MASTER´S THESIS

Course code: BE305E Name: Christian Steensen Holand

Can Decenteralized Finance be used to increase the risk-adjusted portfolio returns?

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Abstract

The goal of this study is to explore how the Decenteralized Finance (DeFi) protocols can be used as a tool to diversify into gold and S&P500. The research question for the paper is:

Can DeFi protocols contribute to increase the risk-adjusted return in a portfolio? How does the portfolio Sharpe ratio measure against other portfolios?

Data collected for this study is from November 2017 to January 2022 and was processes by Rstudio. It was arranged in 52-week simple moving averages, which was optimized with rebalancing each week. This resulted in 168 SMA outputs for each portfolio that was put together to a timeseries and compared, using Sharpe ratio as a performance metric, which was introduced by William Sharpe (1966). As a risk measure, I calculated the VaR 95% and 99% for each SMA, compiling it into a timeseries which displays the change in VaR during the sample. VaR and expected shortfall for the portfolio is also fabricated.

The study is relevant in an economic perspective because of the unique take on portfolio optimalization, using established theory of Traditional Finance and applying it on DeFi. Many researchers have used portfolio optimalization on cryptocurrencies, but in a traditional way. This study uses DeFi to construct a short portfolio that consist of 100% Bitcoin, which borrows 30% of the portfolio value as stablecoins with the Bitcoin as collateral. These funds are put into gold or S&P500. Three other portfolios are constructed and used to compare with the DeFi portfolio.

The empirical finding from the study shows that the DeFi portfolio performs well against the other portfolios using Sharpe ratio as a performance metric. For the DeFi portfolio there are different external risks factors that is hard to quantify such as attacks on the protocol, custodial risk, and liquidity risk. These risks are outside the scope of the study, and without these risks it could give an investor a false view of the true risk of using DeFi protocols.

Preface

This study is written as a final part of the finance master program at Nord University. The course represents 30 credits and marks the end of my master's degree.

The topic chosen for the study is based on my curiosity of cryptocurrencies and my willingness to improve my own portfolio. The inspiration for the study is my fascination of Decentralized Finance, using blockchain technology to create exchanges and banks where the owners of the underlying token decide the future of the project.

Researching and doing all the coding in R has been a blast and has given me insight in how the theories work in practice. It has also been a challenging experience since i authored this paper alone and had no co-student to discuss problems or crossroads that I faced during the research.

I would like to thank my supervisor, Thomas Leirvik for guidance and good discussions which gave me the tools I needed to conduct the study.

At last I want to thank Nord University for five great years at Handelshøyskolen.

Nord University, 18th May 2022.

Christian Steensen Holand

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Keywords

Borrowing, DeFi, Cryptocurrency, Blockchain, Portfolio Optimization, VaR, Expected Shortfall

Flash crash	When price of an asset declines relatively much and very fast with a sharp recovery
Oracles	Oracles are connecting real world data into the blockchain
Mint	Creating a token on the block chain
Burn	Burning is the process of removing tokens from circulation. This is often done by sending the tokens to an address which cannot be accessed
Wrapped Bitcoin	Bitcoin that has been moved from the Bitcoin blockchain to the Ethereum blockchain
IPS	Investment Policy Statement. An agreement between a portfolio manager and the client on how the portfolio should be managed
Cryptoverse	The world of cryptocurrencies
Staking	Locking up cryptocurrency in a smart contract to get yield (by providing liquidity or validating blocks)
Liquidity pool	A collection of an asset that is used for borrowing, lending, or swapping that is in a smart contract.
Fiat currency	Government issued currency not backed by a commodity
Black swan event	Unforeseen events that potentially can crash markets
KYC	Know your costumer
APR	Annual percentage rate

Table 1.1. Definitions.

1. Introduction

This study will investigate the possibility of using Decentralized Finance (DeFi) on a cryptocurrency portfolio, by borrowing against the portfolio value by using its cryptocurrency as collateral. The borrowed capital is put in gold or a broad stock market index such as S&P500. The main objective is to explore the possibility to obtain a better risk-adjusted return. The research question is:

Can DeFi protocols contribute to increase the risk-adjusted returns in a portfolio? How does the portfolio Sharpe ratio measure against other portfolios?

1.1. Why the topic is interesting

In society today, the digital world is becoming a bigger part of our lives. In recent years cryptocurrencies has grown from being seen as a digital asset with zero value, to becoming a contender to the financial system as we know it. there are multiple elements that has given cryptocurrencies a chance to contest the current paradigm within finance. The war in Afghanistan, where the population was unable to withdraw or send money because the money transfer services withdrew from the country (Arnold, 2021), or countries like Turkey who reached 70% inflation in April 2022 (Reuters, 2022). As a result of the Covid-19 pandemic, countries started printing more fiat currency, combined with the war in Ukraine the inflation rate has increased to its highest levels in decades (Federal Reserve, 2022).

My study is looking at DeFi, which is a group of cryptocurrencies that focus on trustless borrowing, lending, and swapping. DeFi allows investors to have custody of their own cryptocurrency while borrowing, lending, and swapping between currencies without the fear of know-your-costumer (KYC) restrictions. DeFi protocols can be compared to traditional banks, but it is unregulated and controlled by the holders of the governance token. It is operated by smart contracts, which executes all the borrowing, lending, and swapping. Investors can insert their funds in a DeFi protocol to obtain interest on their cryptocurrencies, borrow funds with their crypto as collateral, or swap their cryptocurrency.

The digitalization of the financial sector makes this topic relevant today because of its unique perspective on portfolio optimalization, by applying established theory on a relatively new phenomenon. This paper tries to fill a gap in academia by using DeFi as a tool for optimalization.

2. What is Decenteralized finance?

DeFi is a complex topic because of its pitfalls. In this chapter I explain how DeFi protocols work, what’s their purpose and the potential risks involved.

2.1. DeFi

DeFi, is a peer-to-peer financial system that uses decentralized applications with ledger technology. A majority of them are built on the Ethereum blockchain, but there has also been an increase in the use of other blockchains such as Binance smart chain, Avalanche and Polygon.

	Decentralized Finance	**Traditional Finance**
Collateral	Trustless system that uses overcollateralization.	Using credit scores to evaluate the repayment ability. Low or no collateral required.
Transactions	Smart contracts executing the transactions.	Transactions between parties are done by intermediaries
Custody	Held by the investor in their private wallet or within a smart contract.	Custodian of the investor's assets are held by regulated asset managers.
Governance	Governed by the developers and holders of the protocol native token, which grants voting power.	Specified rules set by regulators for the service providers or market.
Auditability	Transactions of the blockchain is open for everyone to see, and the protocols have open-source codes, allowing auditors to verify.	Audited by authorized third parties.
Currency	Digital assets or stablecoins (stablecoins are pegged to fiat currency).	Fiat currency.
Privacy	Transactions on the blockchain is public information and will be visible for everyone. No requirements of KYC.	Mandatory KYC regulated by national laws.
Vulnerability	Faulty smart contracts, attacks on these contracts.	Software attacks and data beaches.
Security for investors	Investors have full responsibility and has no insurance if something happens.	Regulated anti-fraud, exposure limits, insurance, and consumer protections.

Table 2.1. Comparing Traditional Finance to DeFi (Gogel, 2021)

Table 2.1 presents the differences between traditional finance and DeFi to give the reader a better understanding of DeFi.

2.2. Decenteralized protocols

Decenteralized protocols such as Aave, Compound or MakerDao are protocols where users can connect their cryptocurrency wallet to borrow and lend a wide range of cryptocurrencies.

Suppliers supply liquidity to the liquidity pools by locking up their cryptocurrencies in smart contracts, they are rewarded for doing this with interest payments from borrowers. When the supplier adds cryptocurrency to the pool, the contract mints a placeholder token in return that represents their added liquidity, which is interest bearing. This means that the placeholder token increases in value equal to the value of the liquidity provided, plus interest. When the supplier wants to withdraw the liquidity, they swap the minted token for the original token they added to the pool, plus interest. The smart contracts then proceed to burn the minted placeholder token.
Borrowers lend cryptocurrencies from the pool. To be able to lend from the pool they must lock up collateral, for example Ethereum. The value of this collateral must be greater than the borrowed amount. Aave requires at least a loan to value (LTV) of 75% if you use Ethereum as collateral, to borrow 75$ of stablecoins, the investor needs to have 100$ worth of collateral locked up in the protocol. If your underlying asset declines in value, the LTV will increase. If it exceeds 80%, your collateralized assets will be liquidated to cover the debt and the investor will be penalized with a 5% liquidation fee. A question that often surfaces is why someone would want to lock up collateral that is worth more than what you borrow. A possible explanation would be for example be that you need to pay debt in fiat currencies, but you don't want to liquate your cryptocurrency position for tax reasons. It can also be used for leveraging your positions by using the borrowed funds to buy more of the collateralized asset. As a borrower you are still exposed to the volatility of the collateralized asset.

2.3. Governance

DeFi Protocols can be compared to a company, they are governed by those who hold and stake their governance token in the protocol, like stocks for a company. Governance tokens give you voting power on decisions being made and allows holders to propose changes within the protocol. When a protocol has not matured yet, it is prone to governance attacks.

A governance attack is when an individual, or a crowd of individuals obtains majority of voting power in a protocol. They can decide changes for the protocol that is beneficial for them. When a protocol matures it becomes increasingly hard to attack the governance of a protocol, because the capital needed to buy the voting power increases exponentially (Gudgeon et al., 2020).

2.4. Stablecoin

Stablecoins are a broad term used to describe cryptocurrencies that has their value pegged to traditional monetary instruments such as currencies, gold, or oil (Chohan, 2021). The goal of stablecoins is to solve the volatility problem in cryptocurrencies. Stablecoins can be divided in two types of stabilization mechanisms:
Fiat-collateralized stablecoins are pegged to fiat currency. These coins are minted by private companies and are considered as centralized cryptocurrency. In theory these stablecoins should be backed 1:1 by fiat currency, but there have been speculations that the largest stablecoin Tether is not backed fully (Griffin and Shams, 2020). When the volatility in the cryptocurrency market is high, stablecoins will be regulated by burning or minting more stablecoins. If the market has a large upward pressure, the peg tends to fall below 1$. Investors want to sell their stablecoins to ride the upward momentum, this can lead to investors selling their stablecoins at a discount. The stablecoin protocol will burn tokens to reduce the supply to stabilize the stablecoin. The opposite happens when market dips, investors are willing to buy stablecoins at a premium to get out of their positions, when the market is falling. To counteract the loss of peg, they will mint more tokens to dilute the total supply. *Crypto-collateralized* stablecoins are pegged to fiat currency but is backed by surplus of collateral cryptocurrency assets. The peg to fiat currencies is kept by market supply and demand dynamics and uses automatic mechanisms which activates whenever the stablecoin loses its peg to the dollar. The protocol needs real-time data from the oracles to ensure that the collateralized assets is worth more than the debt, so the protocol does not get undercollateralized. Keepers are an external actor who is important for the protocol, they are independent automated actors that will use the arbitrage opportunity when the stablecoin is losing its peg. They will buy stablecoin whenever its below its target price and sell whenever its above.

2.5. Smart contracts

Smart contracts are programs that is kept on the block-chain to automate processes on the blockchain. They trigger when pre-established conditions are met and execute the agreement between participants of the contract without the involvement of a middleman. Example of a smart contract would be the borrowing and lending protocols. When an investor initiate borrowing from the protocol, the smart contract inspects if the conditions are met, in this case it would be that the investor has the necessary collateral to borrow. When the condition is met, the investor is given the borrowed amount from the protocol.
If a smart contract is not deployed properly, there is no way to update the contract to increase the security or secure any vulnerabilities within the contract (Sayeed et al., 2020). If a bad actor can find vulnerabilities in a smart contract, they can for example steal all the liquidity in a smart contract.

3. Literature

DeFi is a relatively new phenomenon, but a lot of research has been conducted during the last few years, but there is a gap in the DeFi theory on how to use the protocol as a diversification tool. The investors who use these protocols today, use the borrowed funds to leverage their cryptocurrency assets (Popescu, 2020). The literature written on the topic of DeFi agrees that there are considerable risks involved with these protocols, see for example Kozhan and Viswanath-Natraj (2021). Perez et al. (2021) investigated liquidations on the lending protocol Compound, and how users gain a false sense of security by the stability of crypto-collateralized stablecoins. They found that a 3% decline in the price of a stablecoin called DAI, would result in liquidations worth over 10 million dollars. Kao et al. (2021) examined the Compound protocol and have assessed the risks of it. They found that the parameters for the protocol will prevent the borrowers from becoming under-collateralized if the assumptions of volatility in the underlying asset does not exceed historical highs. Celeste et al. (2020) claim that cryptocurrency as a market is maturing, and the volatility is declining. this aligns with the work of Kao et al. (2021), suggesting that the protocol will not become under-collateralized. Bartoletti et al. (2021) and Werner et al. (2021) analyzed how DeFi is complex for investors to utilize and outlined the potential technical and economic risks involved.

Sayeed et al. (2020) examines the vulnerability and risk of the decentralized applications and agrees with Bartoletti et al. (2021) and Werner et al. (2021) that there is a challenge to mitigate security flaws in these protocols, as the DeFi space grows. Meshcheryakov and Ivanov (2020) found that Ethereum is a hedge against US stocks and gold market, while Dwita et al. (2021) investigated Ethereum and Bitcoin during the pandemic. They discovered that there is a negative correlation between the two cryptocurrencies during the pandemic, which supports the findings of Meshcheryakov and Ivanov (2020). Bouri et al. (2017) assert that Bitcoin is a hedge against global uncertainty. According to Liu (2019) it is possible to improve the investment results significantly by diversifying within the world of cryptocurrencies. Cryptocurrencies themselves are positively correlated, but the financial markets correlation with crypto markets is negligible (Aslanidis et al., 2019). Brière et al. (2015) studied how Bitcoin performed in a diversified portfolio that included traditional assets and alternative investments. They concluded that even a small fraction of Bitcoin would drastically improve the risk-adjusted return, however the data they examined were from 2010-2013 and diminishing returns of Bitcoin growth needs to be considered. Platanakis et al. (2018) investigated how cryptocurrencies benefits from diversification. Four popular cryptocurrencies were added to a portfolio using weekly data with weekly rebalancing. The concluded that there is minor difference between a naïve portfolio and a mean-variance portfolio. Guesmi et al. (2019) discovered that shorting Bitcoin in a portfolio involving gold, oil equities and Bitcoin, the portfolio will have considerably lower risk than a portfolio made up of gold, oil, and equities only.

3.1. Risk-free rate

The risk-free rate (R_f) is the return an investor can expect to achieve from an investment that has no risk and is often guaranteed by governments. It is used in financial theories such as Modern Portfolio Theory (Markowitz, 1952). Risk-free rate is the foundation for the mean-variance portfolio theory and is the reference point of what return an investor can expect for no risk. An investor will demand a premium for investing in assets that has a risk. This is the theoretical approach to R_f, but in practice it is equal to the rate a government is willing to borrow money from investors. There are different approaches to deciding what risk-free rate to use, but the commonly used are the US T-bills. The US economy has high credibility because of its status as a global currency and the high liquidity it has. If a government security is to be eligible for being a risk-free rate, it must have a high credibility and confidence that the debt will be paid back.

3.2. Portfolio weight

Portfolio weights is the percentage of allocation on each asset in the portfolio. The easiest way to assess the weight of an asset is by dividing the value of the asset by the total amount of value in the portfolio. As a portfolio manager you are often constrained by an investment policy statement which says what kind of investments that is allowed to make and how the portfolio should be weighted. If a portfolio is constrained to be a 0.5/0.5 in equities and bonds, you need to watch how the markets move. If the equities rally, you can end up having a 0.75/0.25 weighting, meaning you must sell off the excess weighting in equities to stabilize the portfolio back to 0.5/0.5. The portfolio manager must constantly rebalance the portfolio to maintain its desired weighting. Portfolio weights are generated by:

$$\text{Portfolio weight} = \frac{\text{Asset value}}{\text{Portfolio value}} \tag{1}$$

For an equally weighted, or naïve portfolio approach, another formula can be used to calculate the weight of each asset in the portfolio. The portfolio weight is found by dividing the number of assets on the total amount of assets and is given by:

$$\text{Naive portfolio weight} = \frac{1}{\text{n}} \tag{2}$$

Where:
n = number of assets in portfolio

For both these approaches the sum portfolio weights always equals to 1. A portfolio can also have negative weights, this occurs when a portfolio has a short position in an asset. In the case of the naïve portfolio, this is not possible.

3.3. Modern Portfolio Theory

In 1952 Markowitz presented the Modern Portfolio Theory. It is a framework that reveal how to construct portfolios that maximize return at a given risk level. Instead of looking at each investment isolated, it considers all investments as a part of a portfolio by assessing the total return and risk. Markowitz (1952) established the foundation on how portfolios is constructed to minimize risk for a given expected return and vice versa. With the portfolio perspective, he was able to show how diversification could remove unsystematic risk from a portfolio.

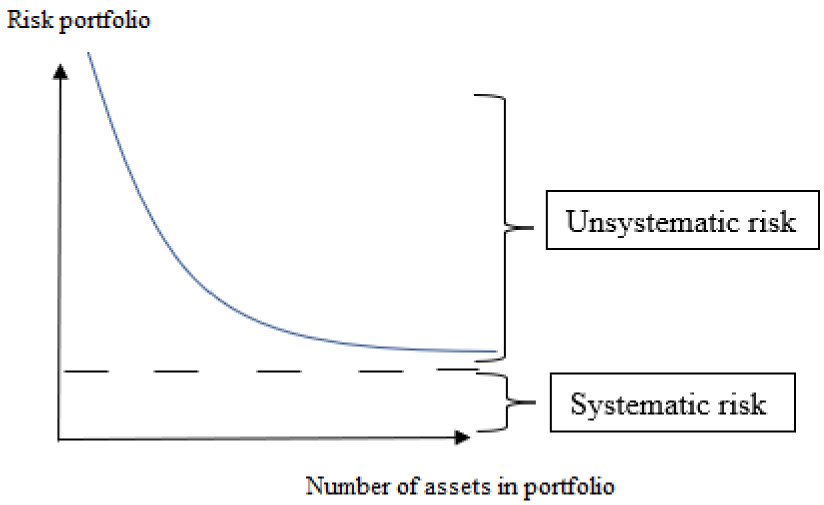

Figure 3.1. How diversifying reduces unsystematic risk.

Unsystematic risk can be removed by adding more assets to the portfolio, but as shown in figure 3.1 there is a diminishing return on the effect of adding more assets. The systematic risk is impossible to reduce because it is inherent to the entire market segment, or market.

Expected return of a portfolio with multiple assets is given by:

$$E(r_p) = \sum_{i=1}^{n} W_i E(r_i) \qquad (3)$$

Where:

$E(r_p)$ = Expected return of portfolio p

W_i = Weight of asset *i*

$E(r_i)$ = Expected return for asset *i*

When multiplying the weight with the expected return of each asset, the expected return for the portfolio is derived.

The variance for the portfolio is given by:

$$\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=i}^{n} W_i W_J \sigma_{i,j} \qquad (4)$$

Where:

σ^2_p = Variance of the portfolio p

W_i = Weight in asset *i*

W_j = Weight in asset *j*

$\sigma_{i,j}$ = Covariance between asset *i* and *j*

Covariance is given by:

$$\sigma_{i,j} = \rho_{i,j} \sigma_i \sigma_j \qquad (5)$$

Where:

$\rho_{i,j}$ = correlation between asset *i* and *j*

σ_i, σ_j = Standard deviation for asset *i* and *j*

The volatility of the portfolio is given by the variance of the portfolio. The correlation between the asset impacts the variance of the portfolio. A lower correlation will reduce the volatility of the portfolio. If one asset is moving up, the other asset is moving down, hedging the risk.

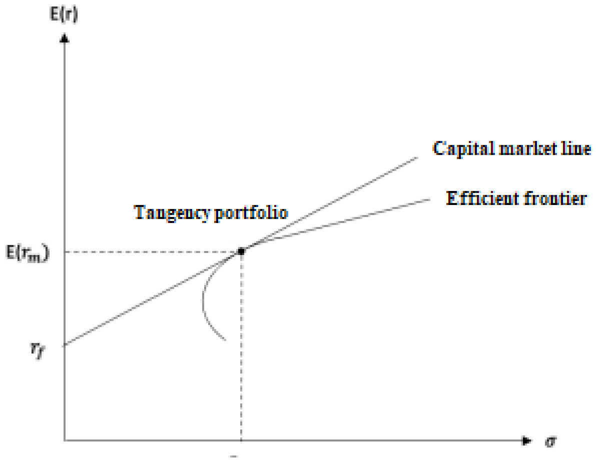

Figure 3.2. Relationship between expected return and risk .

Capital market line is given by:

$$E(r_p) = R_f + \sigma_p \frac{E(r_m) - R_f}{\sigma_m} \quad (6)$$

Where:

$E(r_p)$ = Expected portfolio return

R_f = Risk-free rate

σ_p = Portfolio standard deviation

$E(r_m)$ = Expected market return

σ_m = Market standard deviation

Markowitz (1952) introduced how to calculate a portfolio return given by its variance. The capital market line is a representation of all the optimized portfolios, all rational investors will choose a position on this line. In figure 3.2 the efficient frontier is a set of portfolios that offer the highest expected return at a given risk level. If a portfolio is below the efficient frontier, they are considered as sub-optimal because they are not optimized. The Tangency portfolio is the point where the efficient frontier and the capital market line meets. This is where the portfolio with the best possible ratio between excess return and risk is.

3.3.1. Sharpe ratio

William Sharpe first introduced the Sharpe ratio in 1966. It is a measurement of the ratio between portfolio excess returns and risk. The Sharpe ratio quantifies the risk-adjusted returns and is given by:

$$\text{Sharpe ratio} = \frac{R_p - R_f}{\sigma_p} \qquad (7)$$

Where:

R_p = Portfolio return

R_f = Risk-free rate

σ_p = portfolio's excess return standard deviation

Sharpe ratio will increase if the excess return increases, or the standard deviation decreases. Markowitz (1952) stated that the risk of a portfolio can be reduced by diversification. This indicates that the Sharpe ratio of a portfolio can be increased by diversifying and removing the unsystematic risk of a portfolio.

3.4. Simple Moving average

Simple moving average (SMA) is an unweighted mean of a subset in the sample.

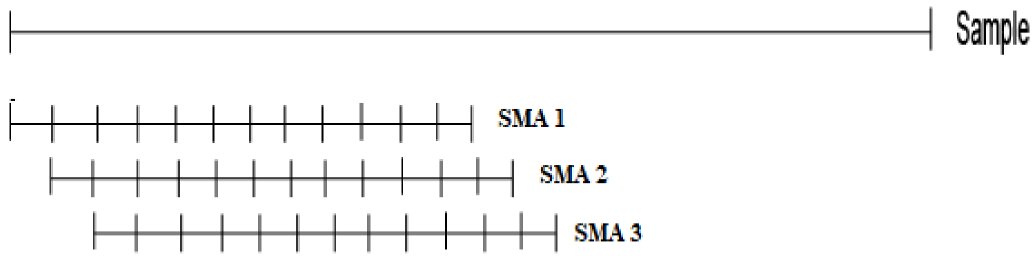

Figure 3.3. Example of how SMA works.

SMA can be calculated multiple ways, using the asset closing price, or return of the asset:

$$\text{SMA} = \frac{R_1 + R_2 + \cdots R_n}{n} \tag{8}$$

Where:

R_n = Return of asset at period *n*

n = Total number of periods

Since a SMA is an unweighted mean, it treats every observation equally. Other methods of moving averages are an exponential moving average (EMA), which weights each observation differently depending on how long since the observation occurred. The recent observations are weighted highest, and for each lag the weight declines, meaning that the oldest observation in the EMA has a lower impact on the result. This makes the EMA more sensitive and reactive to volatility.

3.5. Value at risk

Value at risk is a measurement that estimate the probability of loss. It looks at the left tail of the return distribution at a low percentile, commonly used are 95% and 99%. The estimation tells an investor the probability of loss with a given period and confidence level. If an investor has calculated the 95% VaR to be -1%, it indicates that there is a 95% probability that the portfolio will not lose more than 1% in the given period. There are multiple methods to calculate VaR, two methods will be highlighted are historical simulation and variance-covariance method. Historical simulation is the simplest method, where you rearrange the observations from worst to best. If a sample has 1000 observations and a 95% VaR is desired, the VaR cutoff will be at the 50th worst observation which equals to 5% off the observations. If a 99% VaR is ought, the VaR cutoff is at the 10th worst observation. Variance-covariance method is akin to the historical simulation; the difference is that variance-covariance method uses a normal distribution instead of actual observations. The advantage of this method is that we already know where on the distribution the VaR cutoffs are:

Confidence level	
95 %	-1.65 x σ
99 %	-2.33 x σ

Table 3.1. Factors for VaR confidence levels, variance-covariance approach.

Using the variance-covariance method to find the 95% VaR, multiply the standard deviation by -1.65, or -2.33 for the 99% VaR.

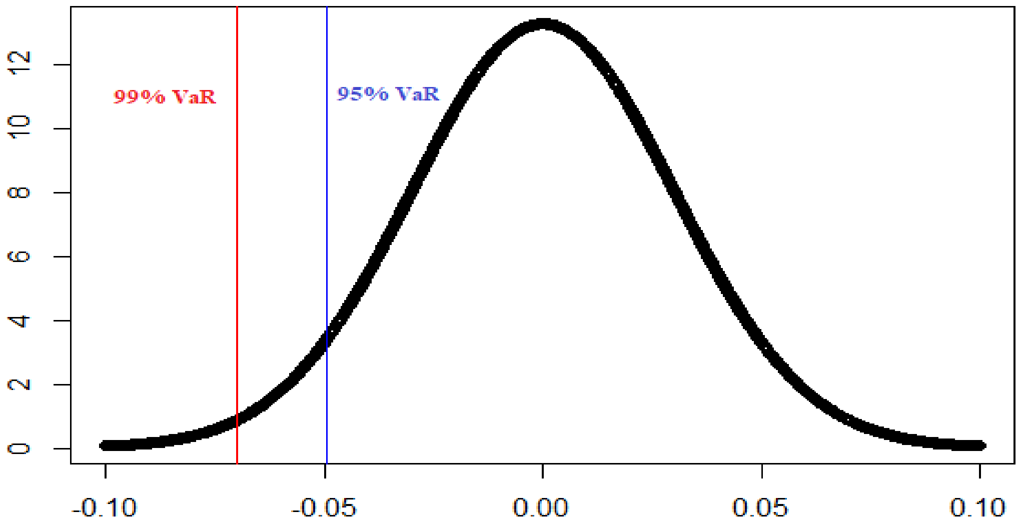

Figure 3.4. 95% and 99% VaR cutoff in the normal distribution.

Angelidis and Degiannkis (2009) has criticized VaR because different VaR approaches grant different results, thus it is inaccurate. The Historical approach has a problem when accounting for *black swan* events, i.e., events that occur rarely and are particularly challenging to account for, where a sample has days with significant losses. The worst losses will not be considered because it does not look at losses beyond the cutoff. Gregory and Reeves (2008) explained that the variance-covariance method's underlying normality is not supported by empirical returns data. There are improved extensions of the VaR such as Expected shortfall which will be discusses in the next chapter.

3.5.1. Expected Shortfall

Expected shortfall (ES), also called conditional VaR or Tail VaR was first introduced by Artzner et al. in 1997. Expected shortfall is an extension of VaR, because the VaR method faced critics on how it only focused on the cutoff of the distribution and not the observations beyond the cutoff. It has the same methodology as VaR, but it considers the losses beyond the VaR level. On a core level ES is a mean of the left tail and will always be greater number than VaR since it accounts for the worst losses.

3.6. Utilization of DeFi liquidity pool

To borrow money on a Defi protocol there must be a framework to keep an optimal utilization of the liquidity pool. The framework decides the interest rates at any given time and the interest rate is set by how much of the available liquidity in the pool is borrowed.

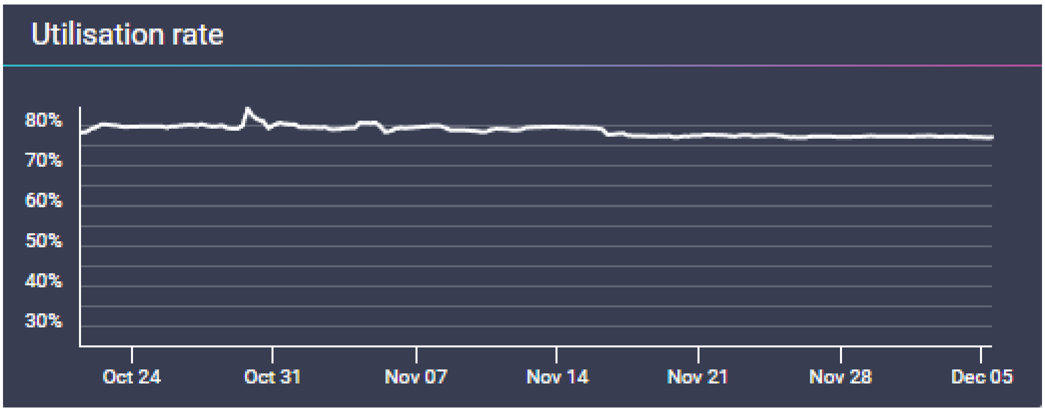

Figure 3.5. Overview utilization rate for stablecoin DAI, n.d., by Aave. (https://app.aave.com).

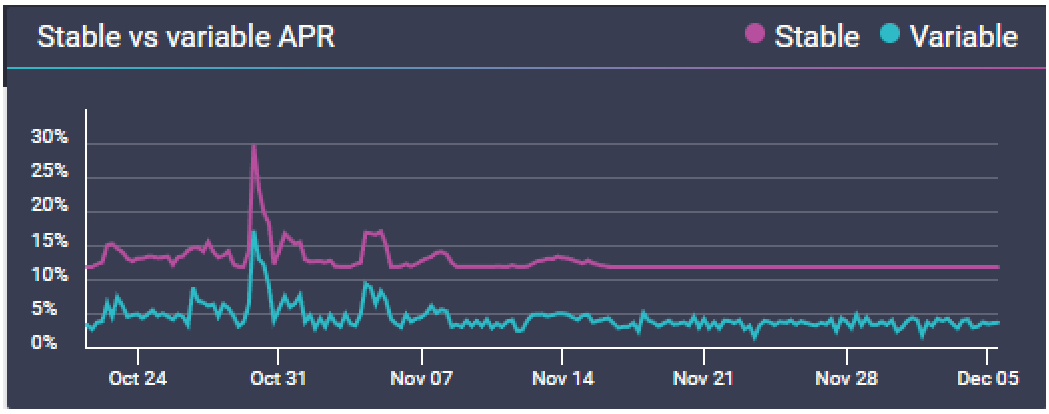

Figure 3.6. Overview interest rate for stablecoin DAI , n.d., by Aave. (https://app.aave.com/).

Figure 3.5 illustrates the utilization rate for the liquidity pool of a stablecoin on the Aave protocol, while figure 3.6 explains the interest rates. The formula for interest rate for the liquidity pool is:

If $U \leq U_{optimal}$ $$R_t = M_r + \frac{U_t}{U_{Optimal}} R_{slope1} \qquad (9)$$

If $U > U_{optimal}$ $$R_t = M_r + R_{slope1} + \frac{U_t - U_{Optimal}}{1 - U_{Optimal}} + R_{slope2} \qquad (10)$$

Where:

U_t = Utilization rate at time t

$U_{optimal}$ = Optimal utilization rate

M_r = Average market lending rate

R_{slope1} = Interest rate slope when U is below $U_{optimal,}$

R_{slope2} = Interest rate slope when above U is above $U_{optimal}$

$R_{t =}$ Interest rate at time t

The optimal utilization rate is a predetermined ratio of utilization that is different for each cryptocurrency asset. In figure 3.5 the utilization of the stablecoin DAI is shown, where the optimal utilization ratio is 80%. When the utilization rate is higher than 80%, the protocol will increase interest rates to incentivize borrowers to pay back their loan, or investors to deposit more liquidity to the pool. When the utilization ratio is below the optimal level, the interest rate is lowered to incentivize borrowing.

4. Method and data

The method and data chapter explains the limitations of the study and how the data were gathered and analyzed. It gives the reader an understanding of the thought processes used to solve the research questions.

4.1. Limitations

The study of the phenomenon stretches over a semester, to limit the scope of the research, I decided to not include any fees that occur from rebalancing the portfolios or fees for moving the borrowed funds from stablecoins to equity and bonds. The interest rates of the protocols are constantly moving, making it complicated to accurately set an interest rate for the borrowed funds. To simplify the interest rate, the stablecoins are set as a constant rate equal to the US 10-year bond, which was 1.8% at the time of conducting the analysis. Stablecoins themselves are not risk-free, but they can be exchanged into bonds after they have been borrowed. There are limitations to the performance measurement used in this thesis which is Sharpe ratio. The Sharpe ratio will only consider the risk associated with the returns of each asset, but not external factors. In the DeFi protocols there are various external factors that will affect the riskiness of the portfolio, such as custodian risks, attacks on the smart contract and liquidation. The external risks are not in the scope of the study. The risk of liquidation is a factor that was briefly discussed but should have been examined in greater detail. Rebalancing the portfolios weekly is theoretical. If an investor wants to move funds from equity to cryptocurrencies, the process itself could potentially take some time depending on the speed a traditional exchange can execute the buy (sell) order. The bottleneck is the transaction speed between traditional exchanges and the banks, not within the cryptoverse because on the blockchain buy (sell) orders are executed rapidly and can be done at any hour (Zhang et al., 2020).

4.2. Data

In this study I have used publicly available data on asset prices that I gathered from Tradingview, and the timeframe of the observations spans from 06.11.2017 to 31.01.2022. When the data is publicly available, it gives the study a high degree of reproducibility which increases the reliability of the study. Equity markets have closing hours and days, while cryptocurrencies are never closed for trading. Cryptocurrencies does not have a long history, thus applying monthly returns will results in very few data points which will be bad for all kinds of analyses. Because of these reasons the research is using weekly closing price data.

The data has 219 weekly observations for each assets in the dataset. See Table 4.1 for descriptive statistics for the variables included in this thesis.

WEEKLY DATA	GOLD	S&P500	BITCOIN
OBSERVATIONS	219	219	219
STANDARD DEVIATION	0.0193	0.0274	0.1123
VARIANCE	0.0004	0.0008	0.0126
MEAN	0.0018	0.0029	0.0152
MEDIAN	0.0018	0.0059	0.0166
MAXIMUM	0.0850	0.1210	0.3649
MINIMUM	-0.0859	-0.1498	-0.3349
KURTOSIS	3.8876	7.6057	0.9238
SKEWNESS	0.0163	-0.9407	-0.0174

Figure 4.1. Descriptive statistics for the weekly data.

4.3. Portfolio strategies

I use Rstudio to process and optimize the portfolios in this paper. The optimization has a mean-variance view, where the optimizer focuses on maximize the return based on risk. I added two objectives in the optimizer to specify this. The portfolios are given constraints depending on what type of portfolio it is. The optimizer is constructing a 52-week SMA of the sample and rebalancing it every week to get the optimal risk-adjusted return. From the output I can calculate the Sharpe Ratio and VaR/ES.

4.3.1. DeFi portfolio

DeFi portfolio is the main portfolio, which will be compared to the other portfolios. The portfolio consists of 100% Bitcoin, where a DeFi protocol is used to borrow 30% of the portfolio value, with Bitcoin as collateral. The borrowed funds are put in either gold or S&P500. In the optimizer Bitcoin is constrained to always weighted to be equal to 1, while stablecoins is constrained to be -0.3. Gold and S&P500 weights have a constrain between 0 and 0.3.

4.3.2. No constraint portfolio

No constraint portfolio consists of Bitcoin, gold and S&P500. It has no weight constraints on the three assets, but it is constrained to be a long portfolio only. The total weights of the portfolio must equal to 1. I decided not to add stablecoins to the portfolio because I am using a mean-variance approach. If stablecoins are included in this portfolio, the optimizer will prefer assets with zero standard deviation.

4.3.4. Naïve portfolio

Naïve portfolio is an equally weighted portfolio with gold, S&P500, Bitcoin and stablecoins, which implies 25% in each asset. It is rebalanced every week to keep all weights equally weighted for the entire duration. Certainly, with the large volatility of cryptocurrencies in general, and Bitcoin in particular, the weights can change substantially intraweekly. In any event, at the beginning of each week, the weight is reset to 25% in each asset.

4.3.5. Buy and hold portfolio

Buy and hold portfolio are a passive strategy that does no trading, only holding Bitcoin. The purpose of this portfolio is to examine if my DeFi portfolio is outperforming a buy and hold strategy.

4.4. Quality of data

4.4.1. Reliability

Reliability describes how precise the data is. Reliability checks the accuracy of the data collection, how it has been treated and how the research is conducted. Reliability is an important subject within quantitative research, a method to check the reliability of the research. A common method is the test-retest, where the researcher assesses the same phenomenon multiple times on separate occasions. If those studies get the same results, it can be said to have high reliability. Another method is to have multiple scientists looking at the same phenomenon. If they get the same result, it has good reliability (Johannessen et al., 2010).

4.4.2. Validity

Validity addresses how well, or relevant the data represents the phenomenon. In method theory, a distinction is made between concept validity, internal- and external validity. Concept validity is about the relationship between the phenomenon being investigated and the specific data. It is common to use discretion to determine if the data material is valid or not The internal validity addresses in what level the study is suitable to causal relationship (Johannessen et al., 2010). If the research has a strong internal validity, it indicates that there is a casual relationship between the phenomenon that is being researched and the result. External validity tell us if the result can be generalized to a bigger population (Johannesen et al., 2010).

5. Empirical analysis

In this chapter the output data from the analysis will be presented. There are preconditions that has been set for the analysis. When borrowing funds, it will be paid out in stablecoins. For simplicity this will be converted into bonds. The fees for doing this procedure but is not taken into consideration.

5.1. Loan to value

The loan must be resilient to volatility, because of the inherent risk that cryptocurrencies have, and the risk of liquidation that happens when the LTV reaches the 80% threshold. If we examine the historical price data for bitcoin in the period from late 2017 to early 2022, there has been multiple drawdowns. From the peak in December 2017 to the bottom In December 2018, there was a decline of 84%. This was a drawn-out decline over a year and would give the investor time to either repay parts of the loan or add more collateral to the position. The issue for the DeFi loan comes from flash crashes, which can liquidate the position in an instant without the possibility to react. The covid crash in March 2020 is a good example of this, Bitcoin price declined 53% in a single week. To obtain the optimal LTV it would be preferred to do a in depth analysis of this phenomenon, but it is outside the scope of this thesis to study the phenomenon. For the DeFi portfolio used in this study it will not be liquidated during the period, since the loan was taken 6/11/17 when Bitcoin price was roughly 7000$. The only time the portfolio was close to being liquidated was when Bitcoin capitulated during March of 2018. When Bitcoin bottomed out. the collateral had declined by roughly 55%. The LTV was at that time 67%, not reaching the 80% LTV liquidation threshold.

BTC Price	Loan	LTV	Decline
USD 100,000	USD 30,000	**30 %**	0 %
USD 95,000	USD 30,000	**32 %**	-5 %
USD 90,000	USD 30,000	**33 %**	-10 %
USD 85,000	USD 30,000	**35 %**	-15 %
USD 80,000	USD 30,000	**38 %**	-20 %
USD 75,000	USD 30,000	**40 %**	-25 %
USD 70,000	USD 30,000	**43 %**	-30 %
USD 65,000	USD 30,000	**46 %**	-35 %
USD 60,000	USD 30,000	**50 %**	-40 %
USD 55,000	USD 30,000	**55 %**	-45 %
USD 50,000	USD 30,000	**60 %**	-50 %
USD 45,000	USD 30,000	**67 %**	-55 %
USD 40,000	USD 30,000	**75 %**	-60 %
USD 37,500	USD 30,000	**80 %**	-63 %

Table 4.1. Example of how LTV develops as Bitcoin price decline.

Table 4.1 shows an example of threshold for liquidation if Bitcoin price was 100 000 USD, and an investor took a loan of 30 000$. Bitcoin can decline roughly 63% from where the loan was taken before the position is liquidated, if a 30% LTV is used.

5.2. Portfolio output

To optimize the portfolios over the selected period, a 52-week SMA with weekly rebalancing is constructed, each portfolio has 168 SMA's made out of the 219 observations in each asset. Rebalancing is needed as the assets in the portfolio changes in value, so the starting weight, for example 20% of total value, can change to for example 25% over a week. At the start of the next week, the weight is reset to wither the optimally computed weight or the default value which depends on the type of weighting scheme is relevant for the portfolio in question. The output weights are optimized to give the best return while minimizing risk, a mean-variance approach. The DeFi portfolio is considered as the main portfolio while the other portfolios are used to compare and see how the DeFi portfolio is performing against them. 10-year US bond has been used, which was 1.8% at the time.

5.2.1. DeFi portfolio

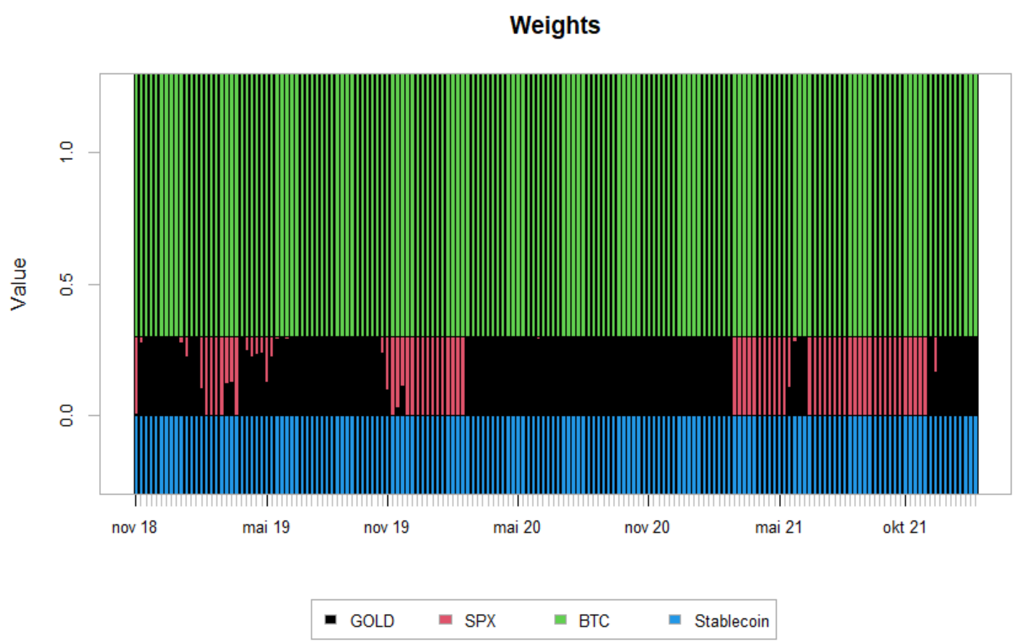

Figure 5.1. Weights DeFi portfolio.

DeFi portfolio is using a short position, where 100% of the asset allocation is in Bitcoin. 30% of the portfolio value is borrowed as stablecoins, with Bitcoin as collateral. The stablecoins are reinvested in gold or S&P 500. Bitcoin weight is constrained to 1, while stablecoin is constrained to -0.3. Rebalancing happens every week and we can see the change between gold and S&P 500 throughout the period. Weights for the portfolio starts with a high allocation in S&P500 in the first SMA, but rapidly changes to gold during the second SMA. This can be explained by the growth S&P500 had during the first 52-week SMA, while gold saw an 8% decline in the same timeframe. In late 2018 S&P500 had a decline of 25%, while gold had an increase of 5% in the same time period, this could explain the rapid change from S&P500 to gold in weights. S&P500 had a quick recovery setting a new all-time high 16 weeks after the correction, this could explain the weight changes that happened during early 2019. After S&P500 claimed a new all-time high in early 2019, gold had a 2-year rally where it rose around 79% during the two years. The only weight change seen in this period is in late 2019, where gold and S&P500 had a negative correlation. Gold had a small correction while S&P500 was moving up. Gold had a peak all-time high in august of 2020, and has been consolidating ever since, while S&P500 kept rising during the pandemic almost achieving a 30% return in 2021. An explanation for this could be the quantitative easing that the governments have been using, with low interest rates and money printing. This has allowed growth companies to borrow money cheap to fuel its growth.

Figure 5.2. DeFi portfolio cumulative returns.

Annualized	DeFi portfolio
Mean	82.22 %
Standard Deviation	74.42 %
Risk-Free	1.80 %
Sharpe Ratio	1.0807

Table 5.1. Annualized statistics DeFi portfolio.

DeFi portfolio has high annualized returns, but with considerable risk. When the portfolio was created in late 2017 this was in the middle of an uptrend in the cryptocurrency markets. The cryptocurrency markets crashed in late 2017 and had a downtrend during 2018, making the portfolio lose close to 25% of its value during this period before it had a trend-reversal. SMA is an average of the last 52-weeks, making it less sensitive to volatility, because of this the market crash of March 2020 can't be noticed in figure 5.2. A combination of quick recovery and the SMA being stretched over 52 weeks can be an explanation. According to White and Haghani (2017) a Sharpe ratio above 1 is particularly good. This portfolio has a Sharpe ratio of 1.0807 and is considered a high Sharpe ratio. The Sharpe ratios for the assets in the same timeframes are 0.677 for S&P500, 0.536 for gold, and 0.955 for Bitcoin. All these assets were outperformed by the portfolio, but the Sharpe ratio only gives an investor information about the balance between risk and return, it does not give an insight in how risky a portfolio truly is. When evaluating a portfolio an investor should examine multiple metrics to decide if a portfolio is suitable for their risk tolerance.

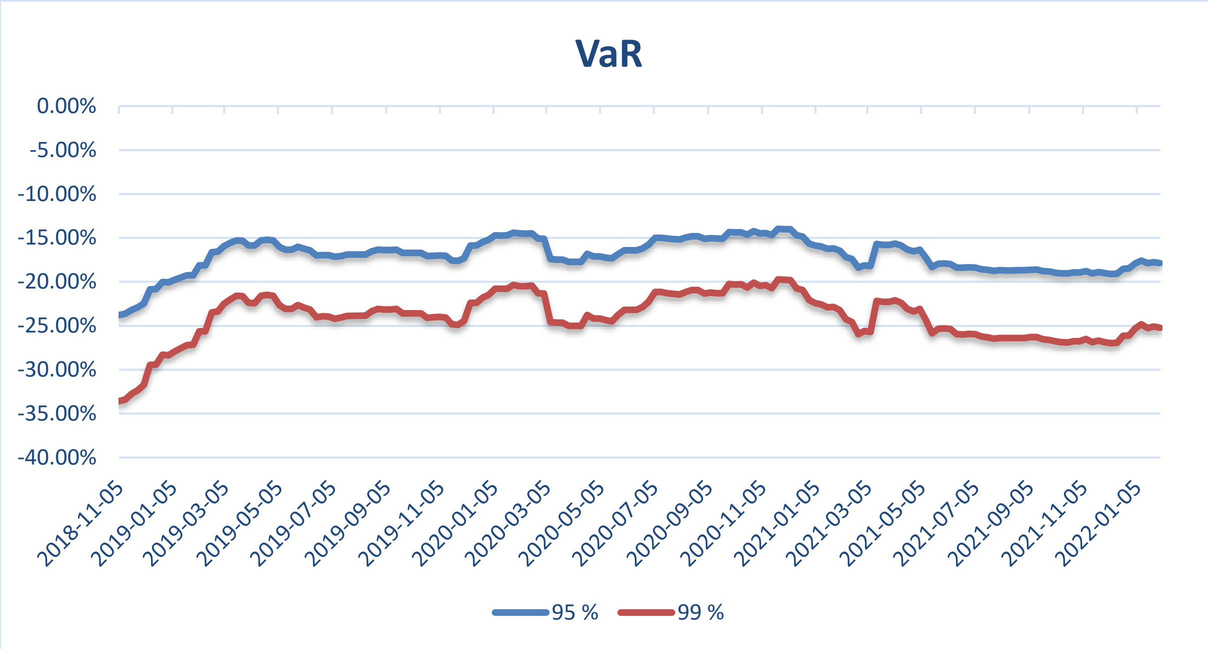

Figure 5.3. Timeseries of VaR for each SMA for the DeFi portfolio.

Figure 5.3 is a timeseries of the VaR for each 52-week SMA across the period. VaR chooses the worst observations from each SMA to generate a probability estimation of loss. The early SMA's in the figure is affected by the cryptocurrency crash of late 2017 and early 2018, They get progressively better as the worst observation of the cryptocurrency crash gets phased out. In Q1 2020 there was also large volatility in Bitcoin price. Bitcoin had a rally in the first few months of 2020 but deteriorated quickly by the *black swan* event in March 2020. This is reflected in the VaR, where a sudden increase in the potential loss of the portfolio to about -25%. Certainly, for a professional fund manager, the realization of such a large decrease would not only be bad for returns, but also bad for business as external investors most likely would have retracted their investments and the fund would go out of business. In any case, this thesis is not about actual fund managers, but rather how one could use cryptocurrencies to construct portfolios and then to analyze possible opportunities and pitfalls. The large VaR is an example of such a pitfall.

Weekly	DeFi portfolio
VaR 95%	-1.06 %
VaR 99%	-2.19 %
Expected Shortfall 95%	-1.75 %
Expected Shortfall 99%	-2.75 %

Table 5.2. VaR/ES for DeFi portfolio.

VaR and Expected Shortfall for the portfolio is considerably lower than the VaR and expected shortfall for each of the SMA's. One plausible reason could be that the VaR and ES for each SMA contains weeks with extreme volatility in Bitcoin. When the VaR and ES is calculated for each SMA, it gives us the worst weeks in the SMA. Each SMA is an average of the last 52 weeks, giving it less volatility and noise than each week separately.

5.2.2. No constraint portfolio

No constraint portfolio consists of gold, SPX and BTC. It is a long only portfolio but has no weight constraint and optimizes the weights throughout the period. The portfolio has lower return and risk than the DeFi portfolio because it has less risky assets than the DeFi portfolio.

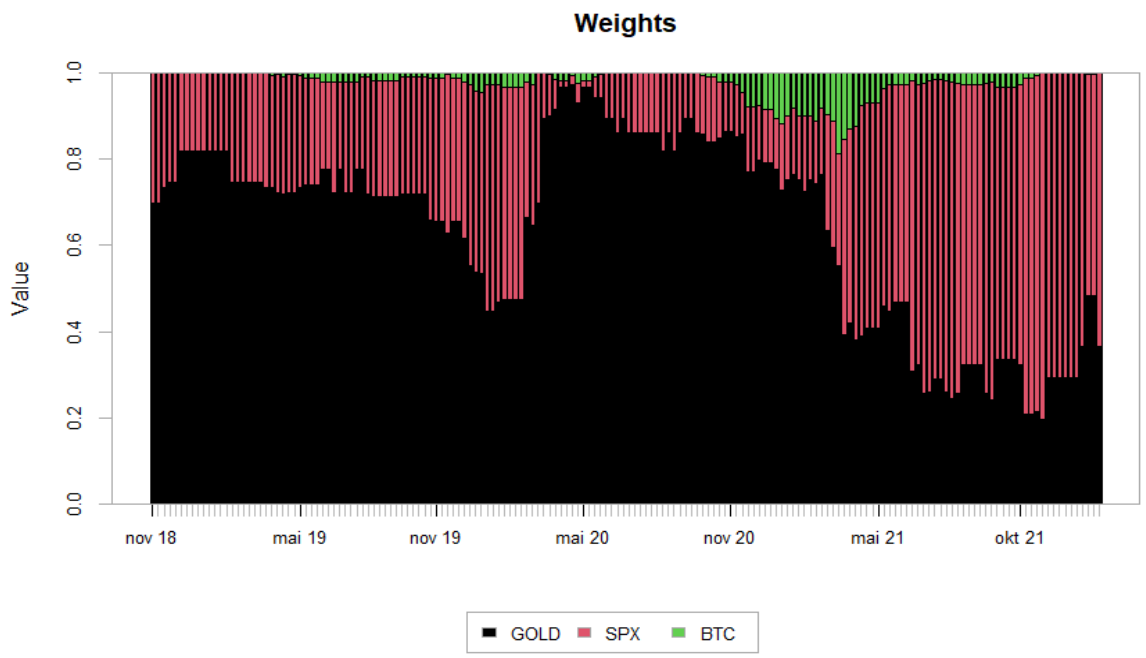

Figure 5.4. Weights no constraint portfolio.

No constraint portfolio starts out with no bitcoin, 70% gold and 30% in S&P500. These weights were found by using a mean-variance optimizer in R. A change happens around the time of the *black swan* even in early March, where the optimizer moves roughly 25% of the gold to S&P500 during late 2019 and early 2020. When the black swan event happened in March 2020, the optimizer moves all S&P500 allocation back to gold, giving the portfolio close to 100% gold allocation in May 2020. In Q3 and Q4 gold still has a majority allocation in the portfolio, but Bitcoin is getting a larger share during the timeframe, peaking at around 20% allocation in March and April of 2021. Bitcoin reached an all-time high at this point at roughly 65 000 USD. At the same time S&P500 got a bigger allocation in the portfolio. At the time S&P500 was rallying, yielding a 22% return between end of March to December 2021. A combination of high returns for S&P500 and a stagnation in the growth of gold price, made the allocation of gold decline during 2021.

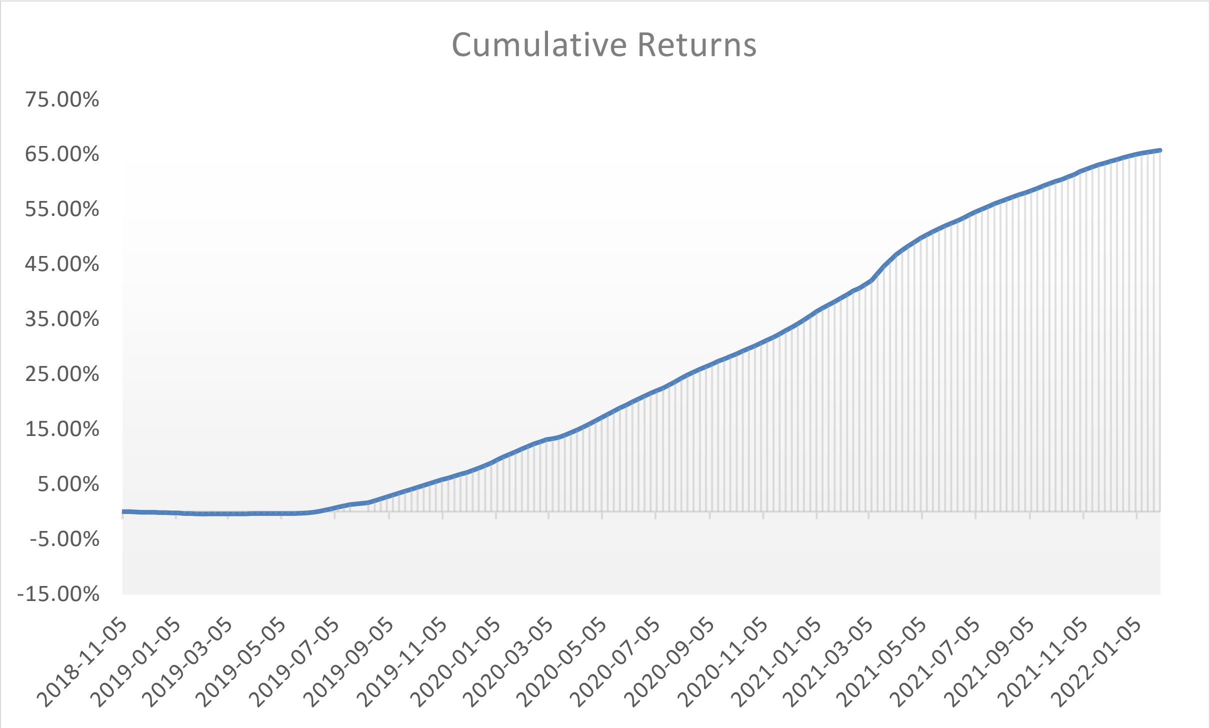

Figure 5.5. No constraint portfolio cumulative returns.

Annualized	No constraint portfolio
Mean	15.45 %
Standard deviation	15.02 %
Risk-free	1.80 %
Sharpe	0.9087

Table 5.3. Annualized statistics no constrain portfolio.

During the first year of SMA the portfolio has no return, its hovering at 0% for a year before it yields any return. The cumulative return of the portfolio is about 65%, while S&P500 had a cumulative return of 62.41% during the same period. Gold had a cumulative return of 38.97% but had a peak return of 49.43% in august of 2020. The return of this portfolio supports the theories of Markowitz (1952), that diversification reduces the risk of a portfolio, since S&P500 had similar returns in the same period, but considerably higher standard deviation, giving the portfolio a Sharpe ratio of 0.9087, while S&P500 had a Sharpe ratio of 0.677. However, Bitcoin has a Sharpe ratio of 0.955 and would give better risk-adjusted returns, but the risk of Bitcoin is substantially higher. According to Brière et al. (2015) lesser amounts of Bitcoin in a portfolio can dramatically improve the risk-return trade-off, and the result from this portfolio agrees with their opinion. Asset managers would be more comfortable choosing this portfolio over a portfolio with higher Bitcoin allocation, because the chances of taking big losses and losing the trust of clients is substantially lower.

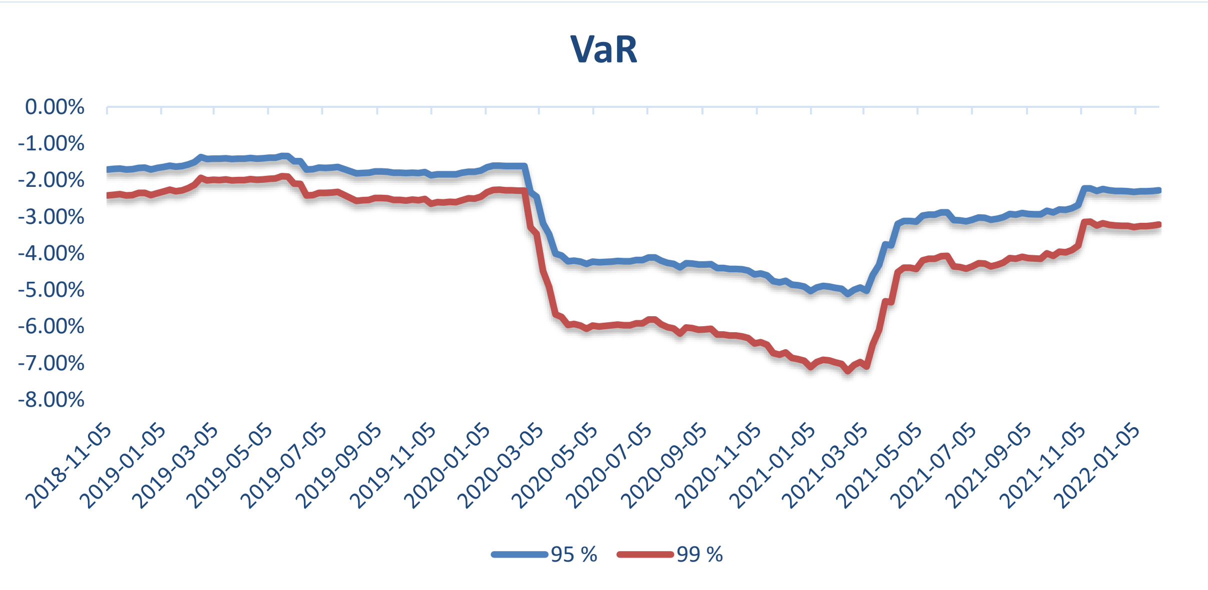

Figure 5.6. Timeseries VaR for each SMA no constraint portfolio.

VaR for each SMA shown in figure 5.6 has a rapid decline during the covid-19 crash of March 2020. The VaR does not recover until March of 2021. This can be explained by the 52-week rolling window that was used constructing the portfolio. Degiannakis et al. (2012) criticized VaR because of the way it treats *black swan* events. When a *black swan* event occurs and a SMA is used, the worst observations will lag for a long time, it does not care if the market recovers within a day, it will still give a low VaR for the following 52 weeks. My findings support this, because S&P500, Bitcoin and gold recovered quickly after giving the portfolio an artificially low VaR. The VaR and expected shortfall as expressed in table 5.4 is close to zero, making the riskiness of this portfolio is significantly lower than Bitcoin heavy portfolios. Even though the risk-adjusted returns are inferior to a portfolio with more Bitcoin allocated, the potential loss for this portfolio is more tolerable for an investor, making it a good fit for a risk-averse investors.

Weekly	No constraint portfolio
VaR 95%	-0.03 %
VaR 99%	-0.20 %
Expected Shortfall 95%	-0.13 %
Expected Shortfall 99%	-0.28 %

Table 5.4. VaR/ES no constraint portfolio.

5.2.4. Naïve portfolio

The naïve portfolio is an equally weighted portfolio, which contains gold, SPX, BTC and stablecoins.

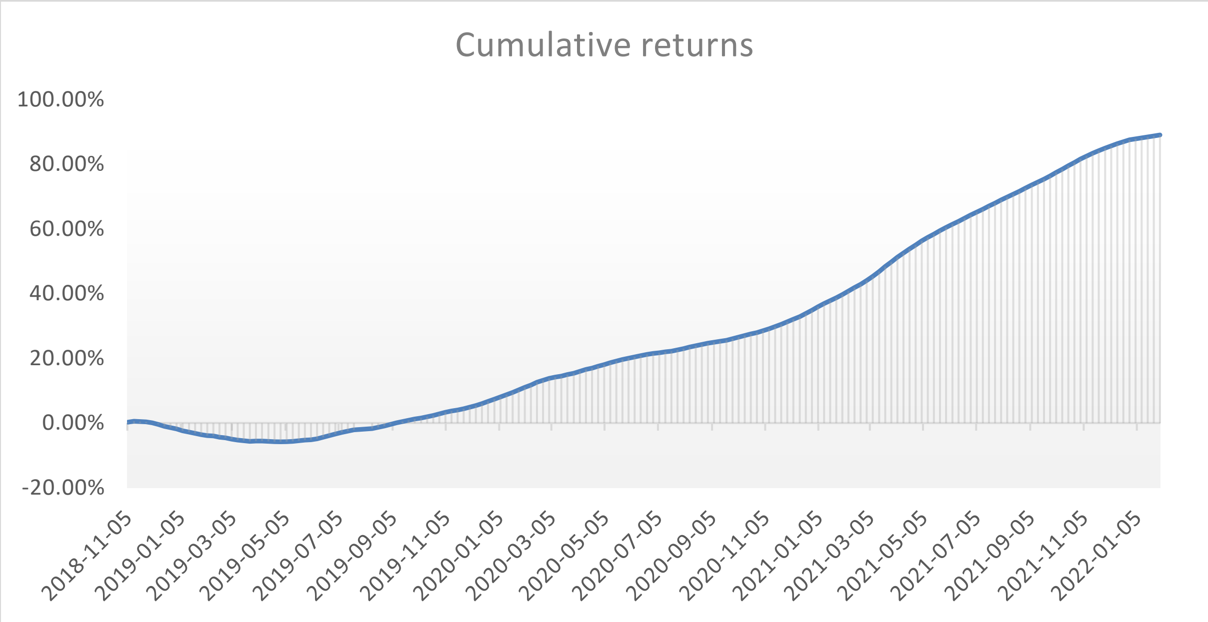

Figure 5.7. Cumulative returns naïve portfolio.

Annualized	Naïve portfolio
Mean	26.18 %
Standard deviation	22.45 %
Risk-free	1.80 %
Sharpe	1.0861

Table 5.5: Annualized statistics Naïve portfolio.

Naïve portfolio has an annualized return of 26.18% and a standard deviation of 22.45%, giving it a Sharpe ratio of 1.0861. A standard deviation of 22.45 gives it a slightly higher risk than only holding S&P500, which had a standard deviation of 19.77%. There is a vast difference in the returns of S&P500 and the naïve portfolio, even though the risk levels are similar. The Sharpe ratio of S&P500 was 0.677 while naïve portfolio has 1.0861 making it a substantially better chose if an investor wants to maximize returns at a given risk level. Comparing the naïve portfolio to my DeFi portfolio which has similar Sharpe ratio of 1.0807, one can argue that each of the portfolio fits different investors. If an investor is a risk taker and is looking for high risk, high return opportunities, the DeFi portfolio would be a better choice, but if the investor is risk-averse and want lower risk, the naïve portfolio is significantly better choice than allocating 100% of funds in S&P500. Another factor for this portfolio is that it has 25% of the asset allocation in a risk-free asset. This gives the investor opportunities to relocate that capital into undervalued assets if an opportunity arises.

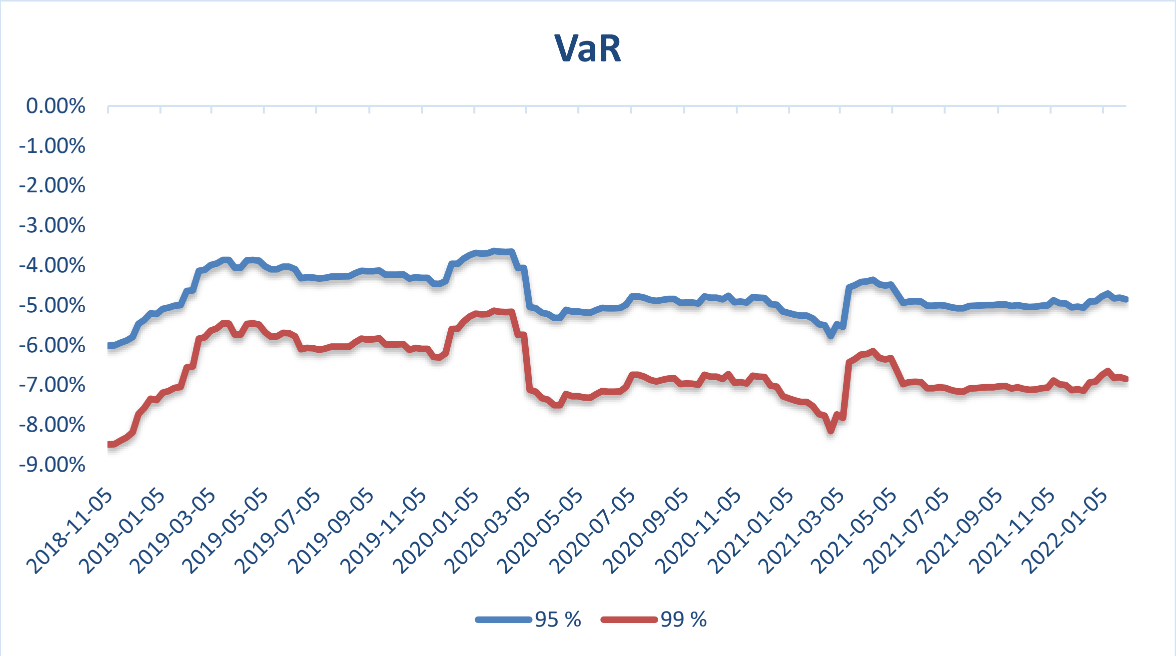

Figure 5.8. Timeseries VaR for each SMA naïve portfolio.

The naïve portfolio is equally weighted and is more exposed to Bitcoin than the no constraint portfolio. We can see that the correction in early 2018 and the black swan of March 2020 has an immense impact on the VaR SMA's, starting off at -8.49% while the no constraint portfolio starts at -2.4%. The same VaR problem occurs as in the no constraint portfolio during the market crash of March 2020. The markets recovered quickly but the VaR has a 52-week lag, giving it a full year with artificially low VaR.

Weekly	Naïve portfolio
VaR 95%	-0.20 %
VaR 99%	-0.51 %
Expected Shortfall 95%	-0.39 %
Expected Shortfall 99%	-0.66 %

Table 5.6. VaR/ES naïve portfolio.

5.2.5. Buy and hold portfolio

Buy and hold portfolio only consist of Bitcoin. This portfolio will be used to compare how the DeFi portfolio is performing against a buy and hold strategy.

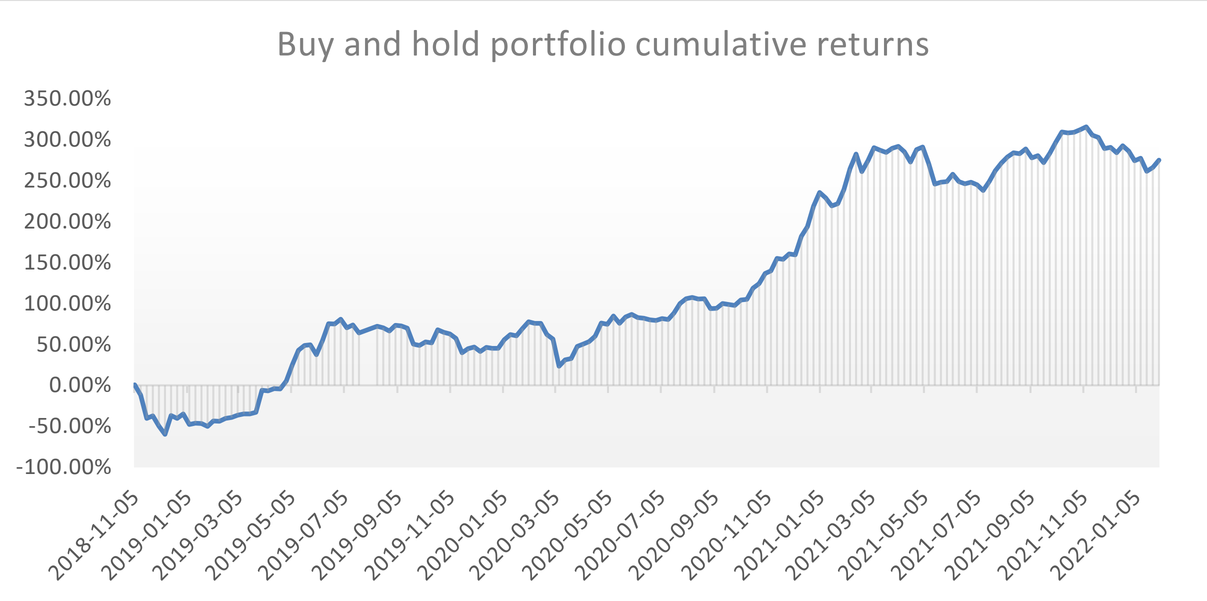

Figure 5.9: Cumulative returns Buy and hold portfolio.

Annualized	Buy and hold portfolio
Mean	79.16 %
Standard deviation	80.95 %
Risk-free	1.80 %
Sharpe	0.9555

Table 5.7. Annualized statistics buy and hold portfolio.

As seen in figure 5.9 there is extreme volatility in the buy and hold portfolio. In December of 2018, the portfolio has a return of -59.89%. If a portfolio manager had presented a loss of -59.89%, all the investors would have left, and the fund would go bankrupt. It has a mean return of 79,16% and a standard deviation of 80.95%, giving it a Sharpe ratio of 0.9555. Compared to the DeFi portfolio which had a return of 82.22% and a standard deviation of 74.42% and a Sharpe ratio of 1.0807. An alternative with even higher risk would be a buy and hold portfolio of Ethereum, which is the second largest cryptocurrency. Ethereum had a mean return of 111.32%, with a standard deviation of 107.75%, giving it a Sharpe ratio of 1.016. If an investor wants a high-risk investment with a buy and hold strategy, it would be better to choose an Ethereum portfolio during this period. To maximize the risk-adjusted return for the high-risk portfolios it would be wise to choose the DeFi portfolio. The DeFi portfolio can be deceiving because it has inherent external risks that are not included in the thesis, these possible risk are for example attacks on the DeFi protocol or custodial risk.

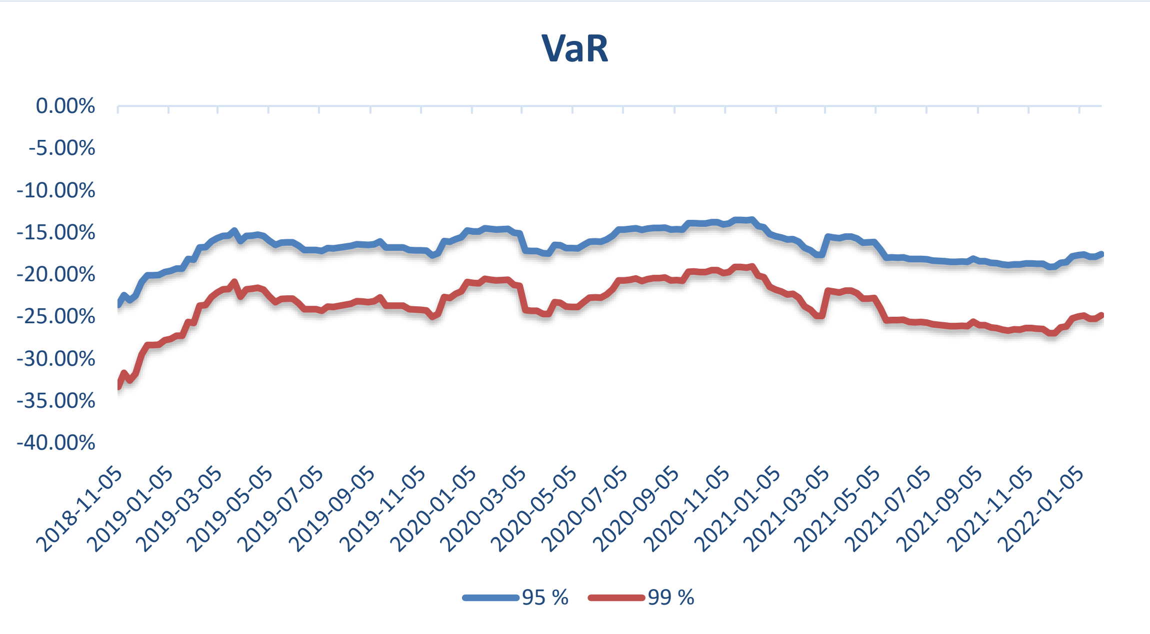

Figure 5.10. Timeseries VaR for each SMA buy and hold portfolio.

The VaR for the buy and hold portfolio is close to identical to the VaR of the DeFi portfolio. This is because both portfolios contain of 100% Bitcoin. The DeFi portfolio holds other assets with significantly less risks. The less risky assets will be overshadowed by the Bitcoin risks, since VaR and ES only consider the worst values and the volatility in Bitcoin makes it have the worst observations.

Weekly	Buy and hold portfolio
VaR 95%	-1.13 %
VaR 99%	-2.24 %
Expected Shortfall 95%	-1.81 %
Expected Shortfall 99%	-2.80 %

Table 5.8. VaR/ES buy and hold portfolio.

VaR and ES of the buy and hold portfolio closely resembles the DeFi portfolio. It is only a slight difference. A plausible reason could be the theory of Markowitz (1952) that assumes more assets in a portfolio will reduce the systematic risk.

5.2.6. Summary

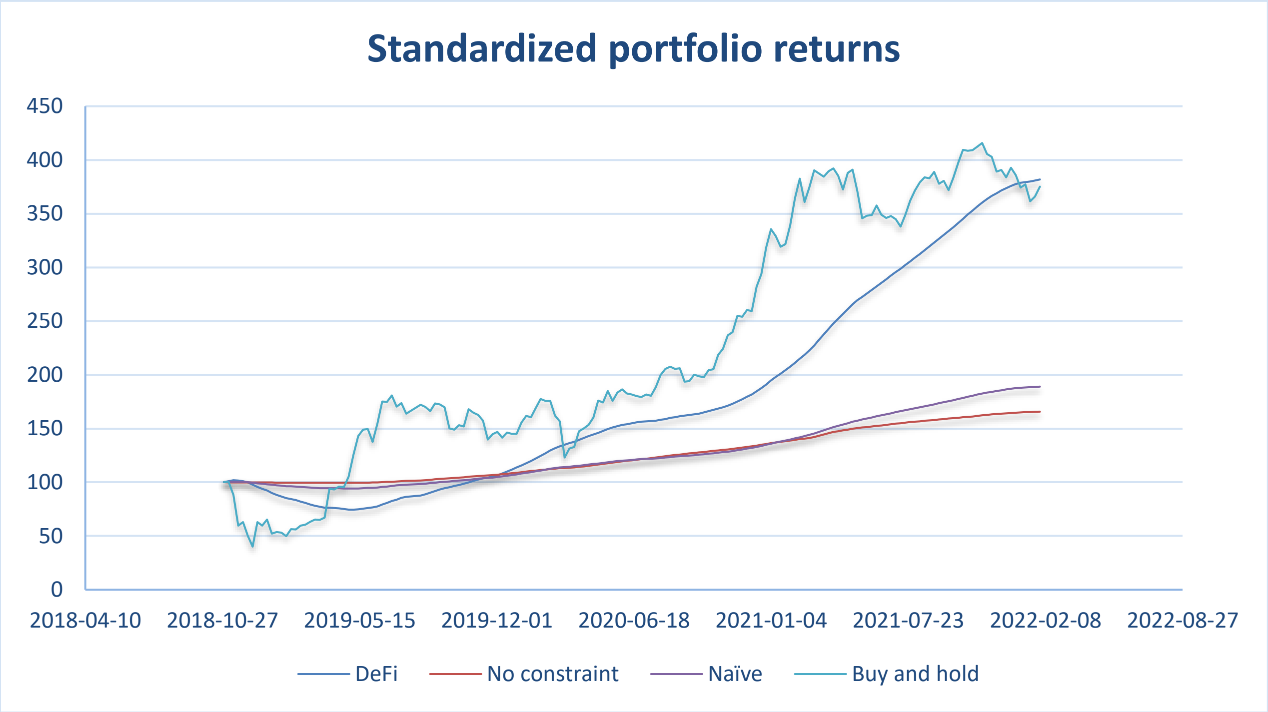

Figure 5.11. Standardized cumulative summary.

In figure 5.11 the standardized portfolio returns of all the portfolios is presented. After a volatile end of 2021 Bitcoin, the buy and hold portfolio gets beaten the DeFi portfolio, which ended with the highest cumulative return of 281.87%. Bitcoin buy and hold came closely after with a 275.23% return, followed by naïve portfolio with 89.04% and the no constraint portfolio with 65.75%. During the same period S&P500 had a cumulative return of 63.96% while gold had 38.97%.

Annualized	DeFi	No constraint	Naïve	Buy and hold
Mean	82.22 %	15.45 %	26.18 %	79.16 %
Standard deviation	74.42 %	15.02 %	22.45 %	80.95 %
Risk-free	1.80 %	1.80 %	1.80 %	1.80 %
Sharpe ratio	1.0807	0.9087	1.0861	0.9555

Table 5.9. Annualized statistics summary.

When comparing Sharpe ratio, the naïve portfolio is the best performer. This can be explained by the weight of risk-free asset in the portfolio. However, it can be discussed that there is a substantial difference in returns between these portfolios. The interesting topic is that DeFi portfolio is outperforming the buy and hold portfolio, supporting the Modern Portfolio Theory that diversification reduces risk (Markowitz 1952). It can be argued that introducing the less quantifiable external risks factors for DeFi portfolio, the naïve portfolio is a better choice if you want to maximize your return for each unit risk. The wide range of different portfolios can also be disputed to be suited for different kinds of risk aversion. One investor might say that the DeFi portfolio is a better suit for them because of their willingness to take on risk, while a risk averse person would choose the naïve portfolio, which have a low risk compared to the DeFi portfolio. However, any investor in the cryptocurrencies market is making the investment decision with the knowledge that this is a market with substantial volatility, though with a potential for huge returns if one can stomach the wild ride as is often the case in this market. Nevertheless, this may not fit everyone; it can be hard to stomach big volatile moves without losing faith. The portfolios in this thesis are optimized in a theoretical way and is presumed to be unfeasible for a human to always act rational in an irrational market, while also being able to correctly rebalance the portfolio every week. For investors who wants a safer option without any cryptocurrency or a tiny amount of it, the no constraint portfolio could be a desirable choice for them, even though it does not have the best risk-adjusted returns.

Weekly	DeFi	No constraint	Naïve	Buy and hold
VaR 95%	-1.06 %	-0.03 %	-0.20 %	-1.13 %
VaR 99%	-2.19 %	-0.20 %	-0.51 %	-2.24 %
Expected Shortfall 95%	-1.75 %	-0.13 %	-0.39 %	-1.81 %
Expected Shortfall 99%	-2.75 %	-0.28 %	-0.66 %	-2.80 %

Table 5.10. Summary VaR/ES.

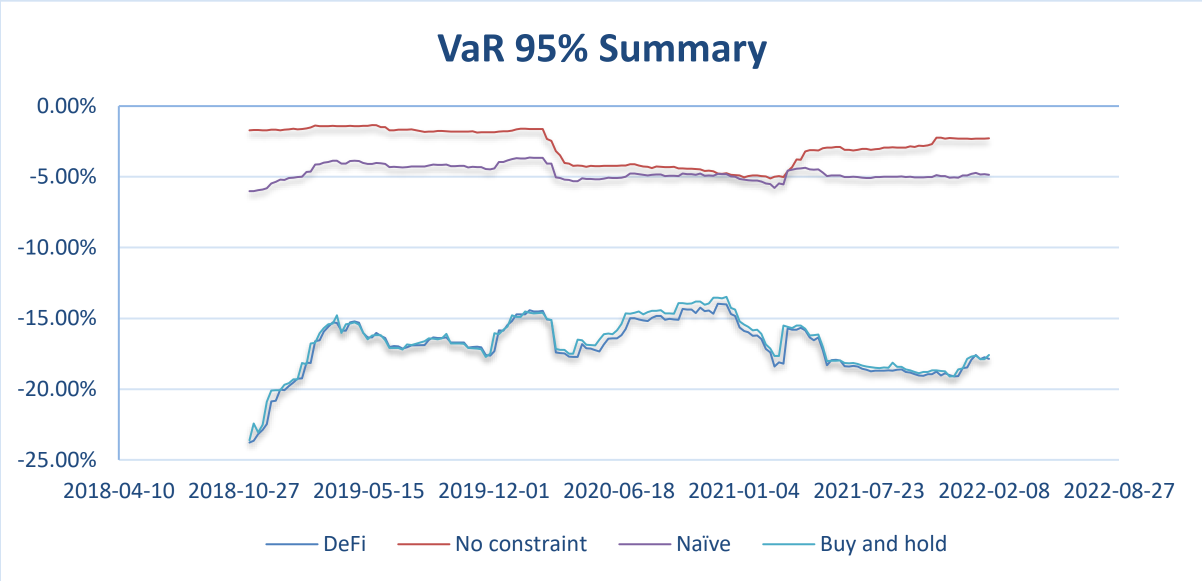

Figure 5.12. Summary VaR 95%.

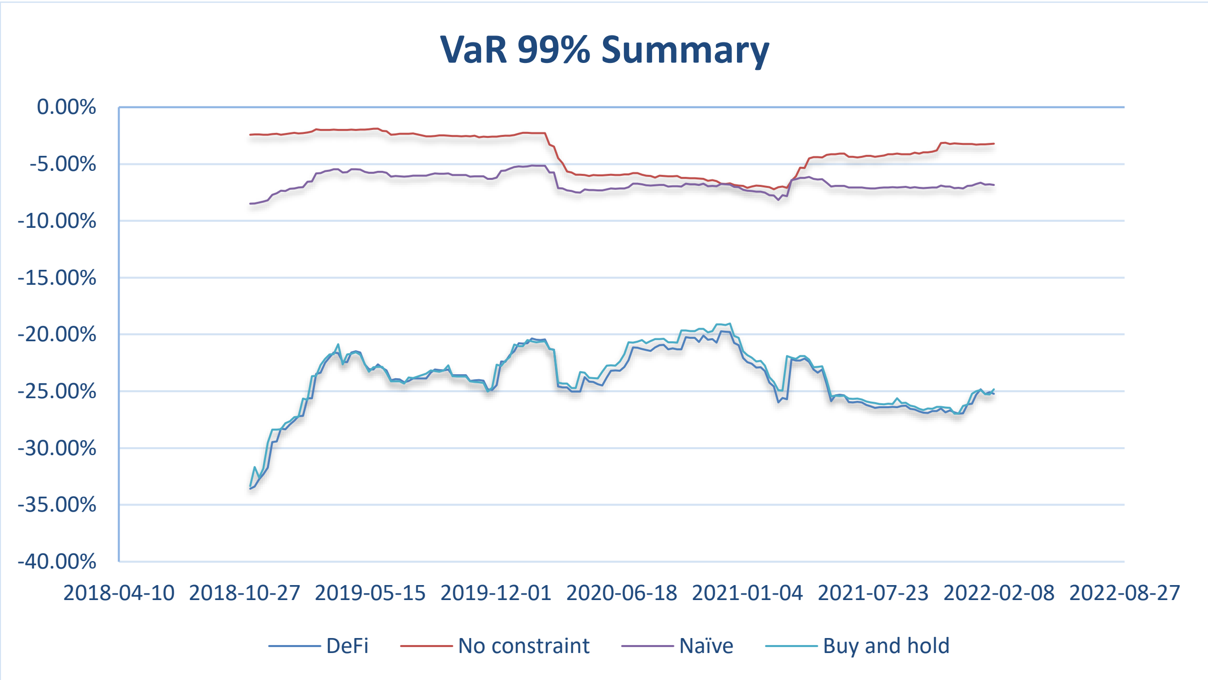

Figure 5.13. Summary VaR 99%.

Depending on risk levels VaR and ES can give you an insight for what kind of losses you can expect. For the portfolios containing Bitcoin there is considerably higher risk involved, giving it a lower VaR. An interesting observation is that the no constraint portfolio has a lower VaR in Q1 of 2021. A flaw with the VaR is when a flash crash happens. The market declines sharply and recovers quickly. As observed in figure 5.12 and 5.13 the flash crash of March

2020 had a profound impact on VaR for a long time, even though the markets recovered quickly. The VaR in the period after the market recovery is artificially low.

6. Conclusion

This thesis show how DeFi can be used as a tool increase the risk-adjusted returns. Four different portfolios were constructed based on the mean-variance strategy of Markowitz (1952). The main portfolio has 100% Bitcoin and uses DeFi to borrow 30% of the portfolio value as stablecoins with the Bitcoin as collateral. The borrowed funds were put into gold or S&P500. In order to compare the DeFi portfolio, a no constraint portfolio, a naïve portfolio and a buy and hold portfolio were created. No constraint portfolio holds Gold, S&P500 and Bitcoin, while the naïve portfolio is an equally weighted portfolio in gold, S&P500, Bitcoin and stablecoins. To test if the DeFi portfolio is outperforming a buy and hold strategy, a portfolio with Bitcoin only were created. The theory suggests that diversifying into multiple assets would reduce the risk of the portfolio, hence giving it a higher risk-adjusted return. The empirical results support this theory because the DeFi portfolio had a better risk-adjusted return than the buy and hold Bitcoin portfolio. Brière et al. (2015) expressed that lesser amounts of Bitcoin would drastically improve the risk-reward trade-off in a portfolio, but this research suggest otherwise. The no constraint portfolio containing small parts of Bitcoin performed poorly against the constructed portfolios, however it outperformed a buy and hold strategy of only gold or S&P500. Platanakis et al. (2018) found that there is a negligible difference between a mean-variance portfolio and a naïve portfolio. This study finds that there is a minimal difference between the risk-adjusted returns of the naïve portfolio and the mean-variance DeFi portfolio. There is a negligible difference in risk-adjusted returns between the DeFi portfolio and naïve portfolio, but there is a major difference in risk levels. The DeFi portfolio is not suited for commercial use because it carries too much risk for a portfolio manager to manage. However, it can work for a risk-taking investor that wants an elevated risk profile. The naïve portfolio is a better choice for a portfolio manager that wants to dip a toe into the cryptoverse. It yields a high risk-adjusted return and does not have extreme a risk level, considering it contains 25% Bitcoin.

6.1. Further research

For further research it would be interesting to test the same framework with a new sample. As of May 18. 2022 there are extreme fear in the markets, equities and cryptocurrencies have plummeted. It would be interesting to see how the framework would react in this environment. I would also suggest examining if there are better options to use as collateral, there is a risk trade-off between external risk and volatility in the underlying asset. This study uses Bitcoin as the underlying asset and collateral for the DeFi protocol, however this comes with a custodial risk. DeFi protocols are mostly run on the Ethereum chain. In order to use Bitcoin as collateral on Ethereum chain you have to move the Bitcoin onto the Ethereum chain, this is done by locking up Bitcoin on the Bitcoin chain and a custodian mints a Wrapped Bitcoin that can be used on the Ethereum chain. The custodial risk can be mitigated by using tokens native to the Ethereum chain, however the cryptocurrencies that run on the Ethereum chain potentially has higher volatility than Bitcoin, increasing the risk of liquidation.

7. References

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