocked, besides this the behaviour is consistent with volatility mitigator on/off. The remaining swaps with a high price impact will be examined afterwards to determine whether they are mev-bot sandwich attacks or not.

Simulations results for distinct VM related parameters

period_size (h)	No TWAP available ratio	Swaps blocked by volatility mitigator
0.5	0.14328	3
1.0	0.05018	3
2.0	0.01520	3
3.0	0.00614	3
6.0	0.00127	3
12.0	0.00001	2

Picture 195: `window_size`=24h, distinct `period_size` values. Stats.

Picture 196: price variation over time with `window_size`=24h, distinct `period_size` values

It can be observed that the overall behaviour is very similar for distinct values for period_size parameter.

After the analysis of the above simulation results run in 2 distinct modes, it can be concluded that in normal market regimes:

- The volatility mitigator mechanism blocks transactions extremely rarely, the blocked transactions are very large compared to the current reserves and in most of the cases they are MEV-bot sandwich attacks;
- The number of missing TWAP value windows for pools with law swap frequency (such as WBTC/DAI or AXS/WETH) is very large (almost 50%), even though during the later period after pool creation there are no cases of no swaps happening during the entire period = window_size = 24h). The number decreases for larger period_size values;

- An observation from a more recent window can be used in such cases in order to significantly reduce the number of cases with no TWAP available). After the discussed modification, the volatility mitigator check is being performed in almost all transactions, leading to a decreased price volatility.

Next steps:

- Rerun the simulations additionally on real-transactions history data of different pools, including NFT;
- Continue running the simulations on the examined pools with distinct volatility-mitigator related parameters, such as window_size, period_size, price_threshold. The final conclusions can be only taken after the analysis conducted on pools with all distinct market regimes (law/medium/large transaction frequency/pool capitalization…), as the optimal parameters should be highly dependent on them, and any preliminary observations could be biased;
- Resume static and dynamic tests done on generated trades, in order to model different possible market behaviours.