RĒZEKNES TEHNOLOĢIJU AKADĒMIJA

UNISWAP - A CASE STUDY OF DECENTRALIZED EXCHANGES ON THE BLOCKCHAIN

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Abstract. *The paper takes a close look at an emerging industry - decentralized finance on the blockchain. The goal of this paper is to compare centralized order book (CLOB)-based exchanges to automated market maker (AMM)-based decentralized exchanges (DEX) and analyze the challenges that AMM-based DEXes are facing today using Uniswap as an example.*

Keywords: *Uniswap, Decentralized exchange, DEX, AMM, Automated market maker, DeFi, Decentralized finance.*

Introduction

Before the emergence of the *Ethereum* network blockchain technology has been a solution that was looking for a problem [1]. The original purpose of *Bitcoin* [2] has been to create a peer-to-peer version of electronic cash that would allow online payments to be sent directly from one party to another without going through a financial institution. But it has struggled to compete with existing payment systems due to the technical limitations [3] of its proof-of-work consensus algorithm and the questionable reputation of *Bitcoin* [4].

The important difference between *Ethereum* and *Bitcoin* is an introduction of *Ethereum Virtual Machine* (*EVM*) [5]. The key to the popularity of *EVM* and its *Turing-complete* language *Solidity* was that it allowed developers to write and execute code on the blockchain using smart contracts [6]. In a way, *Ethereum* blockchain network set out to be a global, decentralized computing platform [7]. According to "*State of the DApps*" [8], which is a not-for-profit curated directory of decentralized applications (*DApps*), over 4000 applications have been deployed on the *Ethereum* blockchain as of April 2022.

This paper will focus on the class of *DApps* that are used in decentralized finance. The Decentralised Finance (*DeFi*) market has experienced exponential growth since the summer of 2020 - the total value of crypto-assets locked in DeFi applications built on the Ethereum blockchain peaked in November 2021, exceeding 240 billion *USD* [9] – an increase from 14 billion *USD* a year earlier, according to the largest *DeFi* "total value locked" (*TVL*) aggregator *DefiLlama*.

The goal of this paper is to analyze the differences between *DeFi* and traditional centralized finance (*CeFi*). This is done by studying one of the most important sectors of financial markets – trading of digital assets. The paper will look at some advantages and disadvantages of *AMM*-based *DEXes* when compared against classical *CLOB*-based centralized exchanges (*CEX*). This includes studying the technical implementations and pinpointing the fundamental differences between the two. The paper will also highlight the regulatory challenges the *DeFi* sector is facing today.

Materials and methods

This paper is a case study of decentralized finance using *Uniswap DEX* as a subject. To gather information about *DeFi* and *Uniswap* the author will be using a collection of research papers that study *AMMs* and the blockchain technology, which is a form of *Distributed Ledger Technology* (*DLT*). Since *DLT* and *DeFi* are emerging fields, looking at the scientific publications won't be enough - there is also a need to look at news articles, blog posts, social media, and source code repositories to gather and analyze information from various experts around the *DeFi* industry.

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Results and discussion

Earlier iterations of *DEXes* on the *Ethereum* blockchain, such as *EtherDelta* and *IDEX*, were implemented using limit-order based model [10]. They both managed their order books off-chain, since it's impractical and too expensive to do that on-chain. Which meant that the degree to which they were decentralized was quite limited [11].

Uniswap was one of the first successful implementations of *AMMs* on the blockchain. It was created by Hayden Adams in 2018 [12] and the first version was based on a concept described by Vitalik Buterin in a blogpost [13]. Uniswap was built around a constant product formula [14], which in its simplified form can be viewed as $C = r1 * r2$, where *r1* and *r2* are reserves of the digital assets in a trading pool and *C* is a constant. This formula is used to price assets in a pool.

As the project gained more traction and more support, it released new versions of the protocol - *V2* [15] and *V3* [16], that added new features to the exchange. *Uniswap Labs*, a company that was built around this project, has made *V2* of *Uniswap* open source licensed under the *GPL*, which lead to the development of many *Uniswap* clones and competitors, some of which improved upon the platform's weaknesses.

For example, *Curve Finance* [17] modified the constant product formula to facilitate stable coin swaps with lower fees and *Balancer* [18] tried solving the impermanent loss [19] problem of *Uniswap* by introducing multi-asset pools that lowered the potential impact of impermanent loss at the expense of complexity of market making in pools with more than 2 assets.

Advantages of AMM-based DEXes in comparison to CLOB-based CEXes

1) Censorship-resistance. Trustless blockchain networks, along with permissionless and immutable nature of smart contracts that were used to build *Uniswap*, have the potential to deny one authority the power to prevent users from using the trading platform. Centralized exchanges like *Binance* can arbitrarily prevent users from accessing the platform according to their terms of service [20].
2) *Uniswap V2* has introduced the ability to use flash loans to trade digital assets. **Flash loans** provide users with the ability to borrow digital assets with no collateral if the assets get returned to the pool within the same blockchain transaction [21]. Flash loans take advantage of a unique property of *Ethereum* blockchain - atomicity of transactions [22].
3) According to the latest study [23], *Uniswap V3* offers **deeper liquidity** on popular trading pairs than the leading centralized exchanges, such as *Binance*, *Coinbase* and *Kraken*. Deeper liquidity means lower slippage on trades, which could make prices of digital assets more stable.
4) Becoming a liquidity provider on *AMM*-based *DEXes* is an easy and trustless process, that can allow **retail investors** with no technical expertise and prior knowledge to **become market makers** in a trading pair and benefit from the ability to get a proportional cut of fees from all the trades performed on the platform [24]. This process is subject to significant counterparty risks, such as adverse selection and principal-agent problem [25].
5) *AMMs* rely on traders that participate in **arbitrage** to adjust the exchange rates of tokens across the market. In volatile markets such as cryptocurrency trading market this generates **extra trading volume** that benefits liquidity providers in *AMM* liquidity pools [26].
6) *Uniswap V2* has introduced the potential to use the smart contracts of the trading pairs to calculate the **time-weighted average price** (*TWAP*) of the token [27]. *Uniswap V3* has made further improvements to *TWAP* functionality [28]. As a result of that a lot of projects in *DeFi* have started using *Uniswap* as a **price oracle** [29]. It's worth noting that some researchers have argued [30] that manipulating such an oracle could be less expensive than originally anticipated.

Disadvantages of *AMM*-based *DEXes* in comparison to *CLOB*-based *CEXes*

1) *CEXes* have been targeted by some high-profile hacks in the past [31], but the chances of third parties exploiting *DeFi* protocols are higher because of **smart contract risk**. The compiled bytecode and the state of all the deployed smart contracts are public [32] and anyone can

analyze them to try and find an attack vector. Bugs in proprietary software can exist for years without bringing any harm to the system. Due to the public nature of smart contracts, their inefficiencies, bugs, and logic errors get exploited on a regular basis [33] [34] [35]. Because of how devastating the impact from smart contract vulnerability can be, a new industry has emerged to try and solve the problem - smart contract **security auditing** [36].

2) The non-custodial nature of *DApps* can also be a disadvantage. For example, **losing the private key** to a non-custodial cryptocurrency wallet would mean there is **no way to recover the funds**, unlike an account on a *CEX* such as *Binance*, where recovery mechanisms exist.
3) To sell or buy a digital asset on a blockchain a user must submit a transaction. These transactions can sometimes get stuck due to a low gas fee in a period of high network activity [37]. This can lead to **bad user experience**. In fact, modern *CEXes* settle transactions faster than *DEXes* due to the need for a blockchain to reach consensus. So, **trade settlement speed** with the technology that exists today will be faster in a centralized solution [38].
4) Most *DEXes* that are competing with *Uniswap*, such as *Sushiswap* [39] and *Pancakeswap* [40] are running *AMM* implementations of open-sourced *Uniswap V2* smart contracts. These pools have **low capital efficiency** [41]. *CEXes* typically offer *APIs* [42] that allow trading bots to cancel and repost new orders into an order book for free so market making in *CEXes* will require more effort but lead to better capital efficiency.
5) **Impermanent loss** (*IL*) is one of the main risk factors for market makers in both *CEXes* and *DEXes*. Impermanent loss is the loss incurred by a market making position versus keeping the initially allocated amounts fixed, it happens when the ratio of tokens *A* and *B* in a pool changes. This is even more relevant for *Uniswap V3*, since it can potentially increase [43] the *IL* of a liquidity provider while offering better capital efficiency.
6) High-frequency trading in traditional stock markets has been brilliantly covered by Richard Lewis in a book called "*Flash boys*". Due to *Ethereum* having a public pool of pending transactions called mempool [44], digital asset trading on *DeFi* is plagued by **frontrunning** [45], which leads to similar abuses of retail traders at the hands of trading bots.
7) The **regulatory challenges** that the *DEXes* are facing is the hurdle that is hurting institutional adoption without which widespread adoption of *DeFi* is highly unlikely. This problem gets looked at in the next section of the paper.

DeFi and regulatory challenges

The chairman of the *SEC* Gary Gensler has signaled that the regulators will focus more on exchanges that facilitate the trading and creation of digital assets that need to be registered with the *SEC* [46]. Some of the tokens that are traded on *Uniswap* can be considered securities [47].

Uniswap governance token *UNI*, which *Uniswap* announced on September 16th of 2020, is the only digital asset *Uniswap Labs* has released [48], and it was done not in exchange for money, but to reward loyalty. Classifying *UNI* token as a security will require it to pass a *Howey test* [49]. Since *UNI* is a governance token, it possesses unique characteristics that frustrate a simple *Howey test* application. A governance token implemented as a loyalty program decentralizes governance to loyal members of the community and cuts against the first element of the *Howey test* in requiring an exchange of money.

That's not to say that *Uniswap Labs* and its advisors and investors have not benefitted from the *UNI* token. *UNI* token emission, supply schedule and distribution [50] is showing that *Uniswap's* team and venture capital investors will have a disproportionate amount of power [51] in the early stages of governance, even though they are unlikely to use it considering the potential damage to their reputation and the impediment to the success of the protocol. Still, it begs the question – how decentralized *Uniswap* really is?

Nonetheless, when it comes to potential legal problems *Uniswap* as a company can't be looked at in the same way as *BlockFi* [52] and *EtherDelta* [53] that were involved in investigations conducted by the *SEC* that led to fines and settlements, since *Uniswap* isn't making any promises regarding the potential profit from the investments [54] and it makes sure that the potential investors are aware that only they are liable for their actions. Still, it remains an open question whether the *Uniswap* terms of service and disclaimer [55] will protect the developers of the project from the *SEC* when it decides to

regulate decentralized exchanges that are using smart contracts on the blockchain to facilitate trading.

The problem lies in the fact that the laws are constantly evolving, and the *SEC* is trying to keep up with the new technology by proposing new amendments [56] to the *Securities Exchange Act.* These amendments redefine what constitutes an exchange and could potentially force companies like *Uniswap Labs* to adopt and maintain a suite of compliance programs covering disclosure obligations, trade reporting, anti-financial crimes, and suspicious activity reporting, as well as passing qualification exams. Complying with this would be impossible given the immutable nature [57] of *Uniswap* contracts.

Since liquidity pools and trades on these exchanges run in permissionless manner [58] *Uniswap* developers have no way of stopping people who want to use the smart contracts of the exchange even if they shut down the website. In fact, according to a tweet from Hayden Adams [59], most of the trading volume on *Uniswap* in 2021 didn't come through the official website but instead came from trading bots, website forks and wallets. The only way to stop people from using these smart contracts would be through extreme reputational damage to *Uniswap*, which a high-profile lawsuit or an unfavorable ruling of the *SEC* theoretically might be able to accomplish.

As far as dealing with other exchanges that do not have a legitimate company behind them, it's going to be up to the government to track the movement of digital assets on the blockchain and look for unlawful activities like tax evasion and money laundering. And the recent signing of a new deal with a blockchain analytics firm *AnChain.AI* to help monitor and regulate the *DeFi* industry [60] goes to show that the *SEC* takes these matters seriously. In addition to cataloguing and monitoring known wallets tied to illicit actors, *AnChain.AI* has built a predictive engine that can be used to identify unknown addresses and transactions that could be suspicious.

Conclusions

Even though the new generation of *AMM*-based *DEXes* are offering some interesting technical solutions and novel approaches to solving old problems, until the regulatory woes and the issues with usability are resolved the widespread adoption of *DeFi* is unlikely, it will remain a tiny niche on the global market. Even as adoption grows, it is likely that instead of using non-custodial wallets most investors will get exposed to *DeFi* via third parties, such as *Binance*, *Revolut* or *Paypal*. Non-custodial nature, censorship resistance and the appeal of high risk/high reward are compelling enough to attract risk-tolerant investors, so *DeFi* is here to stay, and, despite all the problems, it has a real use case and a target audience.

There are some interesting developments in other areas of decentralized finance that might help with institutional adoption, for example *Aave Arc* and *Maple Finance*, that are permissioned lending platforms on the blockchain that are compliant with *KYC* and *AML* regulations. It will be interesting to see if they will bring more institutional capital into the *DeFi* sector.

Regarding technical evolution of *DEXes*, it's fair to say that the open-source nature of smart contracts on the blockchain and a huge influx of venture capital [61] into *DeFi* startups has allowed for a rapid increase in quality and security of decentralized applications. Current blockchain solutions can run into problems with scalability [62], but that's to be expected since the industry is in its infancy and the networks are in active development [63] and are constantly evolving. *DLT* is still in the era of growing pains, high-profile hacks, and non-stop innovation.

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