Abstract—Decentralized Finance (DeFi) is a new financial industry built on blockchain technologies. Decentralized financial services increased consequently, the ability to lend, borrow and invest in decentralized investment vehicles, allowing investors to bypass third party intermediaries. DeFi promise is to reduce transactions costs, management fees while increasing the trust between agents of this financial industry 3.0. This paper provides an overview of Decentralized Finance different components as well as the risks involved in investing through these new vehicles. It also proposes an allocation methodology which integrate and quantify these risks.

I. INTRODUCTION

In a context of expansion of Decentralized Finance Companies [1], to better understand the concept behind Decentralized Finance (DeFi), it is first necessary to have an understanding of its structure and of its constitutive elements. In DeFi, yields are generated using 4) Tokens deposited in 3) Liquidity Pools generated by 2) Protocols hosted on 1) blockchains. We will start by clarifying these terms.

A blockchain is the database of a network. Its main purpose is to record the transactions that have been realized among all the members of the network. For instance, the bitcoin network is composed of all the persons who have downloaded the bitcoin source code (generally through a wallet) and the blockchain will record every bitcoin sent from one person to the other. It is important to note that the bitcoin source code is very basic in the sense that it can only be used to receive and send bitcoins. Other networks such as Ethereum have more complex source code, which can be used to send and receive Ether (the Ethereum native token), but also read programs also called Smart Contracts. So into the Ethereum blockchain, you can save transactions used to send Ether, but also read programs and the transactions that are actioning these smart contracts. In other words, Ethereum (like other smart contracts blockchains such as Solana, Terra, BSC...) will rent its blockchain (to store smart contracts and transactions) and its virtual machine (required to read and execute smart contracts), to projects who want to use a decentralize environment without dealing with all the burden of maintaining a blockchain infrastructure.

Let us take the example of Uniswap, the most famous decentralized exchange ("DEX") on Ethereum. The founders of the project have written a source code (a smart contract) and have decided to host it on Ethereum in order to benefit from Ethereum decentralized's architecture, security and also its important network of miners and users. The purpose of the smart contract is to create liquidity pools that will allow users to swap tokens (more on this in a minute). Concretely, the smart contract is recorded in a block of the Ethereum blockchain and is actioned through transactions. For instance, every time a person wants to swap two tokens in a given pool, he will send a transaction from his wallet (Metamask for instance). This transaction will action a function of the smart contract and the new state of the smart contract (for instance the new amount of tokens in the pool) will be recorded on the blockchain. As illustrated in this example, you can do more operations on the Ethereum blockchain than you can on the Bitcoin blockchain.

In our exemple, Uniswap is a Protocol, also called a Dapp or Decentralized Application. This application is hosted on Ethereum and will also be able to generate its own token (the "UNI"). It has it own business logic and tokenomics which are not related to Ethereum own tokenomics.

Uniswap founders will only pay a fee ("Gas fee") to
Ethereum when the source code is uploaded ("compiled") on the blockchain for the first time and everytimes it is updated. Users of Uniswap will also pay Gas Fees every time they will action a function of this smart contract. Every time you realise a swap or deposit liquidity on Uniswap, you action a function of the smart contract, this is why you pay Gas Fees. Given the popularity of Ethereum, storage and execution of smart contracts is extremly expensive at the moment on Ethereum. This is why this part is increasingly delegated to layer 2 such as, Polygon, Arbitrum or Optimism.

II. DECENTRALIZED INVESTMENT VEHICLES

A. Staking vs Liquidity mining

Before we investigate how Liquidity Pools and Liquidity Mining work, it is important to clarify how different they are from the concepts of "Staking". These terms are regularly confused but are referring to very different areas. The term "Staking" appeared with decentralized protocols developing "Proof of Stake" consensus mechanisms for their mining processes. The purpose of consensus mechanisms with decentralized applications relying on a blockchain, is to secure the network by efficiently selecting the miners who will add the transactions to the blocks, add them to the blockchain and obtain the corresponding rewards. The "Proof of Stake" like "Proof of Work" or "Delegated Proof of Stake" (to only name the most famous), are different types of consensus mecanismes which offer different methods of securely selecting miners. With the "Proof of Stake", miners need to pledge a certain amount of the native tokens they initially bought, in order to be eligible to add blocks to the blockchain. The idea behind this mecanism is that the more stake a miner has in a projet (i.e the more token he has pledged in a protocol), the less interest he has to act viciously as otherwise he will loose his tokens. So the terms "Staking" refers to the pledging of tokens by a miner into a protocol in order to be eligible to the consensus mecanism. The term "Liquidity mining" is confusing because it refers to the mining process when it has nothing to do with it. The reference to "mining" has been added because the concept is similar. The "Liquidity Provider" that we will describe further below, will also pledge his token in the protocol but for a different purpose. The main differencies are that (1) he is not necessarily a miner, (2) he will be able to pledge several tokens, (3) that might not be the protocol native token (4) in a liquidity pool, (5) in order to obtain a trading fee.

In order to explain how a Liquidity Pool works, we will now describe all these differences.

B. Liquidity Pool

Figure 3 describes how a liquidity pool actually works. The purpose of a liquidity pool is to act as a vault in which "Liquidity Providers" can pledge one or several tokens, so that the "Traders" can use these tokens. Liquidity pools are used in DEFI for very different reasons, such as swaping, lending, borowing, derivatives, insurances. All the services of traditional finance are proposed without intermediaries through these liquidity pools.

Indeed, in practice a liquidity pool is only a smart contact hosted on a decentralised blockchain such as Ethereum, Solana or Terra. Since these blockchains are open networks, anyone disposings of a web3 wallet (Metamask for instance) is able to connect to the Liquidity Pool in order to deposit tokens or use the service provided by the pool. Anyone can become a
Liquidity Provider or a Trader and interact directly with each other without intermediation.

We will now describe how the liquidity pool shown in figure 1 allows the Traders to use all the tokens pledged in the pool by the Liquidity Providers in order to exchange them (or "swap" them). Let’s imagine that a Liquidity Pool is dedicated to USDC and USDT, the liquidity Provider will deposit the same amount of both tokens in the pool. In exchange, he will receive a "Liquidity Provider Token" or "LP Token" which corresponds to his share in the pool. If the pool contains 100 USDC/ 100 USDT and the Liquidity Provider deposits 10 USDC/10 USDT, he will obtain 10 percent of the pool and he will receive a corresponding LP Token. In other words, the LP Tokens is the proof of the deposit he made into the pool and he will need it in order to withdraw his token at anytime.

The Trader will use the pool in order to exchange USDT for USDC or vice versa, and pay a small fee for this service. The fee is almost entirely returned to the Liquidity Provider proportionally to his share in the pool, hence the importance of LP Tokens. When the Liquidity Provider wants to withdraw his USDT and USDC, he will send his LP token back to the protocol as a proof of detention. It is also possible to use this LP token on other protocols to obtain additional rewards. This is called "Yield Farming".

III. RISK ASSESSMENT IN DECENTRALIZED FINANCE

As we just mentioned, Blockchains are hosting Protocols that are smart contracts creating Liquidity Pools in which tokens are deposited in order to generate liquidity for traders and yields for the liquidity providers.

So we have four different layers (blockchain, protocol, pool, token), each of them involving its own risks.

A. Blockchain risks

Describing in detail the risks that a decentralized network relying on a blockchain are facing, would need more than a single paper. The general idea is that the blockchain as a database of the network, needs to ensure that the transactions realized among the members of the network are added in a certain order and that this order cannot be changed. Each of the blocks of a blockchain are used to timestamp all the transactions to avoid that a bitcoin is not spent twice. The "double spending" attack is one of the most common attack in decentralized network and one of the most difficult to solve.

In the bitcoin network for instance, it is only possible to revert on a block which has been added to the blockchain (and so double spend one of the transactions the block it includes), by detaining more than 51 percent of all the Hashrate available on the network. The Hashrate is the mining power available on the network at a certain time. Even if one entity were to obtain 51 percent of the hashrate, which already happened in 2014 with one of the main mining pool, it would be far too expensive and an economic non-sense, to complete again the Proof of Work of the blocks that have already been mined, in order to access a transaction.

This discussion is not in the scope of this paper, but it is important to understand that the authenticity and the order of the data added to the blockchain is paramount for decentralized networks. For this reason, the consensus mechanisms in place need to be strong enough to ensure that ill intended miners do not compromise the entire network.

With Proof of Work, the security and the selection of the miners is done through the cost of mining as we just explained. In other words, it is too expensive to revert on a block and double spend a transaction.

With Proof of Stake networks which will be used by Stan, miners are incentivised to behave honestly in a different manner. As we explained above, in order to be eligible to participate to the mining process, i.e to add transactions in blocks and blocks to the blockchain, they need to "stake" (i.e to pledge) a certain amount of native tokens of the chain. If a miner behave badly, he loses his stake. Generally speaking, the more miners are dedicated to a network, the more competition you have among miners and the more secure a network is.

It does not mean that the source code of blockchains cannot be hacked, but it is an unlikely event for the main network, at least the one that have been selected by Stan.

B. Protocol, Liquidity Pool, Token Risks

Protocols are smart contracts that can be represented by state machines [2], i.e programs, that are stored in the blocks of a blockchain and actioned through transactions. In Decentralized Finance, most of these smart contracts create liquidity pools that could be considered a single point of failure. All tokens are indeed locked in these open source programs. Although smart contracts are protected cryptographically, it is common to see hackers finding breaches in these smart contracts and exploiting them in order to steal the tokens of a pool. Since the appearance of DEFI, these hacks have been very common, this is why investing in DEFI requires a very careful selection of the protocols used. The allocation strategy must also be designed to spread the risk as much as possible in accordance with the risk of each protocols.

It is important to note that Tokens could also be a point of failure. For instance certain types of stablecoins are considered more risky than others. This risk should also be taken into consideration in the allocation model. For simplicity reasons, the token risks will net be inserted in the example we are proposing for this paper.

It is also important to note that the contagion of failure works in different ways. A hack on a protocol will very rarely impact the blockchain on which it is hosted or the tokens that are sorted in a pool of liquidity. In other words, the tokens will be stolen, i.e moved to a public address that belong to hackers, but the code of the smart contract that generated these tokens will very rarely be impacted. However the hack of a protocol could impact other protocols especially because of "Yield Farming".
C. Yield Farming Risks

"Yield Farming" refers to the use of different protocols in order to increase the returns on a given token. It is common to talk about "yield farming strategies". For instance a simple strategy could be to deposit bitcoins (wrapped as an ERC20) on Compound.Finance as collateral and borrow stablecoins that will then be deposited on Uniswap on which you will receive a Liquidity Provider token which will possibly be optimized on Beefy.Finance or Autofarm. In other words, you will remain exposed to Bitcoin while generating rewards on Uniswap and Beefy. This is a very simple example of Farming strategy and it can become much more complicated or leveraged and this is out of the scope of this paper.

We just wanted to highlight that with Yield Farming, protocols are getting everyday more connected. In our example a hack on Beefy.Finance would have an impact on Uniswap and Compound.Finance. This risk needs to be taken into account when allocating tokens on different protocols.

IV. Risk Parity Allocation Model

Managing portfolio using blockchain technology is a new research area for financial industry. The objective remains the same as observed in the traditional asset management industry, however risk diversification approach differs because there are new risks inherent to blockchain technology. These risks can be identified but there is not yet a well established methodology to measure them. Stan.Finance is proposing a methodology to rating blockchains and protocols. However, the literature on modeling is not very rich. In this paper we propose a risk parity approach based on the DeFi protocol scoring. Portfolios can be managed by type of management (active, passive) or by risk profile. Portfolios are generally built over one metric, the risk/return ratio. Asset managers, will look forward to generate the higher return for a defined risk establish among the asset allocation.

A. Risk Matrix

Since the risk associated with DeFi is different from that inherent in traditional financial assets, it is appropriate to construct a dedicated risk budget matrix. Here the risk score retained is a score that aggregates the criteria of robustness, security and reliability of a given protocol. The i-th protocol will be denoted $P_i$, then $\sigma_{p_i}$ will be the risk score of the i-th protocol. Let us denote $\sigma_p \triangleq \{\sigma_{p_1}, \ldots, \sigma_{p_n}\}$ our vector of risk scores for each protocol, hence our risk matrix will be denoted $\Sigma$ and defined as:

$$\Sigma = \text{Diag}(\sigma_p),$$

where $\Sigma \in \mathbb{R}^{n \times n}$. The risk score used in equation $[1]$ is obtained from a rating agency, we do not adjust the score. The objective is to propose a portfolio management style. From our risk score matrix we will normalized the scores as follows:

$$\tilde{\Sigma} = \frac{\Sigma}{\|\Sigma\|}$$

B. Weighting Methodology

Let us first defined an equally-risk contribution (ERC) portfolio such a portfolio where the risk contribution $\sigma_i(w)$ is the same for all the assets. where $w$ is the weight matrix such $w \in W$. note that $w^* = \{w \in [0,1]^n, 1w = 1\}$ Let $\sigma$ be a continuously partially differentiable risk measure. From the definition of marginal and total risk contributions $[3]$ we defined this risk measure as:

$$\sigma(w) = \frac{\partial \sigma(w)}{\partial w} = \sum_i w_i \frac{\partial \sigma(w)}{\partial w} = \sum_i \sigma_i(w),$$

and we aim to build a portfolio such:

$$w_i \frac{\partial \sigma(w)}{\partial w} \bigg|_{w=w^*} = w_j \frac{\partial \sigma(w)}{\partial w} \bigg|_{w=w^*}$$

As mentionned, we look for a combination where the risk contribution of the protocols we invest in are equal, from equation $[1]$ we obtain $\sigma_i(w^*) = \sigma_j(w^*)$. The objective is then to minimized the variance of the risk contribution.

$$\min_{w \in W} f(w)$$

$$u.c \left\{ \begin{array}{l}
1^T w = 1 \\
w \in [0; 1]
\end{array} \right.$$

where $f(w)$ is the variance of risk distribution defined as:

$$f(w) = \sum_{i=1}^{n} \sum_{j=1}^{n} (w_i(\Sigma)_{ij} - w_j(\Sigma)_{ij})^2$$

under the fully invested and long only constraint.

V. Application

We introduced a methodology to allocate funds in protocols considering the associated risk of each protocol. In this section we will apply this methodology with market data and therefore simulate portfolios. First we get the data from the DeFi via API. Then we will apply some transformation to build our DeFi portfolio. For the experiment we build three portfolios. One that will be weighted by the TVL, another Equally-Weighted (EW) and finally an ERC portfolio.

A. Data

We build a DeFi portfolios using available yields in DeFi. We will select the project according to our internal scoring methodology. Over the protocol universe we use a score for each protocol that will allow us to measure the risk of our allocation and compute simulation for portfolio and apply the FX effect USDc/USD.
B. Portfolios

For the application we choose five protocols. We computed a score using a discretionary methodology and we selected the top APY available for stable coins. We decied to include only stablecoins to avoid the price fluctuation of the token stacked in the protocol.

If we used other tokens we should have applied the fx performance for each token against the base currency, USD for example. The idea is to draw the backtest of portfolios and to compare the allocation models in terms of performance and risk. Among the weighting methodology we will build our risk ajusted vector. To do so we will use our internal scoring methodology.

1) Equally-Weighted Portofolio: We allocated the same percentage of stable coin on each pool and compute the daily APY of our portfolio. The portfolio is rebalanced everyday at midnight UTC for simplicity.

Considering, an investor is interested in deposit some USD, we applied a the changing rate for stablecoin to obtain a backtest USD based. Ah we can observed some fluctuation.

2) Equally-Risk Contribution Portfolio: We build an allocation using the risk scores to have the same proportion of risk contribution on each protocol and compute the daily APY. The ERC will rebalance the portfolio so that the risk contribution of each protocol is the same on a daily basis.

C. The evolution of risk

As we rebalance the portfolio everyday, at each timestep, the risk exposure is modified. For the simulation we started with two protocols as the others were not deployed and day after day some protocols are added to the allocation. Figure 10 shows the evolution risk shows the evolution of risk following the addition of new protocols.

D. Results

We compare both allocation on DeFi to assess the contribution of applying a scoring methodology on our portfolio. The comparison is based on a ratio performance over the risk of the allocation.

|          | EW   | ERC   |
|----------|------|-------|
| 2021-12-31 | 1.4400% | 1.5290% |
| 2022-01-31 | 1.5250% | 1.5110% |
| 2022-02-28 | 1.0720% | 1.0520% |
| 2022-03-31 | 1.2490% | 1.1750% |
| 2022-04-30 | 1.1180% | 1.0550% |
| 2022-05-22 | 2.1140% | 2.1780% |

|          | EW   | ERC   |
|----------|------|-------|

When we look at the figure[11] we first notice that is difficult to make a difference between both portfolio. The statistics table[1] shows the performance are pretty similar but the risk
of the allocation is not the same for both portfolios observed in figure [10].

VI. CONCLUSION

When we look at the portfolios equally weighted and equal risk contribution weighted the yield obtained are pretty similar, however, [10] shows the difference in risk between the two portfolios. Table [III] shows a slight difference between both methodologies, the equal risk contribution allocation outperform the equal weight methodology when we look at the ratio performance over risk.

The methodology we propose is similar to the approach of traditional asset managers. Nevertheless, using decentralized investment vehicles bring a new structural risk to the allocation. These risk are quantified by analytic providers, nevertheless the aggregated scores might fluctuate according to view of the risk manager. We developed a scoring methodology to include these criterion.
A future interesting work would be to add views to the raw scores as well as introducing dependency between protocols established on the same blockchain. These views could be based on quantifiable criteria but also on a fundamental approach of the DeFi project. It would also be interesting to develop risk scores based on machine learning techniques, scoring methods and decision trees. Theses methodologies could be a guideline for the view matrix construction. It will also allow to measure in real time the risk of each decentralized investment vehicle and to build risk metrics specific to these new investment vehicles.

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