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«HIGHER SCHOOL OF ECONOMICS»

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Извлечение экономических данных из децентрализованных финансовов (DeFi)

Economic Data Mining in Decentralized Finance (DeFi)

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Contents

Introduction

After the release of smart contract systems (most notably Ethereum in 2015), the concept of decentralized exchanges (DEXs) started to shake the traditional financial systems, and millions of users started to use DeFi projects to alternate the current traditional financial systems. That's because DeFi allowed for censorship-resistant participation in digital markets without traditional long procedures, third parties involvements and with absolute freedom for the user to preform whatever financial operation he wants. Specifically, preforming financial trading of cryptocurrencies.

Most of cryptocurrency trading systems before 2018 used Centralized Exchanges (CEXs), which is inconvenient for the end users since this means the involvement of a third party, for example a service provider or a bank, which opens the race for a lot of companies to propose a market makers mechanism to replace the traditional orderbook methods and to get rid of the third-party involvement. Thus, applying the concept of DEXs.

In November of 2018 at Devcon 4, UniSwap labs launched UniSwap V1 protocol, which provided a decentralized, censorship resistant and secure interface to exchange ERC20 tokens on Ethereum block chain without intermediates using a simple yet a revolutionary idea of Automated Market Makers, making it one of the first protocols to start the move from CEXs to DEXs and replace the traditional order book mechanism.

In this paper, a deep dive into UniSwap protocol is presented, exploring the different mechanisms that UniSwap smart contracts provide and understand the added features through the multiple versions of UniSwap. This paper would make use of the whitepapers presented by the platform and from the public UniSwap API to extract data and analysis it, in order to understand one of the highest Total Value Locked DeFi exchange platform, UniSwap.

Chapter 1 - Theoretical Part

Main terminology

ERC20 Tokens: are fungible tokens which are built on top of the Ethereum blockchain, meaning that each individual ERC20 unit is indifferent form another ERC20 unit from the same type. Which is different form the concept of ERC721 better known as non-fungible tokens or NFTs. ERC20 tokens could be a representation of currency, ownership, interest accruing bonds, cryptocurrency and much more.

Smart Contracts: are programs or lines of code that are stored on a blockchain, those programs run when predetermined conditions are met. Typically, smart contract could automate a workflow or an execution of an agreement between parties without time loss or third-party involvement.

UniSwap Protocol

The UniSwap protocol is a peer-to-peer system for exchanging ERC20 Tokens on the Ethereum blockchain, meaning that UniSwap protocol does not require central authorities which may restrict access between parties in a certain exchange, making this protocol secure, fast and efficient due to the efficient implementation of this protocol using a group of constant smart contacts.

Until now there has been three version of the UniSwap protocol, each version is going to be discussed in details in the following sections in order to understand deeply how UniSwap as protocol operates.

1. UniSwap V1:

UniSwap V1 was first lunched on November 2, 2018. It had a basic design to transform transaction on Ethereum mainnet from CEXs that were used previously[1] to a more DEXs, solving the problems that came with CEXs models such as costs and lack of liquidity and providing a better user experience

UniSwap V1 introduced the basic smart contracts that forms the protocol and the basics ideas that would change the ordinary order book exchanges into DEXs. In V1, UniSwap was consisted of two different types of smart contracts: basic Exchange Contract and Factory Contract. [1] Exchange contracts holds the pools for an ERC20 token and Ether. Factory Contract is responsible for creating an Exchange contract for each ERC20 token and registering the address of the

[1] for example, EtherDelta that used order Book model

exchange contact to the ERC20 token address [1]. Each ERC20 token in UniSwap V1 has a unique pool against Ethereum and there was no ability to create an ERC20-to-ERC20 pools.

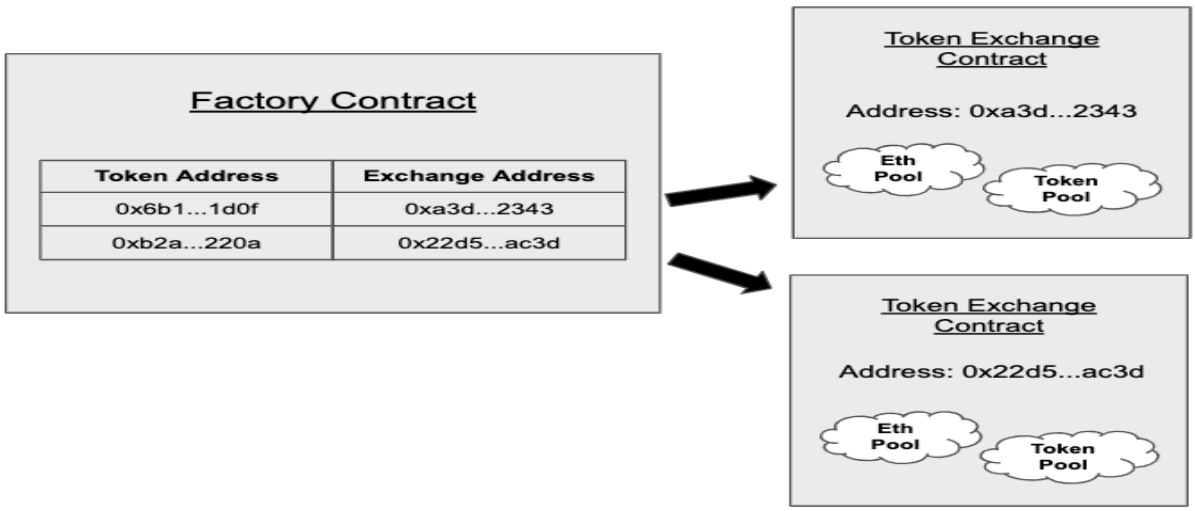

Figure 1: Factory and basic exchange contracts interaction

Traditional centralized Exchanges used orderbook to calculate the price of a Token, meaning that the price of a Token is calculated by the point where the highest price a buyer can pay and the lowest price a seller want to sell meet. Instead, UniSwap introduced the idea of Automated Market Maker to determine the price of a token.

1.1. Automated Market Maker:

As Explained above, UniSwap uses Exchanges contract to interact with a pool that holds Ether and another ERC20 token during trading, meaning that a user can trade Ether for an ERC20 token for example by sending Ether to the Exchange contract pool for the requested ERC20 Ether pair and receive a certain amount of this ERC20 token as a result. To determine the amount of the returned ERC20 token, UniSwap uses a mechanics called Automated Market Maker (AMM).

The idea behind AMM is that in case of a contract that holds x coins of ERC20 token A and y coins of Ether, this contract should always be balanced and satisfies a simple formula called constant product formula which is expressed as following:

$$x * y = k$$

Where k is some constant. So, in order simulate the order book mechanisms, a buy or sell operation can shift the curve to a new position (figure2), the shift distance to the right is the amount of token A that the user have to put and the shift distance downward is the amount of Ether they will receive.

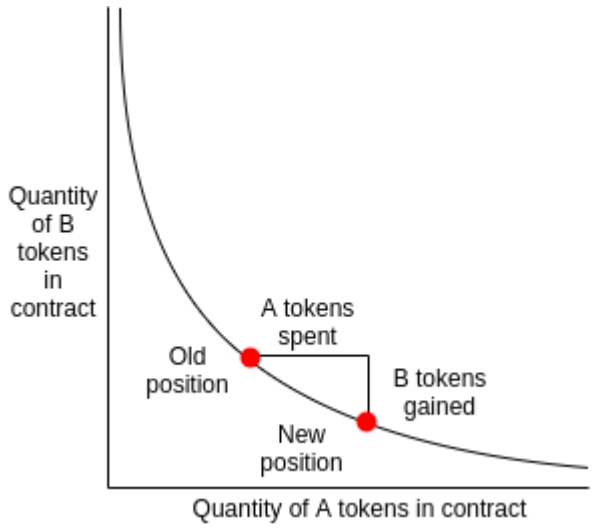

Figure 2:AMM curve for 2 tokens during an exchange

This kind of design has its advantages and disadvantages, the advantage is that the state of the market cannot exceed the curve, because the pool is going to maintain a ratio relative to the price of the market on other platforms using people arbitraging the pool (making use of the difference in the price of the pool compared to the centralized exchange price). Another advantage of this mechanism is that the Market Maker is profitable because of the fee charged by UniSwap.

On the other hand, one major disadvantage of this mechanism is that it is vulnerable to front running attacks, where a miner can 'wrap an order of a specific user with two of his own orders, the example below shows how such attack can occur in a market state of (10,10) of coins A and Ether:

Starting state: (10, 10)

Miner spends one unit of A: (11, 9.090909) and gets 0.909091 units of Ether

The User spend one unit of A: (12, 8.333333) and gets 0.757576 units of Ether

Miner spends 0.757576 units of Ether: (11, 9.090909), gets 1 unit of A

Thus, the miner would gain 0.151515 Ether in profit, with zero risk.

The following table summarize the difference between using traditional orderbook mechanism and AMM mechanism:

	AMM	*orderbook*
User price state	Always price taker (since the prices are calculated by the formula)	Can be price maker or taker
Infinite liquidity	Infinite (since liquidity is provided throughout the price range [0, ∞])	Doesn't have infinite liquidity
Existence of price slippage	Always exist because of the	Not always

price function

1.2. Swapping ERC20 with ERC20

Since UniSwap V1 introduced the idea of a unique pool for each ERC20 token with Ether and hence a single Exchange contract, a user swapping an ERC20 token with another ERC20 token can preform the transaction using UniSwap but with Ether as a mediator. (Figure3) serves as an example of swapping USDC to DAI:

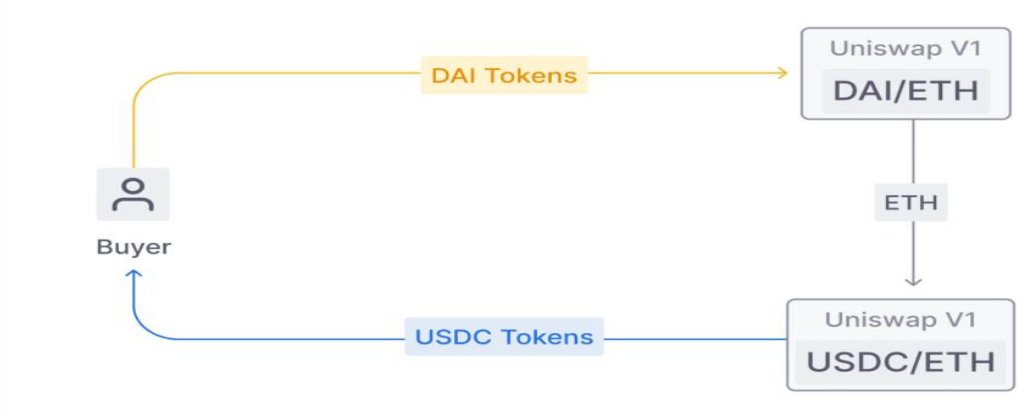

Figure 3: example of swapping USDC to DAI on UniSwap V1

1.3. Liquidity providers

Liquidity providers are the users that provides liquidity for an ERC20- Ether pool, meaning they are the users who supply equal amounts of Ether and ERC20 token to a UniSwap Exchange contract in exchange for a certain amount of a special ERC20 tokens which are called liquidity tokens. The amount of liquidity tokens the LPs receive is proportional to the percentage of total liquidity they added. These LP tokens could be sold, traded or burned to redeem the deposited tokens from that contract which the LP can use to withdraw their share at any time. Since each user must pay a fee of 0.3% on each trade on UniSwap Ether-ERC20 pool[2], this fee is added to the liquidity which means that it would be split between liquidity providers as a profit. And such profit is guaranteed to occur when the price is different from the centralized exchange because of the arbitrage opportunity.

The only problem that faces a LP is the concept of impermanent loss [2] which is the loss that a LP endure due to price changes in pools that have small value trades compared to the size of the liquidity pool. In case of price changes and even though the LP is gaining fees from transactions, a LP user would notice the impermanent loss when he decides to withdraw his liquidity after price changes from the initial deposit price, meaning that he would notice that he lost some of the

[2] 0.6% in case of ERC20-ERC20 pool

liquidity he provided during deposits in comparison with him just deciding to hold his liquidity without depositing it into UniSwap pool. The impermanent loss can be expressed as a function to price ratio between deposit and withdraw prices as follows:

$$divergence\_loss = 2 * sqrt(price\_ratio) / (1 + price\_ratio) - 1$$

It is notable that the loss would appear whichever direction the prices go to and will not disappear unless the price during withdraw is the same as the price during deposits (figure4).

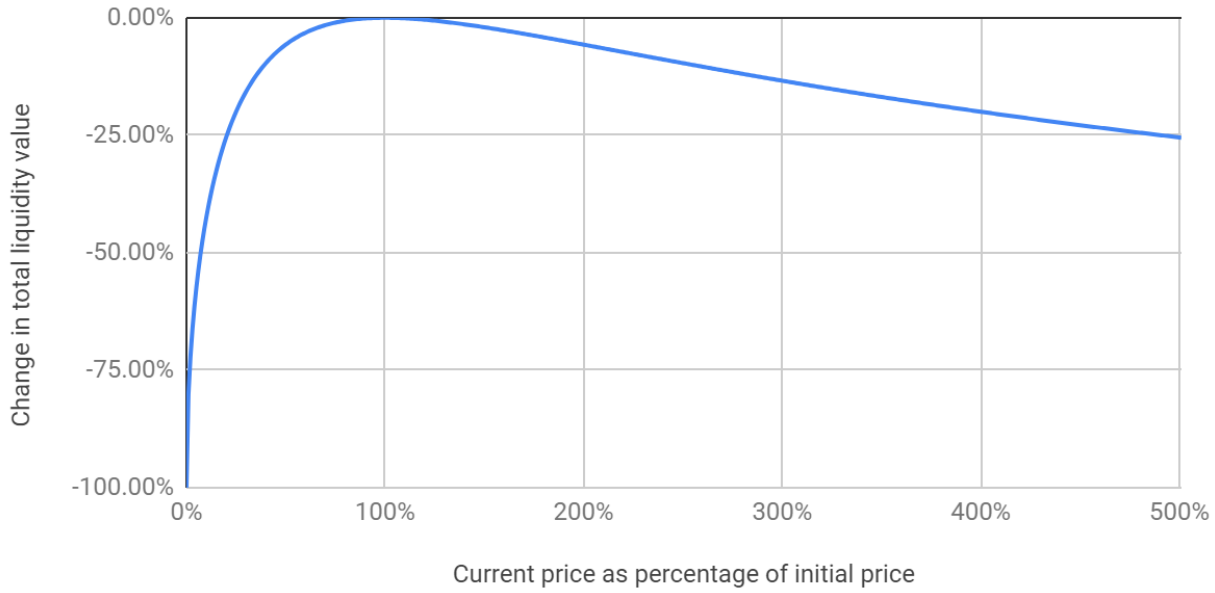

Figure 4: losses to liquidity providers due to price variation compared to holding the original funds supplied

2. UniSwap V2

After the revolutionary ideas that UniSwap V1 proposed, millions of users started to use UniSwap to preform decentralized trading and to move from the traditional order book mechanism, which gave a signal for the developing team in UniSwap labs to improve it an introduced UniSwap V2 in May 2020, which came with a more user- friendly experience and more enhanced features [3].

2.1. ERC20-ERC20 Pools:

As explained above, the initial UniSwap V1 only had ERC20-Ether Pools, which caused the user who want to trade ERC20 to ERC20 to make a trade with higher costs than usual because of the using of Ether as a “bridging” token. UniSwap V2 solved this issue by introducing ERC20-ERC20 Pools which uses Wrapped Ether (WETH), allowing the users to do the transaction between two ERC20 tokens without the need of converting to Ether, and even keeping the option for the end User to keep using Ether as “bridging” token by using helper contracts. (figure5)

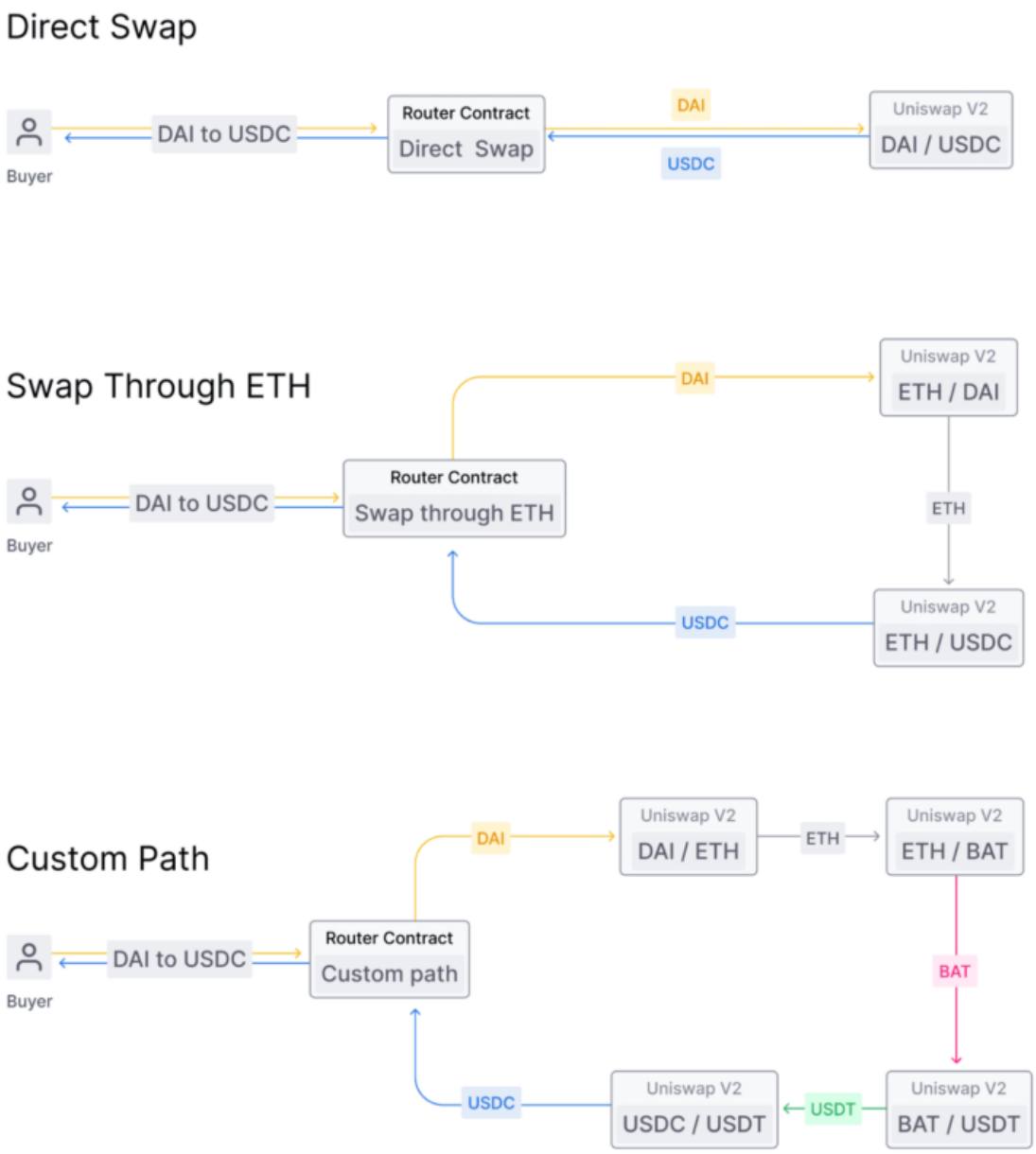

Figure 5: different ways to do an DAI to USDC trade in UniSwap V2

2.2. Oracles

When developing a smart contract to work with DeFi protocols, the developers will always face a problem which is determining the best possible way to define a price for a given assets. The tool that would determine the price of a given assets is called price oracle. Since the lunch of multiple protocols, including UniSwap V1 back in 2019, a lot of DeFi protocols witnessed attacks because or relying on an on-chain decentralized price oracle without checking the validity of the prices returned.

In 2019 DDEX, which was a decentralized exchange platform, was accused of price manipulation in the case of ETH/DAI pair [4]. Although DDEX used UniSwap V1 as an on-chain Decentralized Oracle for DAI, but it faced a number of attacks where the attacker would make a huge trade, uses the function to check

the price oracle, then execute another huge trade synchronously using smart contract, losing only fees.
Therefore, UniSwap V2 added multiple new improvements to enable high decentralized on-chain Oracle [3]. First at the beginning of each block, the price would be determined by the last transactions, so in order for an attacker to manipulate this price, he has to make a bad trade at the end of a previous block and harvest the benefit of arbitraging it back on the next block. UniSwap tackled this problem by adding the end-of-block price to a single cumulative-price variable and used the time this price existed as a weight. This cumulative price would represent the sum of UniSwap price for every second in the contract. And can be used by external contracts (DDEX for example) to calculate the Time-Weighted Average Price (TWAP) for any assets during any time interval using this simple formula:

$$TWAP = \frac{priceCumulative_2 - priceCumulative_1}{timestamp_2 - timestamp_1}$$

This new and improved Oracle in UniSwap V2 would make an attack impractical because the cost of manipulating the price for a time period is now equal to the amount lost in arbitrages and fees for blocks within this period.

2.3. Flash Swaps

Flash Swaps was another important feature that UniSwap V2 presented, allowing the users to withdraw any amount of ERC20 tokens from a UniSwap pool without having to pay any costs upfront. By the end of the transaction, the user has to either pay for the ERC20 that he withdrawn or return the withdrawn ERC20 with a small fee. This feature gives the user the freedom of doing multi-step transactions without having to worry about capital requirements or the constraints on the order of the operation during a transaction.
One such use case for flash swaps is Capital Free Arbitrage, allowing users who don’t have a certain amount of capital to get involved in arbitrage opportunities that would appear in UniSwap or other platforms.

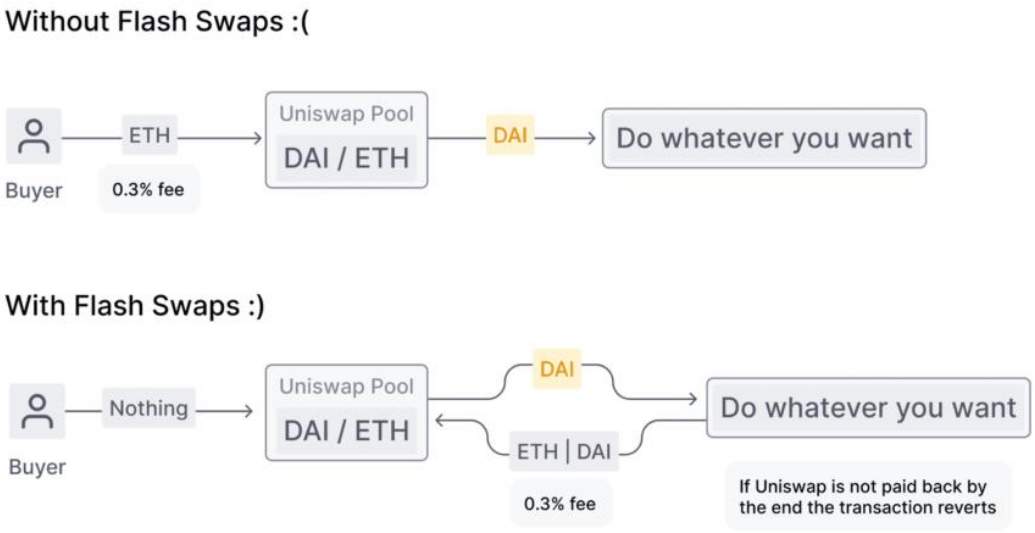

Figure 6: trading DAI/ETH using Flash Swaps

UniSwap V2 with its newly upgraded features and security system experienced a huge success after it was launched, making a name for itself among centralized exchanges protocol and passing them in daily trading volume, making UniSwap one of the most forked projects at the time, which led for rise of some forked projects like SushiSwap that took a big portion of the liquidity from UniSwap and which in turns led to the UNI token dropping in September of 2020 [5].

3. UniSwap V3

UniSwap V3 was released on May 5the, 2021 on the Ethereum main-net and in Optimism[3] , presenting some new features and also upgrades.

3.1. Concentrated Liquidity

In UniSwap V1 and UniSwap V2, liquidity in each price pool is uniformly distributed along the curve in a price interval [0, ∞ [. The main problem with this model can be obvious is the case of a stablecoin pairs. For example, DAI/USDC pool.
In DAI/USDC pool most of the transactions happens in a price range [0.99$, 1.01$] because it is the price where LP would expect most volume and most fees. This on the other hand would make the liquidity outside this range unused because of two reasons: first nobody would trade outside this range because there are other platforms that would provide a better deal since those two coins are stable, second, in case of price changing, this means an arbitrage opportunity and trades would instantly take this opportunity hence returning the price to the above-mentioned range again.
UniSwap V3 solved the above issue by rewarding the LPs for taking the risk of impermanent loss, UniSwap V3 asks every LPs that put assets in liquidity pools to

[3] Optimism is a low-cost and lightning-fast Ethereum L2 blockchain

also determine the price range in which the LP wants to allocate their assets, which would allow LP to collect fees only if the price is within the selected price range. The liquidity which is concentrated to a closed interval is called a Position. And UniSwap V3 gave the LP the freedom to have many different positions within a pool [6].

By providing the ability for LPs to concentrate their liquidity, this would give the LP a higher Efficiency for the assets he is providing or as known as Higher Capital Efficiency. If we look at a stablecoin pools , for Example DAI/USDC , the probability of the price going out of the [0.99$, 1.01$] is really low , which means in case of UniSwap V2 a small portion of the initial deposited assets by the LP is going to be used, hence return fees for the LP, but in UniSwap V3, 100% of these assets are going to return fees to the LP if he chose a Position equal to [0.99$, 1.01$] which in turn means more efficient use of the assets and a reward for the LP for taking the impermanent loss risk [7].

In the case of unstable coins pools, for example WETH/DAI pool, an LP can't assume the price range easily as he can in stablecoin pools, so the LP would choose a Position across the curve, if the price exited the Position, then the LP would not gain fees, hence making his liquidity inactive.

The idea of concentrated liquidity would help in increasing the market depth by making the market decide what is the best distribution of liquidity should look like. In order to implement Concentrated Liquidity feature, UniSwap V3 introduced the concept of Ticks.

3.2. Ticks

Ticks as a concept represents the distances between liquidity positions in the price curve. Each increase or decrease by the amount of 1 Tick represents 0.01% increase or decrease of the assets price inside a pool. So, the price at each Tick can be defined by the Tick number using the following formula:

$$p(i) = 1.0001^{i}$$

Then with every transaction that happens in the pool, the pool contract will use the liquidity available in the current Tick before proceeding to the next Tick and activating every inactive liquidity within the positions which contains the new Tick and so on. And off course for a LP to create a position, he must choose an upper and lower tick to define the position border.

Due to the nature of the smart contracts of the UniSwap V3, the spaces between ticks in related to the transaction fee within a pool, where lower fees mean closer ticks and higher fees means wider ticks. Narrow ticks in stable coin pairs on the other hand would increase the granularity of the liquidity in the pool, leading to a lower price during swapping those stablecoins.

3.3. Non-Fungible Liquidity

Now with the concept of Ticks and Concentrated liquidity, each LP should determine the price range that he wants for the assets he provides. And since every

user could define a different position, ERC20 liquidity tokens that were used by UniSwap V1 and V2 cannot define the share of a liquidity for a LP. Thus, in UniSwap V3 liquidity Tokens are now presented as ERC721[4] to represent the liquidity and position for the LP.

3.4. Flexible Fees

UniSwap V3 introduced 3 tiers for fees depending on the pool, a fee of 0.05% for stablecoin pools (DAI-USDC), 0.3% for standard pools like (ETH-DAI) and 1% for pools that are exotic.
The flexible fees addition to UniSwap V3 allowed for the existence of multiple pools for each pair of tokens, the difference between each pool is by the swap fee. Allowing dynamic fees depending on the nature of the pool.

3.5. Advanced Oracles

Instead for the only one stored cumulative sum oracle that was used in UniSwap V2, UniSwap V3 stores an array of Cumulative sums, hence make it easy to calculate TWAP for the latest 9 days or more.

[4] better known as NFTS

Chapter 2 - Practical Work

UniSwap V3 subgraph API

Since UniSwap V3 has a complex mechanism and multiple smart contracts that interact with each other and since UniSwap V3 stores data on the Ethereum blockchain, it would be hard to extract complex and historical data from the blockchain. Hence, UniSwap V3 uses The Graph hosting service [8], which is a protocol to index and query data directly from the Ethereum blockchain.

By using The Graph, UniSwap V3 created a subgraph on this service which describes UniSwap V3 smart contracts and the events between them and the entities these events represent. And also, provides APIs to query data directly from those subgraphs using standard GraphQL.

By using python with the Subgraph API for UniSwap V3, data has been extracted and stored in the database and several CSV files. More details about the queries used and the process can be found in Extracting_Data.ipynb file [9]. Pay attention that the quires differ depending on the data that the study is interested in during analyzing stage.

Database

In order to deeply understand the structure of the data that data was extracted from UniSwap V3 API and stored in a relational database using Microsoft Sql Server. The Database consists of 7 tables, each table represents an entity or a concept that UniSwap V3 protocol operates on, those tables are:

1. Tokens: is a table that stores general and aggregated information about a specific ERC20 token across all pairs in UniSwap v3 that this ERC20 token participate in, the following table explains some columns in this table:

Column name	*Type*	*Description*
ID	ID	Token address
symbol	String	Token symbol
name	String	Token name
totalValueLockedUSD	Big Decimal	Liquidity across all pools that include the token in question in derived USD
volume	Big Decimal	The volume in Token units
derivedETH	Big Decimal	Derived price in ETH

2. Pools: holds the information about UniSwap V3 ERC20-ERC20 pools, such information are listed below:

Column name	*Type*	*Description*

ID	ID	Pool address
token0 and token1	ID	First and second token id
feeTier	Big int	Fee tier and amount (0.05 , 0.3 or 1)
token0/1Price	Big Decimal	The relative price for each token to the other
volumeUSD	Big Decimal	All time volume swapped from this pool in derived USD
tick	Big int	The current tick in the pool
totalValueLockedUSD	Big Decimal	Total liquidity across all ticks of this pool in derived USD

3. Ticks: holds information about ticks across all pools in UniSwap V3, such information as:

Column name	*Type*	*Description*
ID	ID	ID
poolAddress	String	Pool address fort the specified tick
liquidityGross	Big int	Total liquidity the pool has as the tick chances
price0,1	Big Decimal	Constant value representing the price of token0,1 in this tick and pool
volumeUSD	Big Decimal	Lifetime volume in untracked USD with this tick active

4. Positions: holds information about positions specified by users on a certain UniSwap V3 pool. Such information as:

Column name	*Type*	*Description*
ID	ID	NFT token id provided to the user
owner	String	Address of the owner of this NFT
pool	String	Pool address
tick(lower/upper)	String	IDs of the ticks for the position
deposited0/1 or withdrawn 0/1	Big Decimal	Amount of token0/1 deposited or withdrawn from the position in question.

5. Mints, Burns and Swaps tables: hold information about mints[5], burns[6] and swaps transactions in UniSwap V3, such information as:

Column name	*Type*	*Description*
ID	ID	NFT token id provided to the user
Pool_id	String	The pool address
amountUSD	Big Decimal	Derived amount in USD based on the prices of tokens
Tick information	String	Lower and upper tick in case of mints and burns, the tick address in case of swapping
Owner/sender	Big Decimal	Owner of the position/ sender address.

[5] adding liquidity to position
[6] withdrawing liquidity from position

Other tables include UniswapDayData, TickDayData and PoolDayData which holds historical data about UniSwap protocol, Ticks and pools respectively.

There are 868,184 entities in the database (and also in separate csv files), Historical data starts from 05-05-2021 till 23-9-2022.

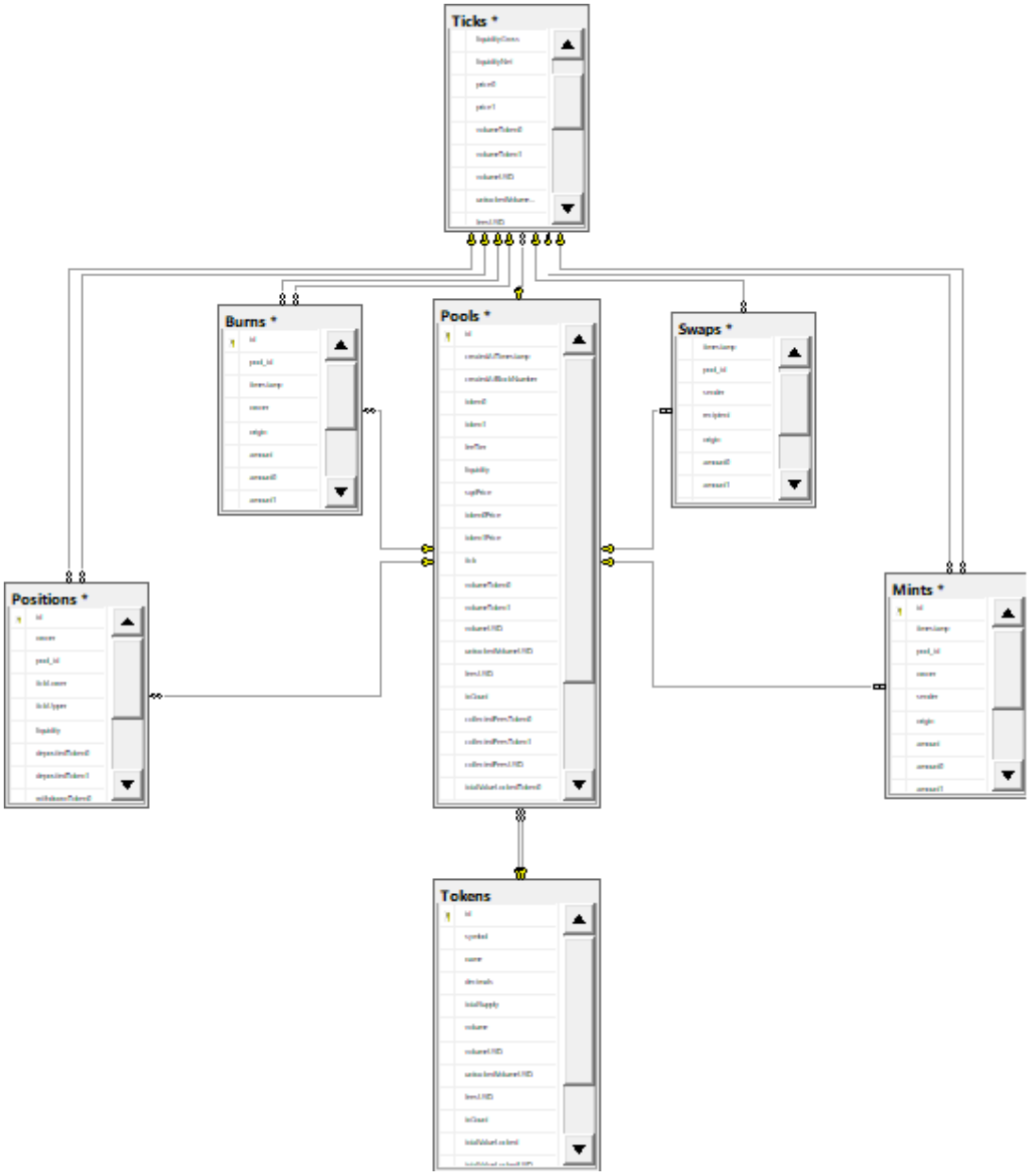

Figure 7:ERD (Entity Relationship Diagram) for the database.

Analysis and Discussion

In this section, multiple analysis and general statistics for the extracted data would be presented, refer to Analyzing_Data.ipynb for interactive plots [9].

1. General UniSwap V3 Analysis

By analyzing table uniswapDayDate, a plot off the TVL and total volume plot relative to the US dollar have been drawn (figure8). It can be found that the TVL in USD has peeked in march 7th 2022 reaching a value of 254B$ before declining back and reaching 10B$ in 23rd of September. This raises suspicion since the peek value is two times bigger than the TVL for the whole Ethereum network [10].

Take into account that the values for the TVL in uniswapDayDates table account for all liquidity events, but doesn't account for fees that can be collected from LPs, making the following graph misleading, since a lot of investors uses TVL as a measure of the trust for the protocol. The actual reported TVL on EtherScan[7] is $3.88b.

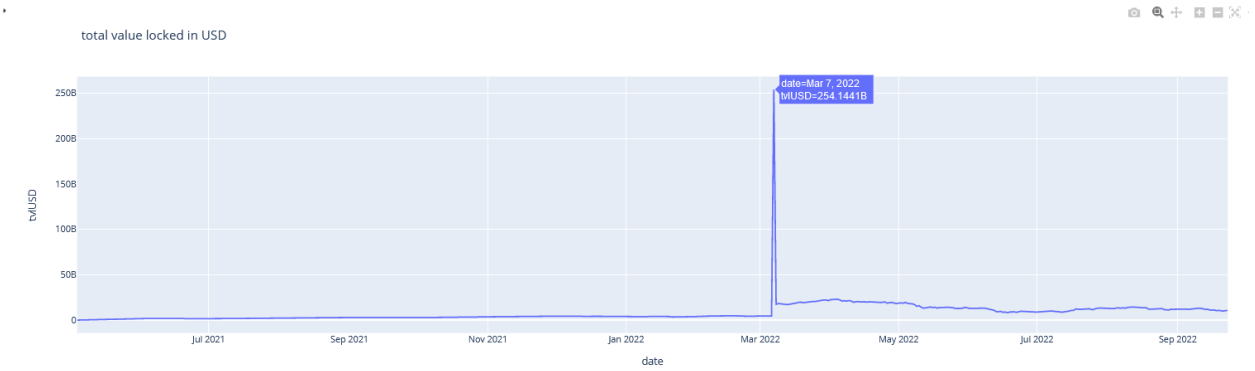

Figure 8:TVL in US dollars - old version

On the 21st of September 2022, UniSwap released an update for the subgraph fixing the problem with the TVL calculations [10]. Thus, an updated version for the UniswapDayDates table has been generated with a new correct plot (figure 9).

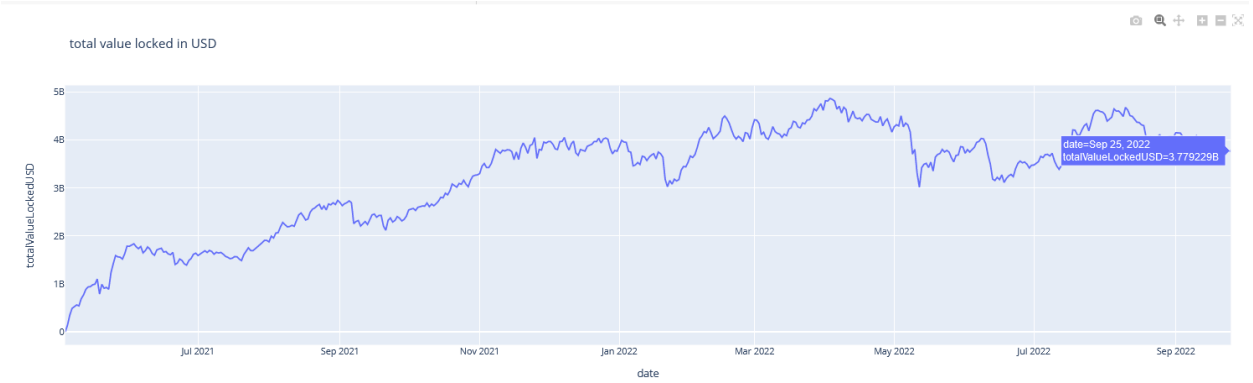

Figure 9:TVL in US dollars - updated version

Which resulted in a better and more realistic data. (figure10) present the total trading volume plot across each day on UniSwap V3.

[7] https://etherscan.io/

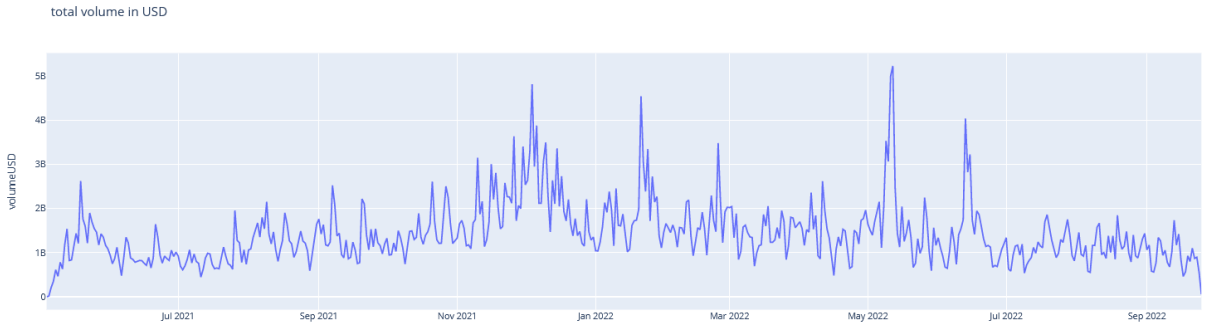

Figure 10:total trading volume in US dollars

It should be remarked that after the update occurred, the schema of the subgraph API has changed, thus the data has to be extracted again with the new enhanced subgraph API, which explains why transforming the Analyzing_Data.ipynb to work with data from csv files rather than the Database itself [9], but this situation can easily be fixed by updating the database.

2. Tokens

This research chooses 5 tokens to spectate and preform analysis on. Those tokens are (USDC, WETH, WBTC, UNI, DAI). Those tokens provide multiple combinations in terms of stability or price changes and types of ERC20, which would help analyzing diverse pools in return.

USDC, WETH and DAI have a relatively large TVL in UniSwap V3, normal TVL for WBTC and a small one for UNI(figure11).

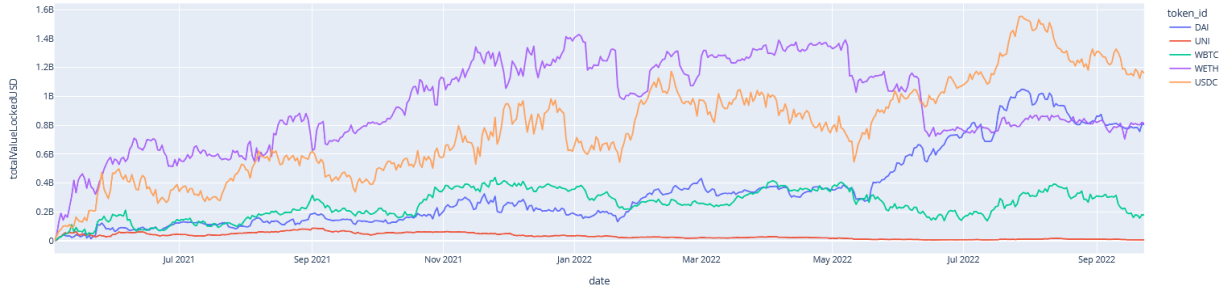

Figure 11: TVL in US dollars for (WETH, WBTC, UNI, DAI)

Now a study on the prices of the above-mentioned tokens in derived USD across dates using OHLC graphs is constructed.

Both USDC and DAI maintain a value close to 1$, since both tokens are stable coins and have the purpose to maintain a 1:1 value with the US dollar (figure 12).

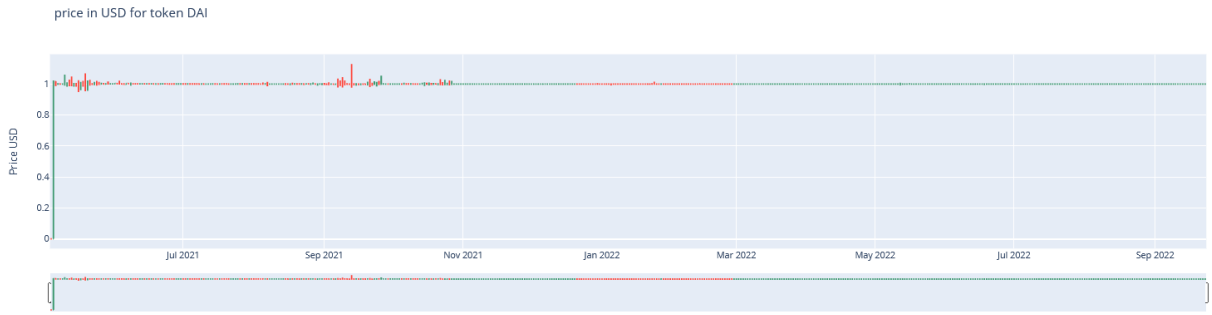

Figure 12:price fluctuation of DAI

On the other hand, WBTC and WETH have been suffering from declining in price throughout the last month. WBTC decline comes after rising interest rates in the US on 21 of September 2022 and the high inflations in general, which causes the lower demand on WBTC and thus dropping in price. The price for WBTC has dropped below $19k on September 2022 [11](figure13).

Figure 13:price fluctuation of WBTC

WETH on the other hand, is suffering from dropping in price due to the same above-mentioned reasons that affected WBTC, and on top of that, WETH suffered a small drop in price also due to The Merge project [11]. This project aims to merge Ethereum mainnet with Beacon chain to reduce Ethereum's energy consumptions. This merge however is expected to boost the price of WETH in the future. The price of WETH have fallen below 1300$ in September the 21st 2022(figure14).

Figure 14:price fluctuation of WETH

On September 17th 2020, UniSwap launched the governance token UNI and distribute it to the traders and LP alike, and it can be earned by liquidity mining. This token would give the ability to its holder to participate in decisions regarding UniSwap development. However due to the current market statues, the price of UNI also dropped to approximately 5$ in September 2022 after it was worth 19$ at the beginning of the year(figure15).

Figure 15:price fluctuation of UNI

3. Pools

In this section, a general statical study on three pools have been made. First pool is DAI/USDC with Fee Tier 0.01%, second is USDC/WETH with fee Tier 0.3% and the third is WBTC/WETH with Tier 0.3%. the study focuses on those pools since they have a relatively high TVL and high trading volume. WBTC/WETH and USDC/WETH are normal pools, because at least one of the tokens are subject to variation price movement. On the other hand, DAI/USDC is a stable pool, because both assets are linked to US dollar and maintain a 1:1 value. Thus, a lower price fluctuation [7].

The difference in the fees tiers in each pool is due to the fact that normal pools charge a higher fee in comparison to stable pools, because there would be a higher impermanent loss on LPs in pools where coins are not stable or have a steady exchange ratio with the US dollar. (figure16) presents the total trading volume[8] for the pools mentioned above. It can be seen that since 2021 USDC/WETH has been the highest volume pool amount the pools under study

[8] relative to US dollar

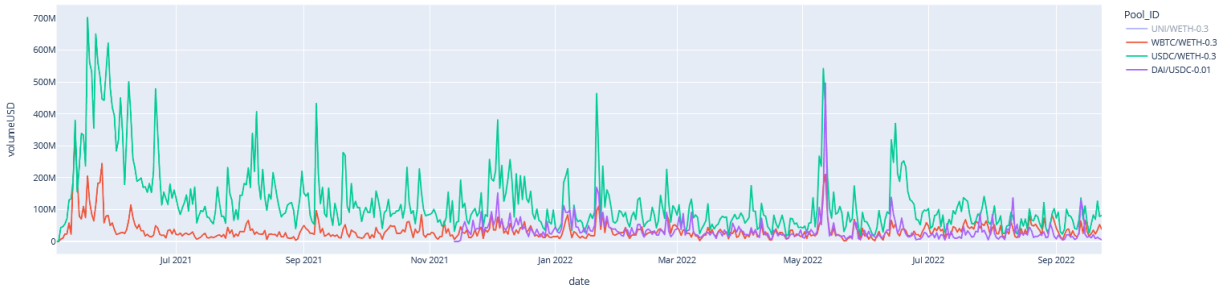

Figure 16:Volume in US dollars for all of the 3 pools under study

(Figure17) presents the TVL (relative to US dollar) for the pools mentioned above. The study shows that DAI/USDC is the pool with the highest TVL among pools under study, which is rational since this pool is stable and almost maintain the 1:1 ration with US dollar.

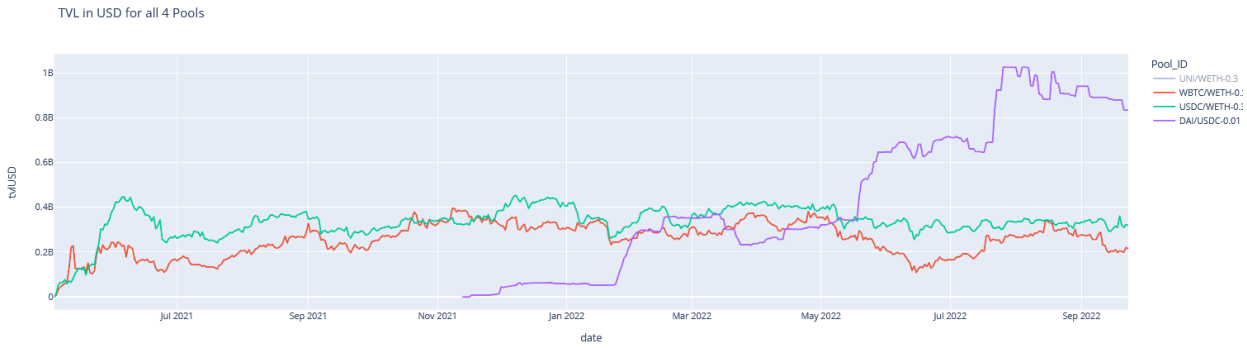

Figure 17:TVL in US dollar for all 3 pools under study

4. Liquidity Distribution

In order to deeply understand the market and as a LP provider for a certain pool, it is important to figure out how the liquidity is distributed across different prices in each pool. The problem is that UniSwap V3 subgraph API does not provide clear data to represent the liquidity distribution. Thus, in the LD.ipynb [9], 3 datasets have been constructed (Ticks_Anylsis_<name_of_pool>.csv) to represent the information about each tick for each of the above 3 pools under study. Such information as tick index, amount of first and second token in this tick, liquidity in the tick and finally the price for the first token relative to the other. Which shows the principle of centralized liquidity in practice. (Figure18) shows the liquidity distribution of USDC/WETH pool. Most of the liquidity in this pool is focused around the current price of USDC per WETH which is 0.0007, but there is liquidity that is focused when the price for USDC reaches 3446 WETH and also liquidity when the price reaches 0.99 and relatively small portion of the liquidity is focused on price range 0.0001 USDC per WETH. It is safe to say that the liquidity is distributed to the right of the current price more, which, means that LP are expecting a drop in the price of WETH more[9].

[9] since USDC is a stable coin

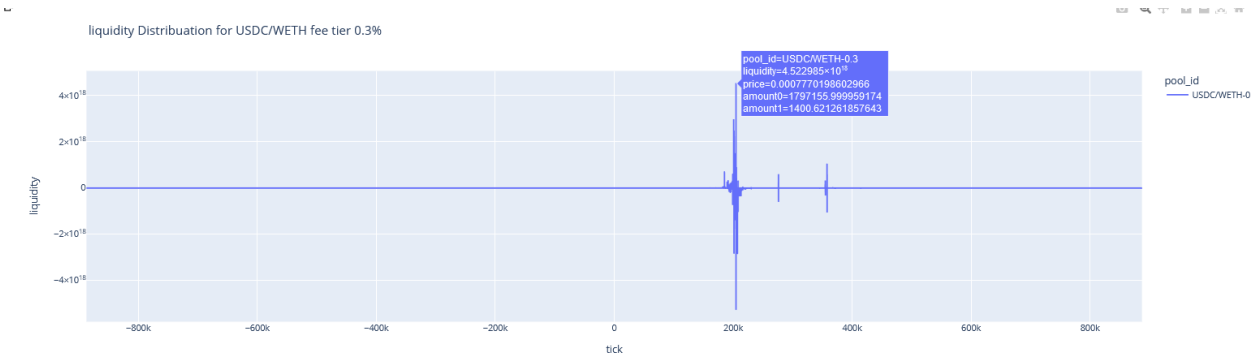

Figure 18: Liquidity distribution for USDC/WETH pool

On the other hand, (figure19) shows the liquidity distribution of WBTC/WETH pool. Most of the liquidity is focused around the price of 17.19 WETH for 1 WBTC, or the current price which is 19.74 WETH for 1 WBTC. A small amount of liquidity is focused on the price of 10 WETH for 1 WBTC, but there is no huge amount of liquidity distributed elsewhere. This can be explained from the fact that both tokens are normal not stable, making them venerable to the price fluctuation, which is different from the case USDC/WETH pool. From (figure19) also we can presume that LP are expecting a decline in the value of the WBTC and WETH at the same time, due to the multiple reasons mentioned in [token price].

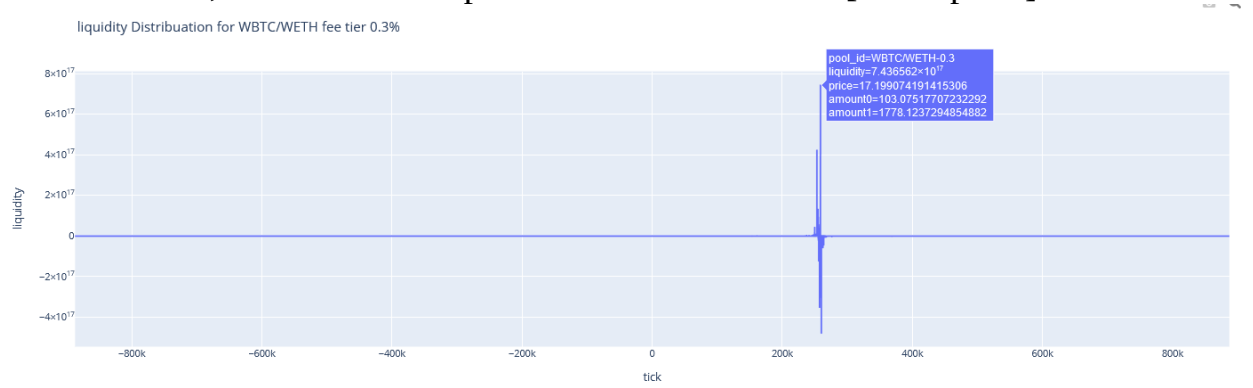

Figure 19: Liquidity distribution for WBTC/WETH pool

5. Mints, Burns and Swaps

By analyzing (figure 20 to figure 28), it was seen from (20)(21) that the total amount of the mints and burns are increasing at the same extent at the same time, reaching a value high at 29th of August 2022, this is explainable by (23)(24) where it can be seen that this peak is mostly from burning or minting USDC/DAI pairs in huge amounts (around 25 – 26 billion in USD value). On the other hand, by checking (22) the study comes to conclusion that the total amount of swaps in comparison to US dollar fluctuate without a strict increase or decrease. This is explainable by checking (25) which shows that those fluctuating comes from the movement of the market and normal pairs, especially from USDC/WETH pair. The total amount of swaps on this pair has peeked at 542 million in US dollar on May 11th this year.

By inspecting (26)(27)(28) it can be observed that the highest count of mints, burns and swaps operations subsequently comes from the USDC/WETH, at an average 160 burn operation, 180 mint operations and around 900 swap operations per day in the last 2 months. Whereas USDC/DAI comes last in number of operations, on average at around 60 mint operations, 25 burn operation and 650 swap operation per day in the last 2 months.

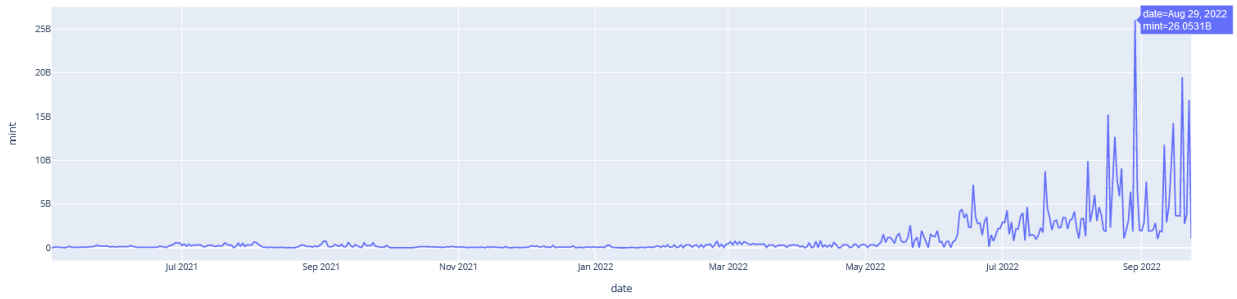

Figure 20: sum of amounts of mints (in US dollars) across pools under study

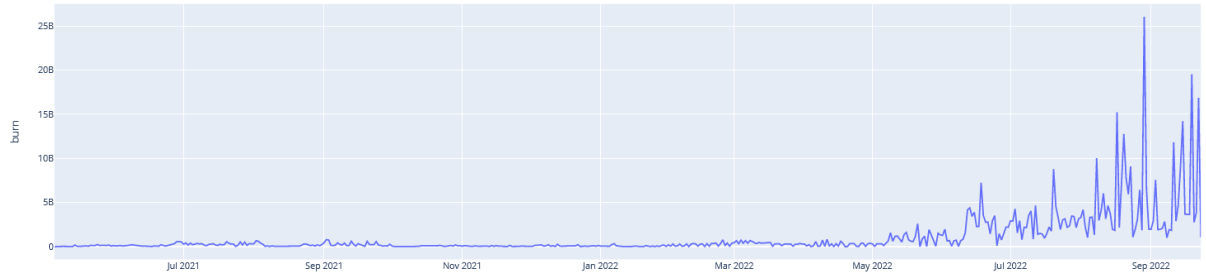

Figure 21:sum of amounts of burns (in US dollars) across pools under study

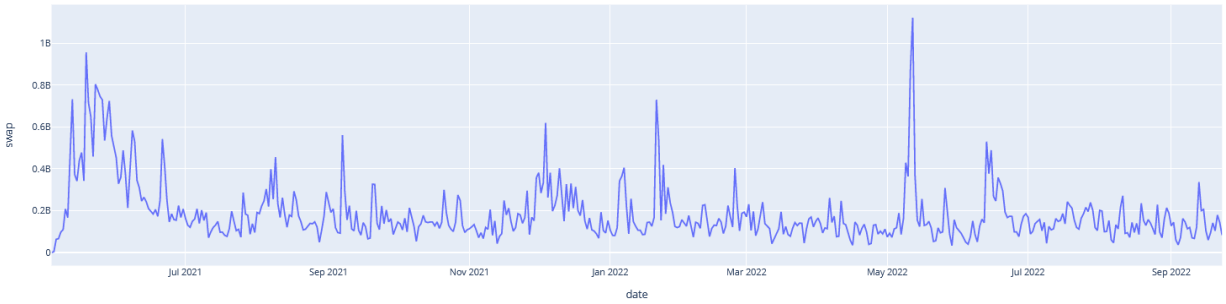

Figure 22:sum of amounts of swaps (in US dollars) across pools under study

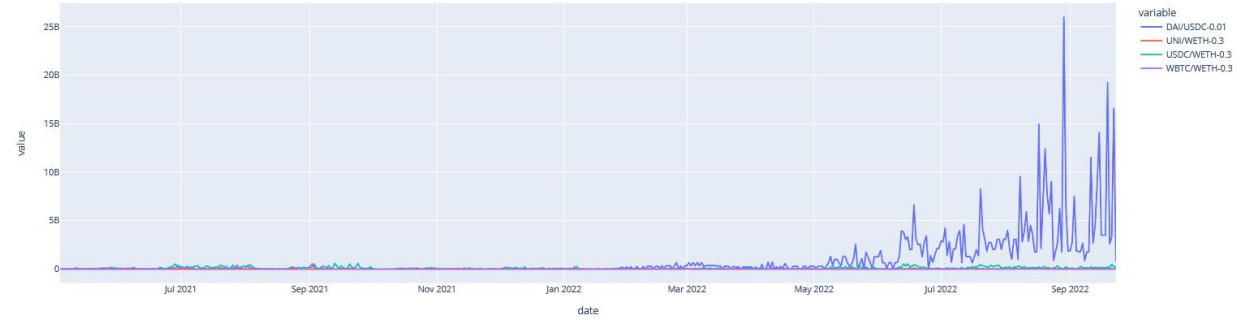

Figure 23:amounts of mints (in US dollars) foreach pool under study

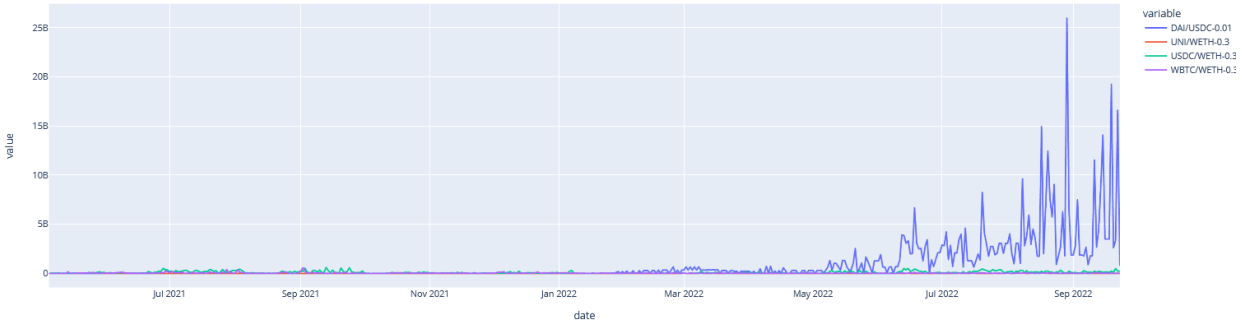

Figure 24:amounts of burns (in US dollars) foreach pool under study

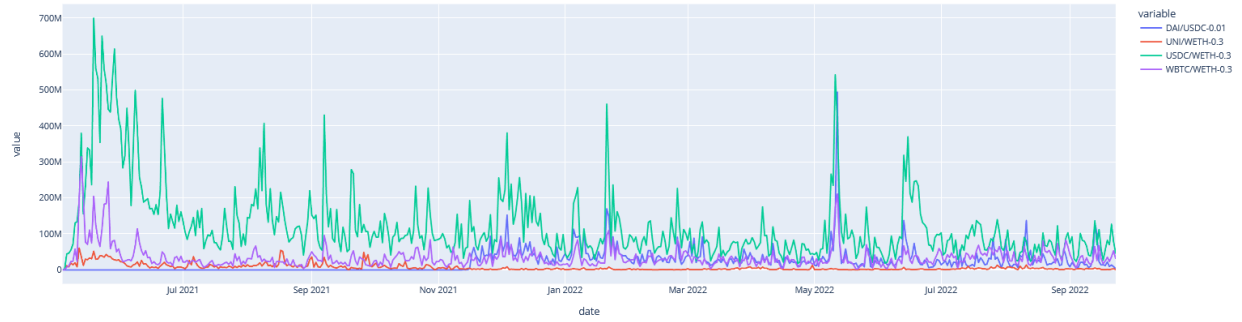

Figure 25:amounts of swaps (in US dollars) foreach pool under study

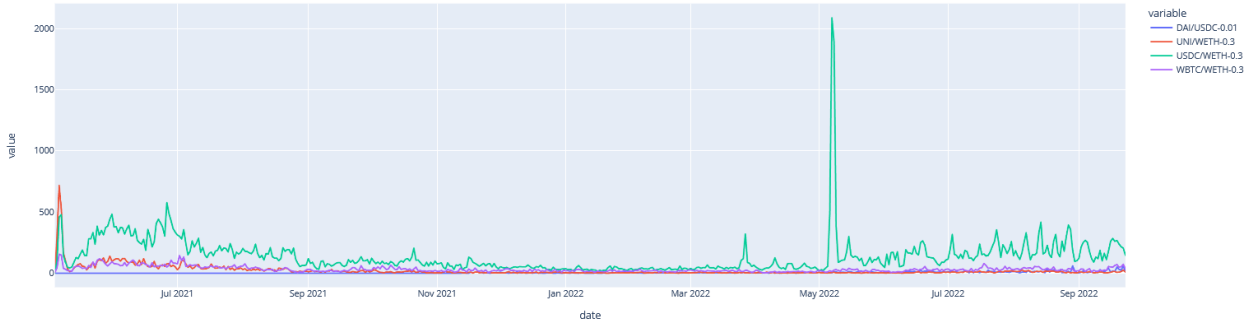

Figure 26:number of mints operation for each pool per day

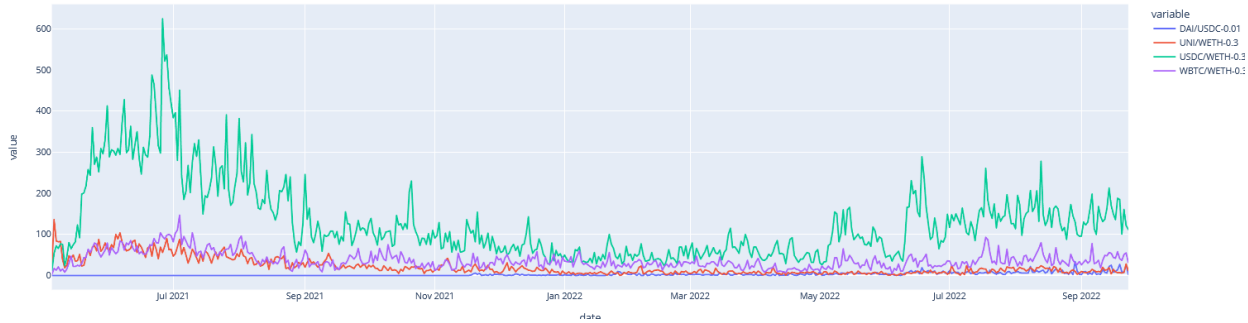

Figure 27:number of burns operation for each pool per day

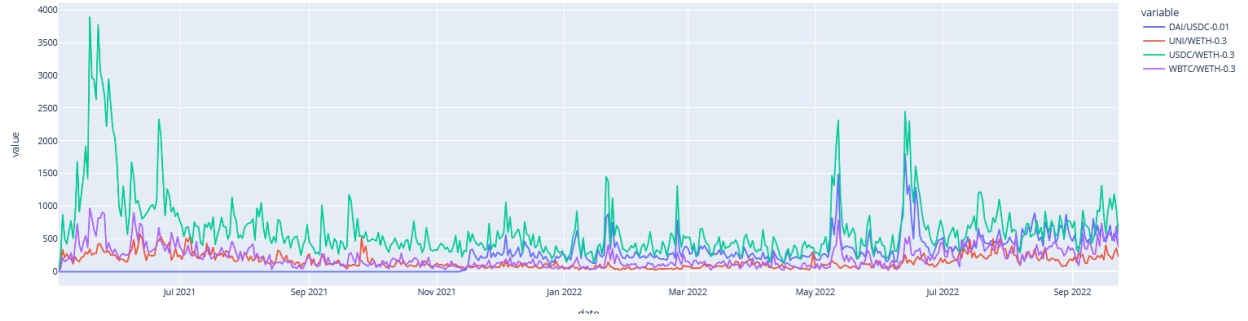

Figure 28:number of swaps operation for each pool per day

Chapter 3 - Conclusion and Future Work

In this project, a theoretical study of UniSwap protocol for DEX has been conducted across all versions of UniSwap since it's lunch in 2018, which provides a deep insight on how this protocol works, what is the structure and main concepts that forms the protocol and what are the differences between the different versions of UniSwap throughout its development form V1 to V3.

On the practical aspect, an analysis of the data extracted from UniSwap V3 has been conducted, and a deeper analysis on USDC, WETH, WBTC ERC20 tokens and their pools has taken place, to understand the different structures of pools with daily trade and to enforce the knowledge gained from the theoretical part of this study. Providing deeper insights on high TVL pools.

This work can be extended by multiple ways:

- A study on positions sizes and counts in each pool can be performed. In order to get a deeper insight on the risks and returns that the LPs in UniSwap face, using metrics like pool's realized volatility.
- Extend the work to a more exotic pools, with unestablished cryptocurrencies.
- Compare UniSwap V3 with the previous V2, or compare UniSwap with other hybrid exchanges like Hydro.
- Use machine learning to detect scam tokens or scam liquidity pools on UniSwap.
- Preform time-series forecasting, assuming that TVL of UniSwap is Time-Series function, to predict the future TVL in UniSwap V3. Resources

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