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Bitcoin in a Pandemic

Did COVID-19 cases or other factors affect Bitcoin's return during the pandemic and did Bitcoin provide diversification benefits during this period?

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Abstract

This master's thesis examines if Bitcoin's return was affected by COVID-19 cases or other factors during the pandemic and the diversification benefits of Bitcoin in European, well-diversified portfolios during this period. The OLS was utilized to analyze the relationship between Bitcoin's return and the chosen variables and the time period was divided into four periods that represented the four waves of COVID-19 cases. This study found no significant effect of COVID-19 cases on Bitcoin. However, Bitcoin was significantly impacted during the first wave by the 5-Year, 5-Year Forward Inflation Expectation Rate, VIX, and gold. In the second wave, VIX, gold, and the dollar had a significant impact on Bitcoin. Only VIX had a significant impact on Bitcoin in the third wave. Lastly, in the fourth wave, no variables had a significant impact on Bitcoin. Further, this study investigates well-diversified portfolios with and without Bitcoin during the pandemic. The results suggest that Bitcoin did provide diversification for the risk-seeking investor, but not for the risk-averse investor. Lastly, this study found through the Fama-French Five-Factor Model that the portfolio returns were not only exposed to the market risk factor, but also the size, value, and profitability factor.

Keywords – Bitcoin, COVID-19, OLS, Portfolio Optimization, Fama-French Five-Factor

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1 Introduction

The emergence of Bitcoin and cryptocurrencies has been on the rise for the last decade, and since the pandemic, the popularity of cryptocurrencies has only increased. Bitcoin is a purely peer-to-peer version of electronic cash, designed to build a decentralized monetary system based on blockchain technology. It was built by a pseudonymous person or group called Satoshi Nakamoto in 2009. One of the main reasons for building Bitcoin was to solve the double-spending problem and have a monetary system that did not rely upon a trusted third party, such as the central authority (Nakamoto, 2008). In the first original block of Bitcoin, also called The Genesis Block, Nakamoto left the following message (Blockchain Block Explorer, 2009):

"The Times 03/Jan/2009 Chancellor on brink of second bailout for banks"

Although it has never been officially confirmed why Nakamoto left the text there, many have interpreted the message as an expression of the financial crisis in 2008. This global crisis weakened the trust in the financial system, government, and financial institutions. Over a decade later, the financial system is yet again put to the test by a global pandemic. At the same time, the popularity of Bitcoin are bigger than it has ever been.

In this study, we wanted to examine if COVID-19 cases or other factors affect Bitcoin's return during the ongoing COVID-19 crisis. Since this was Bitcoin's first encounter with a global pandemic, we also wanted to analyze if Bitcoin provided diversification benefits during this period. Our research question is therefore:

Did COVID-19 cases or other factors affect Bitcoin's return during the pandemic and did Bitcoin provide diversification benefits during this period?

To answer our research question we will use multiple linear regressions to see if COVID-19 or other factors affected Bitcoin. Further, we will run portfolio optimization of scenarios with different constraints for well-diversified portfolios with and without Bitcoin.

In the following sections, we will first provide a general overview of what Bitcoin is and the risk factors involved with investing in Bitcoin, before we discuss the previous relevant literature. Further, we will provide the theories behind our methodology before presenting the data and our methodology. Lastly, we will analyze the results and discuss the limits of our study.

2 Background

2.1 Bitcoin

Bitcoin is, as aforementioned, a purely peer-to-peer version of electronic cash, designed to build a decentralized monetary system based on disruptive blockchain technology. To understand how Bitcoin works, it is essential to have a basic understanding of blockchain and the Bitcoin network.

2.1.1 Blockchain

Blockchain is a type of Distributed Ledger Technology (DLT) where data are recorded and stored in chains of blocks (The World Bank, 2018). In Bitcoin's case, these data are bitcoin transactions from one user to another. The chain of blocks essentially forms a database of all previous transactions. A distributed ledger means that the blockchains are shared and accessible all over the world from nodes in real-time (River Financial, 2021e). A node is is a computer or device that keeps track of the current state of the blockchain. When nodes have achieved consensus about the current state of the block it is said to be confirmed. At that moment the block will be "chained" together with the rest of the blockchain by using a cryptographic technique called hashing (River Financial, 2021c). Once they are "hashed" together by the work of the nodes, they can not be manipulated or reordered without changing all the blocks that come after (Nakamoto, 2008).

2.1.2 Mining

Mining relies on the blockchain-based algorithm called proof-of-work (Hertig, 2020b). This algorithm makes sure that all the nodes that are connected to the Bitcoin network follow the encoded ruleset and are honest when producing blocks. Being honest in this context means that all of the transactions inside the block must be valid. The proof of "work" is when the nodes or computers solve complex mathematical computations to verify transactions and produce a hash (Becker, 2021). The first miner to produce a valid hash is allowed to publish a new block in the blockchain.

The incentive for running a node is that Bitcoin is programmed to give rewards to miners

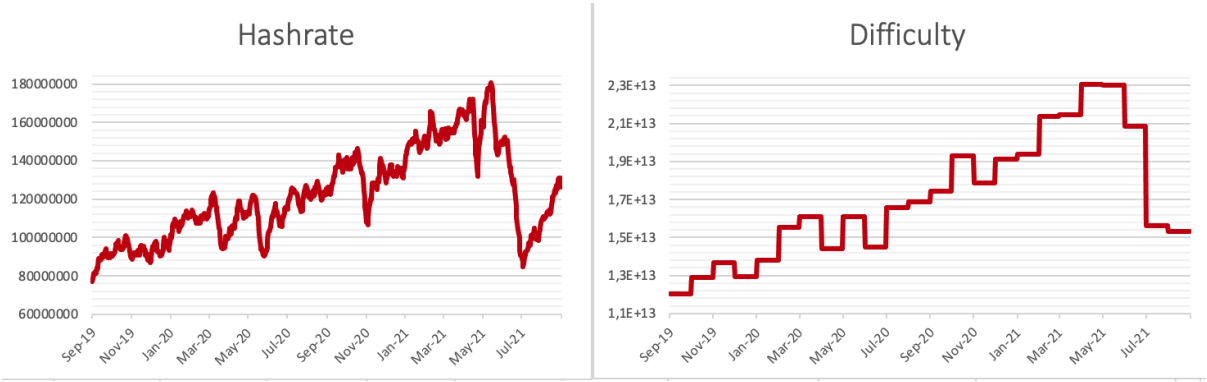
in the form of new bitcoins, in addition to transaction fees. At first, the reward for successfully mining a block was 50 BTC, but for every 210,000 blocks that are added, the reward will be cut in half (Hertig, 2020a). A block takes about 10 minutes to be confirmed. At this pace, it will take approximately four years between each halving. The reward is estimated to reach zero by year 2140. So far, three halvings have occurred, and the reward as of today is 6.25 bitcoins per block.

Bitcoin miners today are mostly organized into mining pools, and only a few are still mining individually (Binance, 2020). Increased difficulty in the proof-of-work computations makes the chances of successfully solving a block volatile and unpredictable for single individuals. The purpose of joining a pool is to increase the shared computation power which will increase the probability of successfully mining a block and receiving a reward. Thereby the reward can be distributed amongst the participants based on how much computational power they provided.

2.1.3 Hashrate

A measure of how secure the Bitcoin network is can be explained by hashrate. Hashrate is essentially the amount of calculations or computational power per second that is contributed to the network (Blockchain.com, 2021b). Hashrate is directly related to the "difficulty", which is a measure of how difficult it is to mine a new block. This relation is illustrated in Figure 2.1 below. The difficulty changes every 2016 blocks and has a stepwise curve as shown from the graph (Blockchain.com, 2021a). The hashrate has increased several hundred times in the last five years, thus getting more secure. It is important to note that hashrate is not a key driver to Bitcoin price. Research suggests the opposite; that Bitcoin price affects the hashrate, with lags from 1 to 6 weeks (Fantazzini and Kolodin, 2020). Miners will join and exit when they find it more profitable to mine. Additionally, hashrate will also be directly affected by electricity prices around the world and efficiency in new mining devices.

Figure 2.1: Hashrate and Network Difficulty

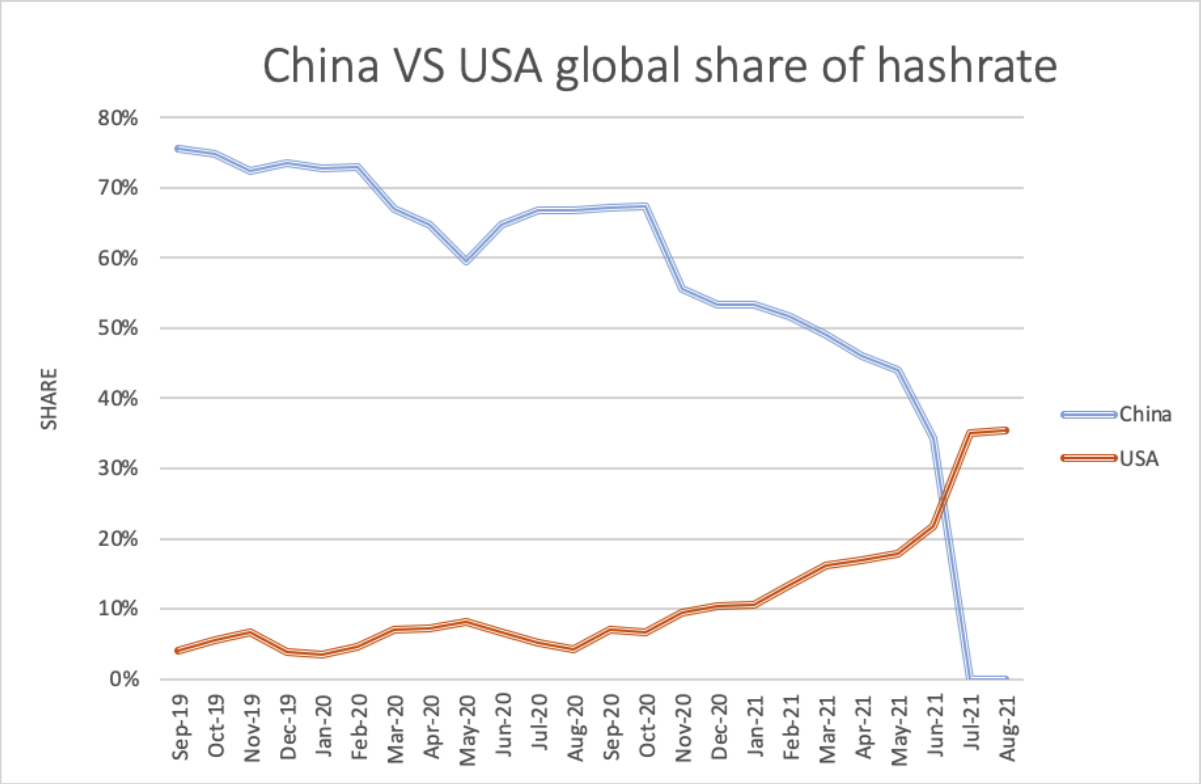


**Note:* This figure shows the hashrate and the difficulty from September 2019 to June 2021. The data is collected from Blockchain.com (2021b)

2.1.4 Miner Allocation

An interesting factor of mining is where the computational power comes from. Figure 2.2 below illustrates how China, which has been the biggest provider of computational power the recent years with a peak share of about 75%, has lost all of its global share. It also illustrates that the U.S. has climbed from about 4% share to now being the biggest provider of Bitcoin's hashrate. Another country that significantly increased their global share was the neighbouring country Kazakhstan that went from around 1% to 18%. This was a consequence of the Chinese government banning cryptocurrency-related financial institutions and payment services (The People's Bank of China, 2021). The first ban occurred in 2019, but it was still possible to use foreign exchanges to trade. However, in the spring of 2021, a more strict ban was issued where transactions in banks could be stopped, and mining was no longer allowed.

Figure 2.2: Global share of hashrate



**Note:* This figure shows the U.S. and China global share of hashrate from September 2019 to August 2021 (CBECI, 2021a)

2.2 Bitcoin as a Currency

Digital currency, digital gold, and digital asset are some of the names people associate with Bitcoin. Satoshi designed Bitcoin to function as a currency, but despite this, many people look at Bitcoin as an alternate investment. In the sections below, Bitcoin will be explained both through the lens of a currency and an investment.

2.2.1 Bitcoin and Fiat

If we want to look at Bitcoin as a currency, we have to look at the definition and essential functions of money and compare it with the money used today.

Economists define money as any good that is widely accepted as the final payment for goods and services. The three functions of money are: 1) Medium of exchange, 2) Store of value, and 3) Unit of account (Federal Reserve Bank of St. Louis, nd).

The money used today is known as fiat money. This money is not backed by a physical

commodity, such as gold or silver, but by the government that issued it. The value of fiat money is derived from the stability of the issuing government and the relationship between supply and demand. Most modern paper currencies are fiat currencies, including the U.S. dollar, the euro, and other major global currencies (CPI, 2021). One danger of fiat money is that governments will overprint, resulting in hyperinflation. This is especially relevant as of now when inflation is at 6.8%, the highest it has been in the U.S. for the past 39 years (BLS.gov, 2021).

Similar to fiat money, Bitcoin does not have an underlying value, but instead of being backed by the government, Bitcoin is backed by a decentralized and transparent network. One of the advantages of using Bitcoin over fiat is the time it takes to transfer between countries independent of the size of the amount sent. A Bitcoin transaction can take from a few minutes to a few hours, while it can take a couple of days for fiat (River Financial, 2021b). On the other side, one of Bitcoin's biggest disadvantages is its volatility, which is related to money's function as a store of value. Although Bitcoin has had a significantly high return year-over-year, the current volatility it comes with can make it too risky and unpredictable as a store of value for most people.

At the time of writing, El Salvador became the first country in the world to accept Bitcoin as legal tender in September 2021 (Presidencia de la República de El Salvador, 2021). Using a radically new form of money does come with its challenges for the people in the country such as lack of internet access and knowledge of digital wallets (Appelbaum, 2021). Nonetheless, this is a big step towards Bitcoin becoming more adopted globally, especially if countries in similar situations as El Salvador start to do the same.

There is no denying that Bitcoin has the potential of becoming a currency, especially if more countries accept it as legal tender and if the volatility decreases as Bitcoin becomes more mature. Despite this, Bitcoin is mostly treated as an alternative investment and this is what it will be classified as throughout this paper.

2.3 Bitcoin as an Asset

In the U.S., Bitcoin is treated as a commodity by The Commodity Futures Trading Commission (CFTC, 2021). This means that it is taxed as a capital gain, similar to stocks (IRS, 2021). To look at Bitcoin as an alternative asset it is important to discuss where

Bitcoin derives its value from and the potential risk factors regarding Bitcoin.

2.3.1 Value of Bitcoin

As mentioned above, Bitcoin does not have any intrinsic value. This means that Bitcoin's price could theoretically go all the way down to zero if people lose trust in the system. What gives Bitcoin value is therefore the relationship between supply and demand. As mentioned, the supply of Bitcoin is halved about every four years and is capped when it reaches 21 million coins. According to the efficient market hypothesis, this is all priced in, which means that the price of Bitcoin is only driven from the demand side. In other words, Bitcoin price is solely driven by future expectations. What these future expectations come from, besides speculative expectations, is the decentralized network and Bitcoin's potential of becoming a global digital currency. After Bitcoin was created, Satoshi Nakamoto left the entire project. This meant that Bitcoin did no longer have a leader or CEO and was fully controlled by its users. The decentralized nature of Bitcoin also eliminates the potential for third-party failure and protects Bitcoin from corporations and regulations that might come in to change Bitcoin's main features, such as the finite supply (River Financial, 2021d). Bitcoin's value also comes from its potential of becoming a global digital currency is already discussed in the section above.

2.3.2 Network Risk

The risk of getting hacked is one of the biggest risks in cryptocurrency. If this was to happen, it is not unlikely that a complete loss in trust of the Bitcoin network would cause the price of Bitcoin going towards zero. Multiple crypto exchanges have been hacked in the past, but the Bitcoin network has never been hacked. One of the most theorized ways of hacking the Bitcoin network is through the so-called 51%-attack.

One of the purposes of validating blocks and storing them on a blockchain is to avoid fraudulent transactions which is a problem of the so-called double-spending. That effectively means that it should not be possible to spend one amount of bitcoin twice. When a Bitcoin is sent to an address, it takes a certain time before it is fully confirmed and accepted in the blockchain. If the sender in the meantime tries to send the same amount to another address, the two transactions are both in the process of being validated,

but only one will be accepted. For a fraudulent or fake transaction to happen, one must have over 50% of all the computational power in the network. In practice, a sender would be able to send a Bitcoin without actually having it by making the blockchain confirm the fake bitcoin transactions as real transactions. One could also halt miners from confirming blocks and manipulate previous transactions. To be able to attack the Bitcoin network, a vast amount of electricity and computer power is needed, and the economic incentive is heavily aligned against it (Ammous, 2018). Technically the 51%-attack has happened once, but the attack was unintentional. A large mining pool called GHash.io obtained 51‰ of all the computation power of Bitcoin in 2014 (CEX.IO LTD, 2014). As the hashrate has increased significantly since then, so has the network security.

2.3.3 Exchange Risk

Although the Bitcoin network has never been hacked, several exchange hacks have taken place as mentioned above. Many people buy Bitcoin through cryptocurrency exchanges such as Binance or Coinbase and find it convenient to store it on the exchanges. This leaves them open to exchange risk.

A major security breach or hack happened to an exchange named Mt.Gox in 2014 (Cryptopedia, 2021). At the time, the exchange handled almost 70% of all Bitcoin trading volume. They had to file for bankruptcy after finding out that 850,000 bitcoins had disappeared from the accounts of their customers. In 2014, that accounted for about 6% of all bitcoins in existence. Later on, 200,000 of the bitcoins were found in an old digital wallet. This made it possible to repay a tiny amount of what investors lost during the breach. An exchange named Bitfinex became the world's largest crypto exchange after the Mt.Gox breach. This also made it a target for hackers. After the Mt. Gox incident, exchanges increased their security by having their customers use multiple signatures before a transaction. Despite this, the hackers still managed to exploit the system. This effectively led to a transfer of 120,000 bitcoins to the hackers' address.

To access a digital wallet, a hacker needs the private key associated with that wallet. This is why exchanges have what is known as "cold storage" and "hot wallets" to reduce the risk of a security breach (Binance, 2019). Cold storage means storing bitcoins offline and

off the exchanges, making it impossible for hackers to retrieve the private key. Hot wallets are used for daily activities such as depositing and withdrawing funds from the exchange.

2.3.4 Regulation Risk

Bitcoin was designed with the intention of being decentralized, but it is unlikely that it will be able to escape regulation.

One regulation risk is exchanges or crypto-related businesses getting banned. Turkey is an example of this where the government issued a ban on any cryptocurrency-related business (Wilks, 2021). The Turkish cryptocurrency exchange Thodex had around 400,000 users. One of the main reasons for its popularity was that people were trying to escape their highly inflated currency. The Turkish Lira had an inflation of 17.14% in April 2021. In the rise of the new ban, the CEO of Thodex fled the country and stole about $2B worth of cryptocurrency from his clients.

The uncertainty of the classification of cryptocurrency and Bitcoin comes with the risk of changes in taxation. While the U.S. treats Bitcoin as a commodity and taxes it in accordance with tax rules for commodities, there is a possibility the the U.S. government may change this view in the future. The same applies for other countries around the world. In addition, there is also a risk that governments can target cryptocurrencies in the future with higher taxation.

Another regulatory risk relates to stablecoins. Stablecoins are cryptocurrencies that are pegged to a fiat currency (SEC, 2021), the most popular being USDT and USDC which are pegged 1:1 to the U.S. Dollar (CoinMarketCap, 2021c). Stablecoins play a big role in the liquidity of cryptocurrencies and Bitcoin, and regulation of these will therefore have a big impact on Bitcoin.

2.3.5 Environmental Risk

As climate change is considered to be one of the biggest challenges of our time, the energy consumption of Bitcoin and the mining process have been an ongoing concern. Bitcoin being a proof-of-work system requires a large amount of energy. As the usage increases, mathematical algorithms that miners need to solve become more difficult. This will result in the miners needing more processing power to solve the problems, which in the end will

lead to higher energy consumption. Until recently, 75% of Bitcoin miners were located in China. The country was responsible for over 50% of the world's coal-fired electricity in 2020 (Jones, 2021). As of writing it is estimated that Bitcoin mining alone has an annualized electricity consumption of about 115 TWh. To put this in perspective, if Bitcoin were a country it would be the 32nd largest energy consumer in the world (CBECI, 2021b). The most recent study done on Bitcoin's energy consumption was a report in 2020 from Cambridge that found that 39% of Bitcoin mining came from renewable energy (Blandin et al., 2020). However, Bitcoin transactions and mining are now illegal in China, and the proportion of Bitcoin miners remaining in China is close to zero. The U.S. seems to have become the largest mining center now, but it is uncertain how this will impact Bitcoin's carbon emissions moving forward. Another environmental concern is the electronic waste from mining equipment that frequently needs to be replaced in favor of more efficient mining equipment. On average, the electronic waste is found to be 272 grams per transaction of Bitcoin (Vries and Stoll, 2021). It is important for an investor to be aware of the risk that Bitcoin comes with in terms of environmental impact.

2.3.6 Competition

A common misconception is to think that most other cryptocurrencies exist in competition with Bitcoin. In reality, most other cryptocurrencies do not claim to try to compete with Bitcoin, especially not anymore (Ammous, 2018). This includes Ethereum, the second-largest cryptocurrency with a total market capitalization of over $500 Billion as of writing (CoinMarketCap, 2021b). After Bitcoin was first created and started to increase in value and adoption, many copied it to produce similar currencies (Ammous, 2018). Despite this, no other cryptocurrencies have posed a serious threat to Bitcoin. A major reason for this is that the attractiveness of Bitcoin comes from its lack of any central authority figure or leader. Most other cryptocurrencies have a team in charge, essentially making them a centralized system, which is the opposite of the decentralized and trustless nature of Bitcoin.

We can not exclude the fact that in the long-term, a new cryptocurrency might be able to compete with Bitcoin, or a new technology comes along and disrupt the crypto market, but that does not seem to be the case, at least in the short-term.

2.3.7 Macroeconomic Environment

Certain macroeconomic environments will be favorable for some assets and unfavorable for others. It is likely that the same applies to Bitcoin. When the economy is doing well during booming and expansion cycles, people will have more wealth they want to allocate to financial assets. More wealth leads to a higher demand, which in the end results in increased prices. On the contrary, recessions and bust cycles force people to use more of their money for immediate consumption. This lowers the demand in the market, including risky assets. (River Financial, 2021a). This is exactly what happened to the global stock market and Bitcoin during the COVID-19 crash. Since the first reported case by WHO on 22 January 2020, Bitcoin tanked 42% and bottomed 12 March 2020 (Yahoo Finance, 2021a). From the first COVID-19 case, the S&P500 experienced a 33% decrease until it bottomed out in 23 March 2020. However, the COVID-19 crash was followed by one of the fastest recovery in the history of American market crashes (Kaplan, 2021). The market eventually recovered after only four months.

Even though the market recovered fast, national and local restrictions worldwide continued and caused a negative revenue shock for a lot of companies related to travelling and tourism. On the other side, companies related to telecommunication, pharmacies, and home delivery services experienced an increase in their profits due to a change in demand for services. In April 2020, an all-time high of 14.8% were unemployed in the U.S. (Bls.gov, 2021). The unemployment rate quickly returned to more normal percentages, but is still elevated.

As discussed in the "Bitcoin as a currency" section, Bitcoin was designed to solve one of fiat's weaknesses, which is overprinting. During the pandemic, we have seen an unprecedented amount of dollar printing. From January 2020 to August 2021, the M2 increased from approximately $15,000B to $20,000B (Federal Reserve Bank of St. Louis, 2021b). This is an increase of 25% in less than two years and could lead to a favorable macroeconomic environment for Bitcoin.

3 Literature Review

This section will provide an overview of previous relevant literature on how the pandemic affected Bitcoin, as well as well-diversified portfolios with Bitcoin.

After the pandemic hit, there have been a few research papers about how the crisis affected the crypto market. Vukovic et al. (2021) examined the impact of the first wave of COVID-19 cases on the crypto market. The study developed a unique COVID-19 global composite index that measures COVID-19 pandemic time-variant movements on each day. The study used ordinary least squares (OLS), quantile, and robust regressions to check whether the COVID-19 crisis had any significant direct influence on the crypto market. The OLS, quantile, and robust regression estimates confirmed that there was no statistically significant direct influence of the COVID-19 crisis on the crypto market in the first wave period. Our study will include four waves and use COVID-19 cases as a measure of the impact of the pandemic, while Vukovic et al. (2021) developed their own COVID-19 global composite index. Additionally, our paper has included other variables that might have impacted Bitcoin during the pandemic.

While there have been a lot of studies regarding Bitcoin as a safe haven, this crisis was Bitcoin's first encounter with a global pandemic. The paper conducted by Conlon and McGee (2020) looked at the downside risk of Bitcoin where the main examination period was from March 2019 to March 2020. More specifically they were looking at a four-moment modified Value at Risk along with Conditional Value at Risk analysis of Bitcoin in the first wave of the pandemic. The final conclusion was that including Bitcoin in the portfolio after the COVID-19 outbreak did not act as a safe haven and in fact, increased downside risk. Our study will look at Bitcoin more as an alternative asset instead of a safe haven. Further, our examination period is from 2019 to August 2021 which takes into account a much longer time period of the ongoing pandemic. In addition, our study includes a Fama-French Five-Factor Model of the portfolio returns. Our study should therefore be an informative addition to the previous literature.

Jaffer (2021) investigated the hedging behavior of Bitcoin. His research used a multivariate GARCH analysis. The time span from 15 June 2018 to 20 July 2020 gives an insight into hedging properties both before and almost a half year into the pandemic. In the

first period, before COVID-19, Bitcoin had a negative correlation with the MSCI world index which captures the global stock market performance of over 1500 large and mid-cap companies from 23 developed markets. In the second period, Bitcoin was positively correlated with MSCI. Therefore, this could indicate that Bitcoin had some hedging capabilities before the pandemic, but not after. He stated that his research only included the beginning of the pandemic and that a broader time span would give a more conclusive result of COVID-19 impact on Bitcoin. Jaffer found that Bitcoin did not act as a "digital gold" and therefore not an effective hedge during market turbulence.

Kumar (2020) did a similar study where he conducted a multivariate GARCH analysis of the safe-haven properties of Bitcoin and Gold in the timespan of 05-01-2015 to 24-04-2020. As a proxy for the equity market, four indexes were used, namely NSE50, DJIA, CAC40, and SSE. The research found that Bitcoin was partially correlated with gold in the initial phase of the pandemic and showed signs of safe-haven properties. Eventually, Kumar found Gold to be a relatively better safe haven than Bitcoin.

4 Theory

4.1 Multiple Linear Regression and Ordinary Least Squares

The multiple linear regression (MLR) model is one of the most popular models for analyzing empirical data in economics and other social sciences. In addition ordinary least squares (OLS) is popularly used for estimating the parameters of the multiple regression model (Wooldridge, 2018).

MLR can be explained by the following formula:

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_n x_n + u \tag{4.1}$$

Where y is the dependent variable. x are the independent variables, and u is the error term. β_0 is the intercept of the independent variable. β_1 measures the change in dependent variable y for the explanatory variable x_1, holding other factors fixed. Likewise, β_n will measure the change in y for explanatory variable x_n, holding other factors fixed. The idea behind the MLR model is to find the parameters of β_0, β_1, and β_n which minimizes the error term u. This means that the model will minimize the squared errors to avoid positive and negative errors to compensate for each other. To ensure that the OLS estimators are unbiased, there are four assumptions that must hold:

1) Linear in Parameters

This assumption is the definition of the MLR model and states that the model is linear in the parameters β_1, β_2, β_n.

2) Random Sampling

The sample is randomly chosen from the population and consists of n observations.

3) No Perfect Collinearity

The independent variables can not have an exact linear relationship with each other. In other words, they can not be perfectly correlated. It is important to note that the independent variables can still be correlated with each other, but just not perfectly.

4) Zero Conditional Mean

This assumption states that the expected value of the error term u is zero given any values of the explanatory variables. Mathematically it can be expressed as:

$$E(u|x_1, x_2, ..., x_n) = 0 \tag{4.2}$$

This assumption does not hold if an important variable that is correlated with any of the explanatory variables, is omitted. If the zero conditional mean assumption holds, independent variables are said to be exogenous. If the zero conditional mean is violated, independent variables are said to be endogenous, and there will be an endogeneity problem.

These four assumptions are enough to make a causal interpretation of x on y, all else equal. In addition to being unbiased, if we want the estimators to be more efficient, a fifth assumption has to hold. This is also known as the Best Linear Unbiased Estimators (BLUE). The fifth assumptions is:

5) Homoskedasticity

The homoskedaticity assumption can be written as:

$$VAR(u|x_1, x_2, \ldots, x_n) = \sigma^2 \tag{4.3}$$

For any value of explanatory variables, the variance in the error term u has to be the same. If the variance changes after an independent variable is introduced, then the assumption is violated and the model suffers from heteroskedasticity. Assumption one through five is also collectively known as the Gauss-Markow assumptions (Wooldridge, 2018).

When dealing with time-series, it is also important that the series are stationary. According to research from Granger et al. (1974), regression results from non-stationary variables

give spurious results. Stationary means that the time-series distribution do not change over time and implies that history is relevant for future predictions (Han, 2021).

4.2 Modern Portfolio Theory

Harry M. Markowitz introduced the mean-variance model (MV) through his paper *Portfolio Selection* in 1952. A few years later, Markowitz published an essay on how the optimization problem could be solved as a quadratic programming problem (Markowitz, 1956). To solve this, you need to have a quadratic utility function, expected returns, and variance of multiple assets and their covariance. The investor's budget restrictions are also important for solving the problem.

The framework behind MV can be seen in the following formulas:

$$E(r_p) = \mu_p = \begin{pmatrix} \mu_1 \\ \mu_2 \\ \vdots \\ \mu_n \end{pmatrix} \begin{bmatrix} w_1 & w_2 & \dots & w_n \end{bmatrix} = \sum_{j=1}^{n} w_j E(r_j) \tag{4.4}$$

where the expected return is a result of the weights of an individual asset multiplied by its corresponding expected return. The sum of this will be the portfolio's expected return.

$$Var(r_p) = \sigma_p^2 = \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} \begin{pmatrix} \sigma_{11} & \sigma_{12} & \dots & \sigma_{1n} \\ \sigma_{21} & \sigma_{22} & \dots & \sigma_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \sigma_{n1} & \sigma_{n2} & \dots & \sigma_{nn} \end{pmatrix} \begin{bmatrix} w_1 & w_2 & \dots & w_n \end{bmatrix} = \sum_{i=1}^{n}\sum_{j=1}^{n} x_i x_j \sigma_{ij} \tag{4.5}$$

To find the portfolio variance, the transposed of each of the weights are multiplied with a covariance matrix and then multiplied with the weights as shown in equation 4.5.

The idea behind MV was further developed by William Sharpe and Merton Miller which led to the Modern Portfolio Theory (MPT) we know today. In 1990, they both received the Nobel Price in Economics for their contribution to MPT (NobelPrize.org, 1990). The

model emphasizes the diversification benefits of dividing the investor's wealth between several assets to find the best trade-off between risk and return. The theory assumes that investors are risk-averse, rational, and want higher expected returns for higher level of risks.

4.2.1 Capital Asset Pricing Model

William F. Sharpe, Jack Treynor, John Lintner, and Jan Mossin introduced the Capital Asset Pricing Model (CAPM) in the 1960s (Perold, 2004). The CAPM was built on the findings and framework from Markowitz's paper in 1952 and 1956. It introduces the idea that assets have two types of risk: systematic and idiosyncratic. Systematic risk is also called market risk, and can not be diversified away. Idiosyncratic or firm-specific risk on the other can be mitigated through diversification. This is the case for well-diversified portfolios (Chamberlain, 1983). A study by Fisher and Lorie (1970) shows that 30 securities spread over various sectors is sufficient for a significant reduction in firm-specific risk.

According to literature by Bodie et al. (2009) there are six assumptions for CAPM to hold:

1. Investors are price-takers.
2. Investors are only planning for one period, and the period is identical for all.
3. Investments is made up by publicly traded financial assets. Investors can borrow and lend any amount at the risk-free rate.
4. There are no fees, taxation costs or transaction costs associated with trading of assets.
5. Investors are rational and want to maximize the trade-off between expected returns and risk.
6. Investors have the same information and analyzes the assets similarly. They have the same risk-free rate and homogeneous beliefs.

Mathematically, the expected return of CAPM is expressed as:

$$E(r_i) = r_f + \beta_i(E(r_m) - r_f) \tag{4.6}$$

Where $E(r_i)$ is the expected return of investment, r_f is the risk-free rate and β_i is the beta of the investment. The introduction of a risk-free asset is simply the rate an investor would get by having money in the bank, treasury bills, or money market funds that do not have any risk of loss at all. Inside the parentheses $(E(r_m) - r_f)$ we find what is referred to as the market excess return or market risk premium. β_i is further defined by:

$$\beta_i = \frac{Cov(r_1, r_m)}{\sigma_m^2} \tag{4.7}$$

where the equation explains how the stock is behaving relative to the market portfolio. The beta of the market portfolio β_m is always one. If β_i is lower than one, it means that the asset has less volatility or risk than the market.

4.2.2 Sharpe Ratio

William Sharpe included the risk-free asset into the MPT and found that the best portfolio was found through maximizing the Sharpe ratio (Sharpe, 1966, p. 122):

$$SR_p = \frac{E(r_p) - r_f}{\sigma_p} \tag{4.8}$$

Where SR_p is the Sharpe ratio of the portfolio p, $E(r_p)$ is the expected return, r_f is the return from the risk-free asset, and σ_p is the standard deviation of the portfolio. $E(r_p) - r_f$ is also known as the risk premium. The higher return per unit of risk, the better the Sharpe ratio.

4.2.3 Capital Allocation

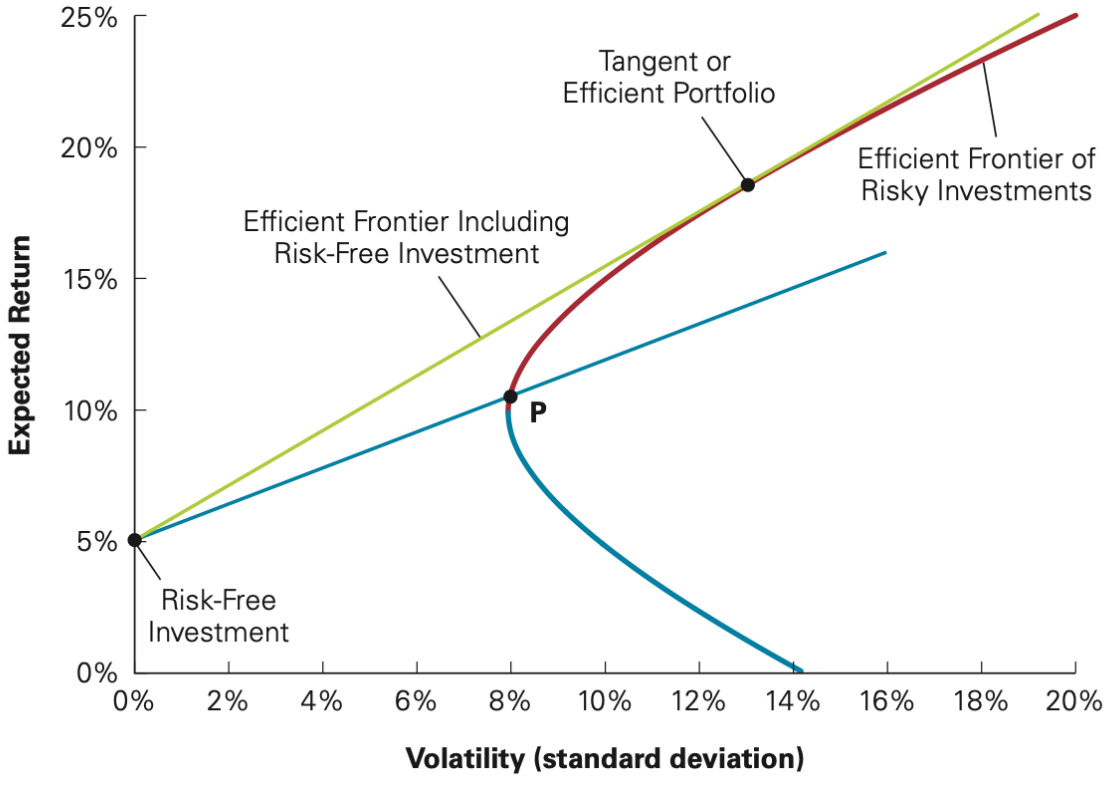
CAPM can be illustrated graphically as shown in Figure 4.1. The curved red line is the efficient frontier and represents portfolios with the highest expected return for a certain amount of risk. This means that a rational investor would prefer portfolios that are located on the curved red line. The curved blue line is "dominated" by the red line as all points in the blue line have a lower expected return for a given risk.

The green line is the Capital Allocation Line (CAL). This line starts at the risk-free rate in the y-axis, and the point where CAL is tangent to the efficient frontier represents the

Tangent Portfolio. This portfolio has the highest Sharpe ratio and does not depend on the risk attitude of the investor. The risk attitude only affects where in the green line the investor wants to be. The tangent point is where the investor is invested 100% in the tangent portfolio. Any point to the left of the green line represents more allocation to the risk-free asset and less to the tangent portfolio. Going all the way to the left means that the investor is 100% invested in the risk-free asset. Any points to the right of the tangent point mean that the investor is invested more than 100% in the tangent portfolio. In other words, the investor is using leverage or shorting the risk-free asset.

Point P represents the minimum variance portfolio. This portfolio has the lowest risk and suits the risk-averse investors (Bodie et al., 2009, p. 223).

Figure 4.1: CAPM



**Note:* This figure shows a graphical illustration of CAPM. The y-axis represents the expected return and the x-axis represents the volatility (standard deviation) (Berk and DeMarzo, 2016, p. 413).

4.3 Fama-French

4.3.1 CAPM and Jensen's alpha

A few years after CAPM was developed, it was used as a performance measure of mutual funds by Jensen (1968). Mathematically the model can be expressed as:

$$E(r_i) - r_f = \alpha_i + \beta_i(E(r_m) - r_f) + u_t \tag{4.9}$$

where α_i is the alpha, also known as excess returns or abnormal returns. If the alpha is positive and significant, it means that the portfolio is outperforming the market. u_t represents the error term.

4.3.2 Fama-French Three-Factor Model

Expanding on the CAPM model, Fama and French (1993) introduced a Three-Factor Model with two new risk factors, SMB and HML. SMB stands for "Small Minus Big" and represents the size factor. This factor shows the excess return of investing in publicly traded companies with smaller market capitalization versus larger companies. HML stands for "High Minus Low" and represents the value factor. More specifically, the excess returns of investing in firms with high book-to-market ratios versus low book-to-market. The model is expressed as follows:

$$r_{it} - r_{ft} = \alpha_{it} + \beta_1(E(r_m) - r_f) + \beta_2 SMB_t + \beta_3 HML_t + u_t \tag{4.10}$$

where $r_{it} - r_{ft}$ represents the excess return of portfolio i, a is abnormal returns, and $(E(r_m) - r_f)$ is the excess market returns, or the systematic risk factor. SMB_t and HML_t represents the size and value factor.

4.3.3 Carhart Four-Factor Model

Carhart (1997) introduced a momentum factor called UMD to the Fama-French model. He wanted to explain cross-sectional variation in portfolio returns with a focus on momentum. UMD stands for "Up Minus Down" and focuses on the return of portfolios consisting of

winner stocks in excess of portfolios with loser stocks:

$$r_{it} - r_{ft} = \alpha_{it} + \beta_1(E(r_m) - r_f) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 UMD_t + u_t \tag{4.11}$$

4.3.4 Fama-French Five-Factor Model

The previous models have existed for decades before Fama and French (2015) introduced two new factors:

$$r_{it} - r_{ft} = \alpha_{it} + \beta_1(E(r_m) - r_f) + \beta_2 SMB_t + \beta_3 HML_t + \beta_4 RMW_t + \beta_5 CMA_t + u_t \tag{4.12}$$

where the new factor RMW stands for "Robust Minus Weak" and represents the firm profitability factor. The RMW factor is the excess return of investing in firms reporting higher operating profitability versus lower. The other new factor CMA stands for "Conservative Minus Aggressive" and represents the firm investment factor. In other words, the excess return of investing in firms that invest in conservative projects versus aggressive.

5 Data and Methodology

5.1 OLS Data

In the OLS analysis the dependent variable will be BTC, or Bitcoin daily returns. The independent variables will be NEW_CASES: a proxy for the effect of COVID 19; EXP_INFL: a proxy for expected inflation; F&G: a measure of fear and greed in the crypto markets; VIX: a proxy for the fear in the stock markets; GOLD: an important global commodity; and DOLLAR: the world's reserve currency. Further explanations for each variable are provided below.

BTC is the daily returns derived from closing prices for Bitcoin and is the dependent variable (Yahoo Finance, 2021b). Since Bitcoin is traded individually on each cryptocurrency exchange, the price will not be the same everywhere. The prices are therefore based on an average of Bitcoin prices from several cryptocurrency exchanges. The source of data that Yahoo Finance use is CoinMarketCap which is, as of writing, the most popular website to collect price information about cryptocurrencies (CoinMarketCap, 2021a).

New_ cases is the change in worldwide daily new cases and will be our first independent variable. This is used to measure the global effect of COVID-19 cases. The dataset which is downloaded from OurWorldinData relies on data from Johns Hopkins University (JHU) (Ritchie et al., 2020). Their source of information comes from nations and local affairs that report on behalf of national governments. Since JHU collects data from numerous sources, some with a longer reporting chain and credibility than others, the actual number of cases can differ. In addition, the dataset is corrected several times due to estimation errors. This includes situations where negative values have appeared in the dataset.

Exp_ infl is the label for the 5-year, 5-year Forward Inflation Expectation Rate (Federal Reserve Bank of St. Louis, 2021a). This index is a measure of average expected inflation over the five-year period that begins five years from today. The rate is derived from yields on 5-year and 10-year Treasury Inflation Protection Securities (TIPS) compared with their respective nominal Treasury yield. Our choice of using this proxy instead of using a 10-year or 5-year breakeven inflation rate is because of the time perspective. Another reason is

that it sees through short-term noise that affects consumer prices (McCormick, 2021). In the context of this study, the COVID-19 pandemic could cause a lot of short-term noise when only looking at the first five years into the future.

F&G is an index that measures the fear and greed in the crypto markets (Alternate.me, 2021). It is made up by 25% volatility in Bitcoin which compares the current volatility and maximum drawdowns with previous average values from the last 30 and 90 days. The next 25% measures the current volume and market momentum of the cryptocurrency market in comparison with the last 30 and 90-day average values. 15% is made out of social media, where it focuses on Reddit and Twitter sentiment analysis where posts on various hashtags for each cryptocurrency token are gathered and counted. It focuses especially on the frequency and amount of interactions to determine which state the market is in. The index also consists of 15% surveys. In collaboration with strawpoll.com, they conduct weekly crypto polls that aims to give a better picture of the overall market sentiment amongst crypto investors. The next 10% is dominance which means the share of market capitalization a coin has, compared to the whole market. Lastly, 10% is made out of trends. Google Trends data to analyze various Bitcoin-related searches, their frequency, and change in search volumes.

VIX is an indicator for the volatility in the global stock market. The origin of the ticker VIX is Chicago Board Options Exchange Volatility Index. Earlier, when the index was introduced in 1993, it was based on S&P100 prices which only included eight at-the-money put and calls (Whaley, 2009). Today it reflects the market expectations for 30-day forward-looking implied volatility in S&P500 put and calls (CBOE, 2021). In general, VIX tends to peak during the crisis and is often called the "investor fear gauge" (Bodie et al., 2009). VIX has been tradable for investors since CBOE introduced VIX futures in 2004 and option contracts in 2006. It is important to add that since VIX is essentially based on S&P500, we have decided to not include the S&P500 as a variable.

Gold is one of the most important global commodities. It is collected from Yahoo Finance under the ticker GC=F (Yahoo Finance, 2021f) and represents a gold future derivative that is being traded on COMEX also known as Commodity Exchange Inc.. COMEX is a derivatives marketplace for precious, base, and ferrous metals (CME Group, 2021).

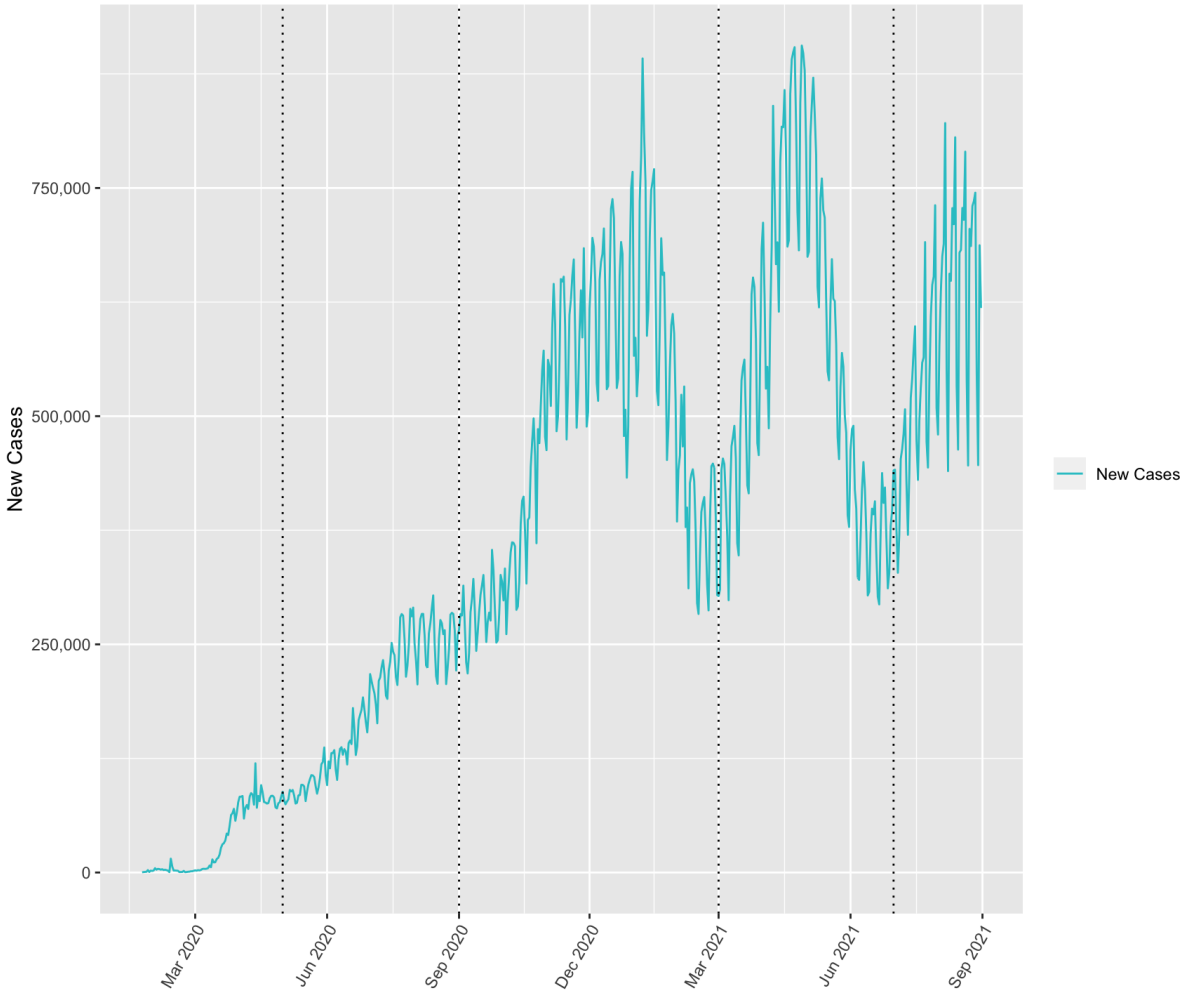
Dollar is the last independent variable in the regression. As Bitcoin was designed to be a

global digital currency, its biggest challenge will be to compete with the current global reserve currency, the dollar. It is therefore interesting to examine the relationship between Bitcoin and the dollar during the pandemic, especially because of the unusual amount of overprinting that has occurred. The data is extracted from Yahoo Finance with the ticker DX-Y.NYB (Yahoo Finance, 2021l). It measures the dollar against six major currencies in the following weighted order; EUR, JPY, GBP, CAD, SEK, and CHF, with EUR being over 50%.

5.2 OLS Methodology

To further look into how Bitcoin's return was affected, we have divided the pandemic into four periods. These periods are divided on the basis of the four waves of the COVID-19 cases.

Figure 5.1: Daily New Cases (global)



**Note:* This figure shows the daily new cases (worldwide) from January 2020 to September 2021. The dotted vertical line represents the start and end of a wave.

From Figure 5.1 we can clearly see the different waves during the pandemic. The waves are defined as the period from a local bottom to the next local bottom. Period 1 is from 23 January 2020 to 1 May 2020, Period 2 is from 2 May 2020 to 1 September 2020, Period 3 is from 2 September 2020 to 1 Mars 2021, and Period 4 is from 2 Mars 2021 to 1 July 2021. This means that we have excluded the period after 1 July 2021.

The OLS regression will be as follows:

$$BTC_t = \beta_0 + \beta_1 New\_cases_t + \beta_2 Exp\_infl_t + \beta_3 F\&G_t + \beta_4 VIX_t + \beta_5 Gold_t + \beta_6 Dollar_t + u_t \tag{5.1}$$

where t denotes the time period, β_0 is the intercept, u is the error term, and the different β's are the coefficient for each dependent variable.

5.2.1 Variable Tests

It is important to note that the independent variables do not suffer from severe multicollinearity. This was tested for using the Variance Inflation Factors (VIF). Further, the Breusch-Pagan (BP) test was used to test for heteroscedasticity. Heteroscedasticity was only present in Period 1. However, we do not consider this important in our context as heteroscedasticity does not threaten the causal interpretation of the regression result. The results from VIF and BP can be found in the Appendix. Lastly, the variables are also tested for stationary. Using daily returns or daily changes for the variables is the equivalent of taking the first difference of the level value of each variable. The variables are stationary according to the Augmented Dickey-Fuller (ADF), Philip-Perron (PP), and Kwiatkowski–Phillips–Schmidt–Shin (KPSS) test.

5.3 Portfolio Optimization Data

To perform the portfolio optimization and the Fama-French Five-Factor model, the data in this study have been extracted from several sources. The sources and descriptions of the data are given below. Bitcoin and gold will not be included as they have been discussed previously.

Corp_Bond represents the Invesco Euro Corporate Bond with the ticker symbol PSFE. The data is collected from Investing.com and it origins from the German stock exchange Xetra (Investing.com, 2021a). It has approximately 95% allocated to bonds, about 5% in convertible bonds, and 0.25% in cash holdings. Over 75% of its bonds are allocated to European Developed countries and around 20% to North America. Its high exposure to

Developed Markets in Europe is the reason we use this as a proxy for the corporate bond markets.

As a proxy for the forex market, the *Euro Index* with ticker name "inveur" is used. The source of this index is Investing.com and represents the arithmetic relationship between major and highly liquid currencies against the euro. Some of the currencies used in this index are JPY, USD, GBP, and CHF (Investing.com, 2021b).

SP500 is the Standard & Poor's 500 Index for the U.S. stock market and has the ticker GSPC. It is collected from Yahoo Finance (2021k) and consists of a mixture of the largest companies from NYSE, Nasdaq, and Cboe. The index weights the companies based on their market value divided by the total market value (S&P 500 Global, 2021). More specifically, the market value of the company is based on the tradable public shares. This index is well-diversified and widely used as a benchmark both for the U.S. and the global stock market.

FTSE is an index of the 100 biggest companies on the London Stock Exchange and is used as a proxy for the UK stock market. The prices are extracted from Yahoo Finance (2021e).

DAX prices are collected from Yahoo Finance (2021c) and is listed on the German stock exchange Xetra with the ticker name GDAXI. The index consists of 30 large stocks and a big share of Germany's GDP comes from companies in DAX (CFI, 2021). It is a popular index used as a proxy for the German stock market.

Euronext is the Euronext 100 index with ticker N100 and the prices are collected from Yahoo Finance (2021d). The index is solely made out of stocks that are large in size, financially stable, and well established. It mostly consists of stocks that are listed on Euronext Paris and Euronext Amsterdam. It also consists of other Euronext-owned stock exchanges such as Belgium and Portugal. The stocks are chosen based on liquidity with a requirement of 20% of shares outstanding being traded in a rolling one-year period (Euronext Paris, 2021).

EUR600 is an ETF called iShares STOXX Europe 600 and has the ticker EXSA.DE (Yahoo Finance, 2021j). It has a fixed number of 600 stocks from all small, mid, and large-capitalization companies across Europe (Justetf.com, 2021). 60% of its allocation is

in the United Kingdom, Switzerland, France, and Germany. The remaining percentage is allocated amongst 13 other countries including Scandinavian countries. The ETF has replicated the underlying assets and is one of the biggest ETF's in Europe. Due to its broad specter of countries and size of countries, *EUR600* is used as a proxy for the overall European stock market.

Real_ est represents the iShares STOXX Europe 600 Real Estate with the ticker EXI5.DE in Yahoo Finance (2021i). It is an ETF that invests in Europe-focused Real Estate Investment Trusts but also directly in real estate companies. This will therefore be the proxy for the European real estate market.

Emerging Markets represents the iShares MSCI Emerging Markets ETF with the ticker EEM from Yahoo Finance (2021h). The index is exposed to emerging markets, especially in Asia with the highest allocation being in Hong Kong followed by Taiwan, South Korea, and India. It consists of mostly large- and midcap companies and will be used as a proxy for emerging markets.

Technology represents the Ishares Stoxx 600 Euro Technology ETF and the data is extracted from Yahoo Finance (2021g). This index has over 75% invested in technology stocks in Europe and will be the proxy for the European technology market.

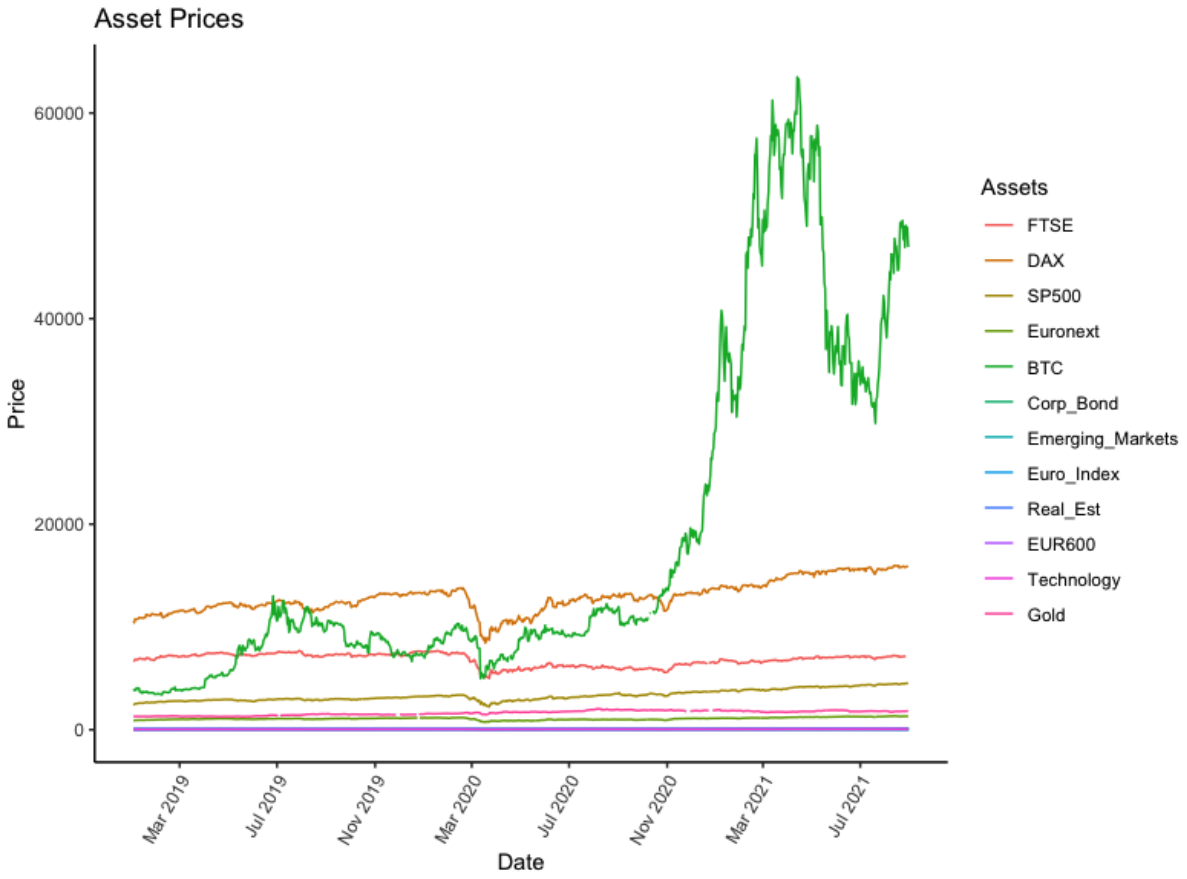
As a proxy for the risk-free rate, the three-year average of the risk-free return in Germany has been used. The average return is 0.833% and is extracted from Statista (Statista, 2021). With the largest economy in the eurozone, the risk-free rate in Germany acts as a good proxy for a European investor.

The Fama-French factors are extracted from Kenneth French's website (French, 2021). The five factors are explained previously in the *Theory* section.

5.3.1 Descriptive Statistics

Figure 5.2 shows the asset prices from 1 January 2019 to 31 August 2021:

Figure 5.2: Asset Prices



**Note:* This figure shows the asset prices from 1 January 2019 to 31 August 2021.

It is apparent that Bitcoin had the highest return and volatility out of all the assets. An interesting factor, apart from the COVID-19 stock market crash, is that Bitcoin also had another crash in May 2021 where it fell around 50%. This crash is tied to a combination of Elon Musk's Twitter critics about Bitcoin's impact on the climate and environment, China reinforcing its standpoint against cryptocurrencies, and highly leveraged market leading to a cascade of liquidations (Jain, 2021).

Table 5.1 shows that the mean for Bitcoin was considerably higher than all the other assets. The annualized return corresponded to 236%. This is considerably higher than all the other assets. However, Bitcoin also had the highest standard deviation. The biggest

drawdown was almost a 40% decrease in single day, which occurred during the crash in March 2020. Nonetheless, Bitcoin had the highest Sharpe ratio with around 8.5%.

Table 5.1: Descriptive Statistics

	Min	Max	Mean	StdDev	SharpeRatio
FTSE	-0.108738	0.090530	0.000119	0.010697	0.008990
DAX	-0.122386	0.109759	0.000491	0.012038	0.038891
SP500	-0.119841	0.093828	0.000683	0.012219	0.054028
Euronext	-0.119722	0.081760	0.000435	0.011052	0.037294
BTC	-0.371695	0.187465	0.003333	0.038995	0.084887
Corp_Bond	-0.051852	0.030134	0.000073	0.002996	0.016745
EEM	-0.124792	0.075139	0.000371	0.012944	0.026898
Forex	-0.022367	0.018753	0.000193	0.002157	0.078891
Real_Est	-0.115086	0.082229	0.000332	0.010691	0.028919
EUR600	-0.122594	0.085375	0.000412	0.010401	0.037416
Tech	-0.097759	0.098724	0.000824	0.013042	0.061430
Gold	-0.049787	0.059477	0.000394	0.008815	0.042107

**Note:* This table shows the descriptive statistics of each asset. More specifically, the minimum and the maximum value, mean, standard deviation, and Sharpe ratio.

5.3.2 Correlation

To maximize the diversification benefits, investors should reduce the correlation between the returns of the assets in their portfolio (CPI, 2019). From Table 5.2 below, we can see that, apart from forex, Bitcoin had the lowest correlation with all the other assets. Therefore, Bitcoin will be able to reduce the unsystematic risk and give diversification benefits during the period analyzed.

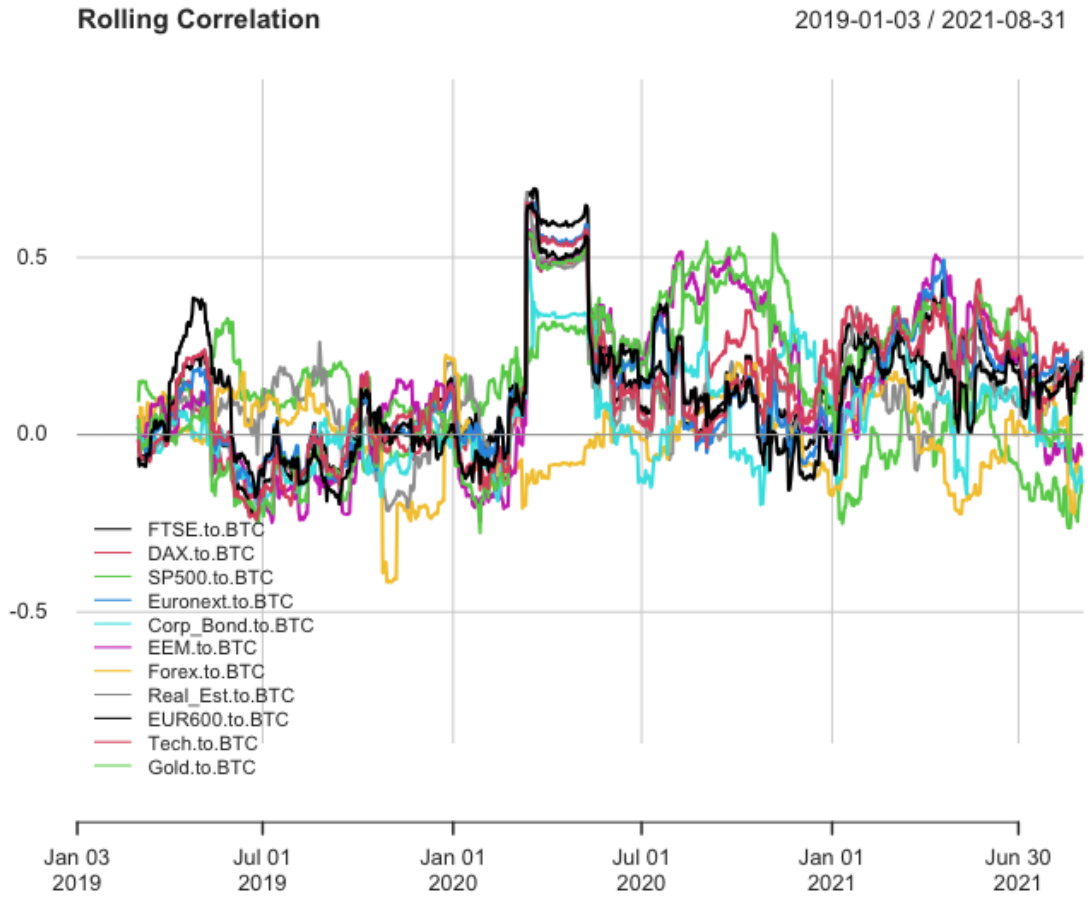
Table 5.2: Correlation Table

	FTSE	DAX	SP500	Euronext	BTC	Corp Bond	EEM	Forex	Real Est	EUR 600	Tech	Gold
FTSE	1.0000	0.8552	0.6518	0.9049	0.1957	0.3978	0.6437	-0.0531	0.6619	0.9034	0.7106	0.0715
DAX	0.8552	1.0000	0.6572	0.9466	0.2090	0.4622	0.6307	-0.0477	0.7349	0.9511	0.8486	0.0800
SP500	0.6518	0.6572	1.0000	0.6712	0.2354	0.3821	0.8259	-0.0279	0.4859	0.6972	0.5947	0.1103
Euronext	0.9049	0.9466	0.6712	1.0000	0.2174	0.4979	0.6797	-0.0570	0.7568	0.9699	0.8405	0.0578
BTC	0.1957	0.2090	0.2354	0.2174	1.0000	0.1407	0.2176	-0.0152	0.1914	0.2311	0.1980	0.1265
Corp_Bond	0.3978	0.4622	0.3821	0.4979	0.1407	1.0000	0.4127	-0.0366	0.5512	0.4762	0.4245	0.2495
EEM	0.6437	0.6307	0.8259	0.6797	0.2176	0.4127	1.0000	-0.0168	0.4789	0.6731	0.6243	0.1371
Forex	-0.0531	-0.0477	-0.0279	-0.0570	-0.0152	-0.0366	-0.0168	1.0000	-0.0441	-0.0538	-0.0344	0.0326
Real_Est	0.6619	0.7349	0.4859	0.7568	0.1914	0.5512	0.4789	-0.0441	1.0000	0.7588	0.6458	0.1327
EUR600	0.9034	0.9511	0.6972	0.9699	0.2311	0.4762	0.6731	-0.0538	0.7588	1.0000	0.8396	0.0550
Tech	0.7106	0.8486	0.5947	0.8405	0.1980	0.4245	0.6243	-0.0344	0.6458	0.8396	1.0000	0.0983
Gold	0.0715	0.0800	0.1103	0.0578	0.1265	0.2495	0.1371	0.0326	0.1327	0.0550	0.0983	1.0000

**Note:* This figure shows a correlation table of the assets. Bitcoin is marked with yellow.

One weakness of only using a correlation table is that correlations between assets in the real world do not remain constant. We have therefore included rolling correlations in figure 5.3. One period that stands out is the crash in March 2020, where almost all assets had a big drawdown. During this period, the correlation between Bitcoin and all other assets spiked up, except forex. Apart from this period, the correlation seemed to be relatively stable.

Figure 5.3: Rolling Correlation



**Note:* This figure shows the 60-day rolling correlation between Bitcoin and the other indexes.

5.4 Portfolio Optimization Methodology

5.4.1 Time Period, Different Lengths, and Daily Data

The pandemic have lasted around 1.5 years, and having approximately the same time period before the pandemic, seemed to be the most reasonable to isolate the pandemic. For that reason, the analysis period of the portfolio optimization is from 1 January 2019 to 31 August 2021.

A challenge that arose from doing portfolio optimizations with traditional indexes and Bitcoin was different lengths of data. Bitcoin was trading seven days a week throughout the year, while the other indexes were trading five days a week in addition to being subject to different holidays. Omitting Bitcoin prices during weekends and holidays would result in over 100 omitted observations yearly. Since Bitcoin was the main focus of this analysis, we decided to keep Bitcoin's return unchanged. This was dealt with by keeping the return at zero throughout the weekend and holidays for the other indexes.

The short time span of two years and the focus on Bitcoin which trades 24/7 makes it convenient to use daily data instead of weekly or monthly. Weekly or monthly observations would only consist of 52 or 12 observations yearly in comparison to daily data of 365. This would result in less accurate estimations of expected return and risk.

5.4.2 Simple vs Log Return

The returns used in the portfolio optimization are simple returns. The reason for this is because we can not use the weighted average of log-returns for different assets, and use that as the return of the portfolio. This is because log-return is a compounded rate of return. The same logic applies to *beta* in CAPM because the derivation of the CAPM is based on portfolio returns formed as the weighted average of asset returns. In addition, the difference between simple returns and log-returns increases as the time period increases. With a time period of only two years, the difference would probably be insignificant. In fact, we ran the portfolio optimization with both methods which led to almost identical results.

5.4.3 Portfolio Constructions

To examine the diversification benefits of Bitcoin in a well-diversified portfolio during the pandemic, different scenarios with different constraints were created. One of the reasons for doing this is because the theoretical best portfolio does not necessarily translates to the best practical portfolio. In addition, investors have different attitudes towards risk and some might have a constraint of the amount they can allocate to Bitcoin.

5.4.3.1 Scenario 1: Tangent Portfolio

The Tangent Portfolio is the portfolio that gives the highest Sharpe ratio. In this scenario, no shorting is allowed. This scenario is created to give an insight to the theoretically most optimal portfolio. However this portfolio does not take into account the practical issue of overexposing by allocating too much to certain assets.

5.4.3.2 Scenario 2: Restricted Tangent Portfolio

The Restricted Tangent Portfolio is the tangent portfolio with a constraint of maximum 20% on any given asset, where shorting is not allowed. This scenario is a more realistic scenario as the tangent portfolio allocates a disproportional big amount into certain assets.

5.4.3.3 Scenario 3: Semi-Restricted BTC Tangent Portfolio

This portfolio is the same as the portfolio in scenario 2 in addition that Bitcoin can only have a maximum of 5% allocation. A lot of institutions and investors have an upper limit on how much they want or are able to invest in Bitcoin. This scenario can therefore show an even more realistic view than scenario 2.

5.4.3.4 Scenario 4: Restricted BTC Tangent Portfolio

Scenario 4 includes an even more restricted portfolio with only a maximum of 1% allocation in BTC. With the same argument as scenario 3, some institutions and investors are only willing to invest a maximum of 1% into BTC.

5.4.3.5 Scenario 5: Minimum Variance Portfolio

The Minimum Variance Portfolio (MVP) is the portfolio that has the least amount of risk where shorting is not allowed in this scenario. This portfolio is most suitable for investors that are risk-averse and was created to see the theoretical portfolio with the least amount of risk given that shorting is not possible.

5.4.3.6 Scenario 6: Restricted Minimum Variance Portfolio

The Restricted Minimum Variance Portfolio is the minimum variance portfolio with a maximum of 20% allocation in any asset. This scenario was created to give a more realistic minimum variance portfolio. Similar to the tangent portfolio, MVP is likely to suffer from overexposing.

5.4.3.7 Scenario 7: Short Tangent Portfolio

The Short Tangent Portfolio is the tangent portfolio where shorting is allowed. A maximum of 100% for both longs and shorts is permitted. With the same logic as in scenario 1, we wanted to have an insight on the theoretical best portfolio. However, this portfolio would likely give an even higher Sharpe ratio because shorting is allowed.

5.4.3.8 Scenario 8: Restricted Short Tangent Portfolio

To make the short tangent portfolio more realistic, a 20% restriction for both longs and shorts was added.

5.4.3.9 Scenario 9: Short MVP

We also wanted to create a minimum variance portfolio where shorting was allowed. This portfolio will have the theoretically lowest risk of all the portfolios.

5.4.3.10 Scenario 10: Restricted Short MVP

Again, to make scenario 9 more realistic, a 20% restriction was placed on each asset for the Restricted Short MVP.

6 Results and Analysis

6.1 OLS Regression

The OLS results are given by the following table:

Table 6.1: Regression Results

	Dependent variable:			
	BTC Period 1	BTC Period 2	BTC Period 3	BTC Period 4
	(1)	(2)	(3)	(4)
New_cases_t	0.0001 (0.001)	−0.014 (0.020)	0.011 (0.021)	0.051 (0.031)
Exp_infl_t	−0.232** (0.089)	−0.074 (0.140)	0.088 (0.216)	−0.194 (0.291)
$F\&G_t$	0.012 (0.026)	−0.031 (0.028)	−0.028 (0.026)	−0.027* (0.016)
VIX_t	−0.229*** (0.044)	−0.077** (0.034)	−0.155*** (0.038)	−0.097 (0.072)
$Gold_t$	1.089*** (0.323)	0.894*** (0.229)	0.002 (0.351)	−1.058* (0.634)
$Dollar_t$	0.371 (0.981)	−1.894** (0.724)	−1.353 (1.229)	−3.191* (1.733)
$Constant_t$	0.005 (0.005)	0.001 (0.002)	0.009*** (0.003)	−0.001 (0.004)
Observations	99	123	181	122
R^2	0.318	0.237	0.132	0.100
Adjusted R^2	0.273	0.198	0.102	0.053

*p<0.1; **p<0.05; ***p<0.01
Note: This table shows the regression result in period 1, 2, 3, and 4.

The results in table 6.1 show that new cases have minimal impact on Bitcoin's return in all four periods. In addition, the coefficients are all insignificant. These results are similar to what Vukovic et al. (2021) found through their COVID19-index for the first COVID-19 wave. In addition, the OLS results show that new cases have no significant impact on Bitcoin in the following Period 2, 3, and 4.

Expected inflation has a negative coefficient in Period 1 and is significant at the 5%-level.

This means that if the return of expected inflation rises by 1%, Bitcoin will decrease by 0.232%. Some investors still look at Bitcoin as an inflation hedge which would imply a positive coefficient, but our result in Period 1, where the COVID-19 market crash occurred, suggests otherwise.

The Fear&Greed index has minimal impact on Bitcoin in all periods and is at most significant at the 10%-level in Period 4. This indicates that the Fear&Greed index does not has any significant impact on Bitcoin and investors should therefore be careful to rely on this index as an indicator.

VIX has negative coefficients of -0.229, -0.077, -0.155, and -0.097 for Period 1, 2, 3, 4 respectively. The coefficients are significant for all periods except the last period, and was at its highest in Period 1. This is consistent with what one would expect as the first period was the period with the most uncertainty. An interesting factor to note, is that VIX has a low and insignificant coefficient in Period 4. This could imply that VIX is more relevant during highly uncertain times, and less relevant during times with more stability.

In Period 1 and 2, gold has significant coefficients of 1.089 and 0.894 respectively. This implies that gold and Bitcoin moved very similarly during the most uncertain times, and indicates that also gold did not act as a safe haven during these periods. In Period 3, gold's coefficient is close to zero, and in Period 4 the coefficient turned negative. Both these coefficients are insignificant, which implies that gold lost its significant impact on Bitcoin as time passed during the pandemic.

Apart from Period 1, the dollar had negative coefficients in all periods. However, the dollar was only significant at the 5%-level in Period 2. With a coefficient of -1.894, this means that if the dollar goes up by 1%, Bitcoin will decrease with 1.894%. It is interesting to note that the coefficient is relatively lower in Period 4 with a value of -3.191. In other words, if the return of dollar rises by 1%, Bitcoin's return would decrease by -3.191%. However, this coefficient is only significant at the 10%-level. All things considered, it would still be interesting to keep track of this relationship as Bitcoin further adopts.

The table also shows that the R-adjusted gradually decrease throughout the periods. In theory this means that the variables gradually explain less of Bitcoin's performance. It is important to mention that even though R-squared in an OLS regression is low, it does

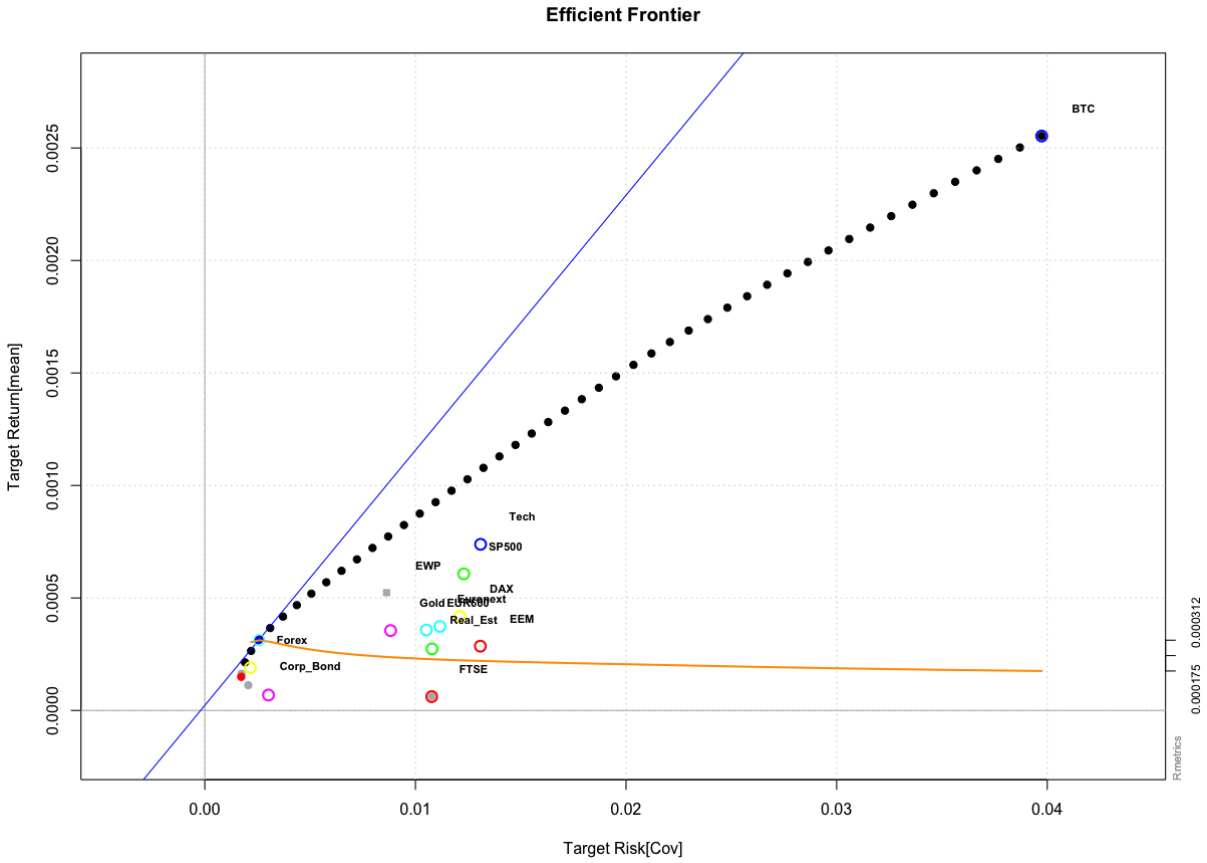
not mean that the regression output itself is bad (Wooldridge, 2018, p. 128). The use of R-squared or R-adjusted to determine if a model is good or bad can therefore be a vague indicator.

6.2 Portfolio Optimization

As concluded from the OLS analysis above, Bitcoin's return was affected by certain factors during the pandemic. We therefore wanted to examine the diversification benefits of Bitcoin in well-diversified portfolios during this period. This analysis consists of portfolio optimization for 10 different scenarios and the construction of these portfolios is described in detail under the methodology section. The analysis compares the portfolios on the basis of daily returns, standard deviation, and Sharpe ratio, with and without Bitcoin. The risk-free rate is also incorporated. The portfolio optimization is found through the use of the package "ROI" in R.

Figure 6.1 below presents a graphical illustration of the tangent and minimum variance portfolio where no shorting are allowed.

Figure 6.1: Capital Allocation



**Note:* This figure shows the graphical illustration of all the assets alongside the efficient frontier, the Tangent Portfolio, and the Minimum Variance Portfolio. The return is represented by the y-axis, and the standard deviation is represented by the x-axis.

The dotted line represents the efficient frontier. The spot where the blue line and the efficient is tangent is the Tangent Portfolio. This is marked with a light blue circle. The Minimum Variance Portfolio is represented by the red dot furthest to the left. These portfolios will be discussed further in detail below.

Table 6.2 further down shows that for all portfolios except the MVP, a portfolio with Bitcoin increases the return, standard deviation, and Sharpe ratio.

The Tangent Portfolio with Bitcoin in scenario 1 allocated 4% to Bitcoin and increased the return from 0.0256% to 0.0361%, the standard deviation from 0.2249% to 0.2793%, and the Sharpe ratio from 11.37% to 12.91%.

For The Restricted Tangent Portfolio, including Bitcoin almost doubled the return from 0.0411% to 0.0820%. The standard deviation increased from 0.536% to 0.7818%, and the Sharpe ratio increased from 7.66% to 10.36%. This means that the return increased relatively more than the risk, hence the considerably higher Sharpe ratio.

Since the Restricted Tangent Portfolio was shown to allocate 14.14% into Bitcoin, it is self-evident that the Semi-restricted and Restricted BTC Tangent portfolios would include the maximum allowed allocation of Bitcoin. Both the portfolios increased the return more than the standard deviation. In other words, including Bitcoin in these restricted portfolios increased the Sharpe ratio.

The only portfolios that did not include Bitcoin were the MVP portfolios where no shorts were allowed. This was expected as the increased return and Sharpe ratio of including Bitcoin, also came with increased risk.

Scenario 7 (The Short Tangent portfolio) allowed for 100% allocation to both the long and short side. This portfolio allocated 4.95% to Bitcoin, which is slightly higher than the Tangent Portfolio. The return increased from 0.0484% to 0.0618%, the standard deviation from 0.3560% to 0.4037%, and the Sharpe ratio from 13.60% to 15.31%. This is the portfolio with the highest Sharpe ratio, but as stated earlier, this portfolio is a theoretical portfolio that is not practical.

The Short Tangent Portfolio becomes more realistic when 20% constraints are implemented for longs and shorts. In this scenario, 12.76% was allocated to Bitcoin. Similar to the Tangent Portfolio, the return almost doubled from 0.0463% to 0.0841%, while the standard

deviation only increased from 0.5368% to 0.7388%. This corresponded to an increase in Sharpe ratio from 8.63% to 11.39%.

Allowing for shorting in the minimum variance portfolios resulted in an insignificantly small allocation to Bitcoin. In addition, including these small allocations to Bitcoin resulted in a lower Sharpe ratio.

These results suggest that Bitcoin offered diversification benefits for a risk-seeking investor, but not for the risk-averse investor, during the pandemic. For all the portfolios except the portfolios that minimized risk, including Bitcoin increased the Sharpe ratio. The Short Tangent Portfolio with Bitcoin had the highest theoretical Sharpe ratio of 15.31%, but the more realistic portfolios; the Restricted Tangent, The Semi-restricted BTC Tangent, and the Restricted BTC Tangent Portfolio had a Sharpe ratio of 10.36%, 9.54%, and 8.13% respectively. These results might also suggest that Bitcoin is more established now as an alternative investment because it managed to increase the Sharpe ratio for well-diversified portfolios, even during the pandemic.

Table 6.2: Portfolio Optimization

Portfolios		BTC	Mean	StdDev	Sharpe Ratio
Tangent	With BTC	4,00 %	0,0361 %	0,2793 %	12,91 %
	Without BTC		0,0256 %	0,2249 %	11,37 %
Resctricted Tangent (20%)	With BTC	14,14 %	0,0820 %	0,7918 %	10,36 %
	Without BTC		0,0411 %	0,5360 %	7,66 %
Semi-restricted BTC (5%) tangent	With BTC	5,00 %	0,0543 %	0,5691 %	9,54 %
	Without BTC		0,0411 %	0,5360 %	7,66 %
Restricted BTC Tangent (1%)	With BTC	1,00 %	0,0437 %	0,5375 %	8,13 %
	Without BTC		0,0411 %	0,5360 %	7,66 %
MVP	With BTC		0,0152 %	0,1719 %	8,86 %
	Without BTC		0,0152 %	0,1719 %	8,86 %
Restricted MVP (20%)	With BTC		0,0266 %	0,4745 %	5,60 %
	Without BTC		0,0266 %	0,4745 %	5,60 %
Short Tangent (+/- 100%)	With BTC	4,95 %	0,0618 %	0,4037 %	15,31 %
	Without BTC		0,0484 %	0,3560 %	13,60 %
Short Tangent Restricted +/-(20%)	With BTC	12,76 %	0,0841 %	0,7388 %	11,39 %
	Without BTC		0,0463 %	0,5368 %	8,63 %
Short MVP (+/- 100%)	With BTC	-0,003 %	0,0129 %	0,1672 %	7,71 %
	Without BTC		0,0130 %	0,1672 %	7,76 %
Short MVP Restricted (+/- 20%)	With BTC	-0,44 %	0,0228 %	0,4593 %	4,97 %
	Without BTC		0,0241 %	0,4596 %	5,23 %

**Note:* This table shows the 10 portfolios with and without Bitcoin. The mean, standard deviation, and the Sharpe ratio are also presented.

6.2.1 Fama-French Five-Factor Model

The portfolio optimization is based on the framework of CAPM and assumes that the portfolio returns only come from the market risk factor. To control for this, the Fama-French Five-Factor Model is utilized by regressing the daily returns of each portfolio against the Fama-French factors. The results are as follows:

Table 6.3: Portfolio Returns regressed against Fama-French Five Factors

	Dependent variable:									
	Port 1	Port 2	Port 3	Port 4	Port 5	Port 6	Port 7	Port 8	Port 9	Port 10
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mkt.RF	0.150***	0.454***	0.391***	0.375***	0.026***	0.258***	0.218***	0.421***	0.015***	0.246***
	(0.017)	(0.040)	(0.021)	(0.012)	(0.005)	(0.011)	(0.020)	(0.037)	(0.005)	(0.012)
SMB	0.118***	0.275***	0.168***	0.094***	0.029***	0.057**	0.097**	0.240***	0.027**	0.016
	(0.035)	(0.082)	(0.043)	(0.024)	(0.011)	(0.023)	(0.041)	(0.077)	(0.011)	(0.024)
HML	−0.095***	−0.192**	−0.122***	−0.080***	0.008	0.016	−0.141***	−0.170**	0.007	0.016
	(0.030)	(0.071)	(0.037)	(0.021)	(0.010)	(0.020)	(0.035)	(0.066)	(0.010)	(0.021)
RMW	−0.126**	−0.225*	−0.111*	−0.017	−0.026	−0.022	−0.123*	−0.229*	−0.025	−0.047
	(0.056)	(0.129)	(0.067)	(0.038)	(0.018)	(0.036)	(0.064)	(0.121)	(0.018)	(0.037)
CMA	0.132*	0.167	0.072	0.008	−0.025	0.014	0.156*	0.154	−0.012	0.051
	(0.069)	(0.161)	(0.084)	(0.047)	(0.022)	(0.045)	(0.080)	(0.151)	(0.022)	(0.047)
Constant	0.0004*	0.001*	0.0005	0.0002	0.0001	0.00004	0.001**	0.001*	0.0001	0.00001
	(0.0002)	(0.001)	(0.0003)	(0.0002)	(0.0001)	(0.0002)	(0.0003)	(0.001)	(0.0001)	(0.0002)
Observations	644	644	644	644	644	644	644	644	644	644
R^2	0.154	0.213	0.404	0.654	0.080	0.505	0.197	0.209	0.044	0.451
Adjusted R^2	0.147	0.207	0.400	0.651	0.073	0.502	0.190	0.203	0.036	0.447

*p<0.1; **p<0.05; ***p<0.01

Note: This table shows each of the 10 portfolios regressed against the Fama-French Five-Factors. Portfolio 1 to 10 represents the portfolios in the respective scenarios 1 to 10. The Constant represents the alpha or the abnormal returns.

The regression output from Table 6.3 shows that only portfolio 7 had a significant constant at the 5%-level. In other words, the Short Tangent Portfolio was the only portfolio that generated abnormal returns. However, this return was relatively low at 0.001%. All of the portfolios had a positive coefficient of the systematic risk factor "Mkt.RF" and was significant at the 1%-level. In other words, all the portfolios was positively exposed to the market risk factor. However, all portfolios except portfolio 10 (the Restricted Short

MVP), can be explained by more than just the market risk factor.

The size factor SMB was present for all the portfolios except portfolio 10, and all the coefficients were positive. In other words, the return of smaller firms was higher than the returns of bigger firms. Another way to look at this is that the portfolios were betting on smaller firms.

Portfolio 1, 2, 3, 4, 7, and 8; the Tangent, Restricted Tangent, Semi-restricted BTC Tangent, Short Tangent, and Restricted Short Tangent Portfolio, was exposed to the value factor HML. These coefficients were negative, which mean that the portfolios were betting on low book-to-market firms.

The profitability factor RMW was only present for Portfolio 1, the Tangent Portfolio. With a negative coefficient, this portfolio was betting on weak firms.

None of the portfolios had a significant coefficient for CMA and was therefore not exposed to the investment factor.

7 Discussion

The results show that Bitcoin's return was affected by certain factors during the pandemic, and the inclusion of Bitcoin in a well-diversified portfolio increased the Sharpe ratio of all portfolios except the minimum variance portfolios. However, there are some factors and weaknesses from this study that are important to discuss.

7.1 Wave Definition and Length of Data

In this study, the period for the OLS analysis was divided into four, based on the waves of global COVID-19 cases. A wave was defined as the period from a local bottom of cases to the next local bottom. A different definition of waves might have led to different time periods and different results. In addition, one might want to examine the pandemic by using a whole period instead of dividing it into "waves". This might lead to different results and conclusions as well.

The analysis of portfolio optimization had a time period from the start of 2019 to the end of August 2021. In addition, the return of the indexes was held constant at zero during the weekends and holidays to synchronize with Bitcoin. Using a different time period and method to synchronize the length of the data will affect the expected return and risk of the assets. This could lead to differences in the portfolio optimization results.

7.2 Historical Data

The expected return and volatility derived from MPT is based on historical data. Although valuable insights can be gained from historical data, past performances do not guarantee future performances. In reality, stocks can be affected by a variety of macroeconomic and local factors such as political uncertainty, industry trends, change in interest rates, and investors' market sentiment.

7.3 Measurement of Risk-adjusted Return

Sharpe ratio was used to measure the risk-adjusted return of the portfolios. The Sharpe ratio uses the standard deviation from both the upside and the downside as a measure of

total risk. This means that an asset can have frequent small losses and have the same variance as an asset that has a few extraordinary declines (Trading Education, 2021). Normally, this will attract different kinds of investors based on their appetite for risk, but the normal Sharpe ratio is not able to properly distinguish this. The Sharpe ratio also assumes normally distributed returns, but in financial markets, the distributions are normally skewed. This is especially true for Bitcoin that has a leptokurtic distribution with excess positive kurtosis (Swift, 2019). In addition, the standard deviation includes upside volatility. This might give a wrong view about the total risk as upside volatility does not affect the investors negatively. In Markowitz's paper (1959) he addressed that a semi-variance, that focuses on negative price fluctuations, would produce more efficient portfolios. A variation of the Sharpe ratio, called the Sortino ratio, was introduced by Sortino and Van Der Meer (1991) and takes into account that downside variance is a better measurement in investment decisions. It could therefore have been more reasonable to use this ratio instead.

7.4 Transaction Cost, Bid-Ask Spread, Borrowing/ Lending Rate

Since the study uses the framework of MPT, it does not take into account transaction cost, bid-ask spread, and the rate of borrowing/lending for investors. Transaction cost and bid-ask spread will occur for Bitcoin and all the other indexes, and investors are not able to borrow and lend at the same rate. By including these costs and differences, the results might have turned out differently.

7.5 Future of Bitcoin

As of writing, a new variant has emerged from COVID-19 called Omicron (WHO, 2021). There are signs suggesting that Omicron is more transmissible, but this has not been officially confirmed. Further, there is uncertainty in the severity of disease of the Omicron variant. This uncertainty has caused a lot of fear in the market. Although there are a lot of similarities between crises throughout history, each crisis is unique. Not only is COVID-19 a new type of virus that has never been seen before, but the increased

globalization also comes with a new and different macroeconomic environment. It is also important to note that investors are not likely to act rational during crisis. This goes against one of the assumptions of CAPM that all investors are rational.

While the pandemic has been ravaging the world, Bitcoin and cryptocurrency adoption has continued to increase. The biggest cryptocurrency exchange Coinbase was listed on Nasdaq in April 2021. In October 2021 the first Bitcoin ETF in the U.S. was listed in the New York Stock Exchange (Fox, 2021). The launch of ProShares Bitcoin Strategy ETF was the second biggest launch of all time in terms of volume. 24 million shares was traded and generated more than $1B of turnover. However, the ProShares Bitcoin Strategy ETF is based on bitcoin futures contracts, and not actual bitcoin prices. While the U.S. has not approved a Bitcoin Spot ETF yet, other countries like Australia (ASIC, 2021), Brasil (Oosterbaan and Kaloudis, 2021), Canada, Germany, Switzerland, and Singapore (Partz, 2021) have listed Bitcoin Spot ETF's in their country exchanges. In addition, as mentioned previously, El Salvador has also officially accepted Bitcoin as legal tender as of September 2021.

With more crypto-related companies being listed, Bitcoin ETF's getting approved around the world, and bitcoin being accepted as legal tender, the adoption and accessibility of Bitcoin and cryptocurrency will only continue to increase. While it is impossible to guarantee where the price of Bitcoin will go, it is certain that Bitcoin will be an alternative asset that more investors will consider investing in.

8 Conclusion

This study has analyzed if COVID-19 cases or other factors affected Bitcoin's return during the pandemic. Further, the diversification benefits of Bitcoin in a European, well-diversified portfolio during the pandemic were analyzed. This was done through the framework of Modern Portfolio Theory where 10 different scenarios were created. Lastly, the daily returns for each of the 10 portfolios were tested against the Fama-French Five-Factors.

In the first part, a general background to blockchain and Bitcoin, as well as the risk factors for investing in Bitcoin, were introduced. Further, this part presented the relevant literature review and theory applied in this study.

In the second part, the data and methodology for the analysis were presented. The first analysis was done by regressing the daily returns of Bitcoin against global COVID-19 cases, expected inflation, Fear&Greed Index, VIX, gold, and the dollar. This analysis was divided into four periods which represented the four waves of COVID-19 cases. The result was that both new daily cases and F&G had no significant impact on Bitcoin's return. Expected inflation only impacted Bitcoin in Period 1 during the COVID-19 crash, where it had a significant negative impact. This indicates that Bitcoin acted as a risk-on asset, similar to stocks. This is further supported by the negative relationship with VIX in all periods except the last. Gold and Bitcoin moved very similarly during the first two periods, but in the last two periods, gold no longer had a significant impact on Bitcoin. Lastly, Bitcoin often had a negative relationship with the dollar, where the coefficient was significantly negative in Period 2.

Since Bitcoin was impacted by certain factors during the COVID-19 crisis, this study analyzed the diversification benefits of Bitcoin in European, well-diversified portfolios during this period. 10 portfolios were created to give an insight to both the theoretical and practical optimized portfolios with Bitcoin. This study found that including Bitcoin significantly increased the risk-adjusted return for the portfolios. However, a risk-averse investor should not invest in Bitcoin, as none of the optimized minimum variance portfolios allocated anything to Bitcoin.

Lastly, the 10 portfolios were tested against the Fama-French Five-Factors. The study

found that all portfolios except portfolio 10, the Short MVP Restricted Portfolio, were not only exposed to the market risk factor, but also the size factor. Some of the portfolios were exposed to the value factor, and one was exposed to the profitability factor.

This study concludes both that Bitcoin was significantly affected during the pandemic, and that a well-diversified portfolio with Bitcoin had a higher risk-adjusted rate of return than one without Bitcoin. However, this was not the case for minimum variance portfolios. In other words Bitcoin did provide diversification for the risk-seeking investor, but not for the risk-averse investor. This study also found that most of the portfolio returns did not only come from the market risk factor, but also the size, value, and profitability factor.

References

Alternate.me (2021). Crypto fear greed index. Retrieved from: https://alternative.me/crypto/fear-and-greed-index/. Accessed: 2021-11-02.

Ammous, S. (2018). *The Bitcoin Standard*. John Wiley Sons, Inc., Hoboken, New Jersey.

Appelbaum, B. (2021). Bitcoin cosplay is getting real. Retrieved from: https://www.nytimes.com/2021/09/14/opinion/bitcoin-el-salvador.html. Accessed: 2021-10-28.

ASIC (2021). Asic consultation paper 343: Crypto-assets as underlying assets for etps and other investment products. Retrieved from: https://asic.gov.au/media/b20dhy3c/cp343-submission-fintech-australia.pdf.

Becker, S. (2021). Bitcoin hash rate and why it matters. Retrieved from: https://www.sofi.com/learn/content/bitcoin-hash-rate/. Accessed: 2021-11-29.

Berk, J. and DeMarzo, P. (2016). *Corporate Finance, eBook*. Pearson Higher Ed.

Binance (2019). What is a crypto wallet? Retrieved from: https://academy.binance.com/en/articles/crypto-wallet-types-explained. Accessed: 2021-11-01.

Binance (2020). Five reasons why you should be mining crypto with binance pool. Retrieved from: https://www.binance.com/en/blog/mining/five-reasons-why-you-should-be-mining-crypto-with-binance-pool-4214998246849006 01. Accessed: 2021-10-25.

Blandin, A., Pieters, G., Wu, Y., Eisermann, T., Dek, A., Taylor, S., and Njoki, D. (2020). 3rd global cryptoasset benchmarking study. *Cambridge Centre for Alternative Finance*. Retrieved from: https://www.jbs.cam.ac.uk/wp-content/uploads/2021/01/2021-ccaf-3rd-global-cryptoasset-benchmarking-study.pdf. Accessed: 2021-12-17.

Blockchain Block Explorer (2009). Summary; Included in Block: 0. Retrieved from: https://www.blockchain.com/btc/tx/4a5e1e4baab89f3a32518a88c31bc87f618f76673e2cc77ab2127b7afdeda33b. **Note: Copied HEX sigscript from input of first transaction. Converted this code from HEX to ASCII via https://www.rapidtables.com/convert/number/hex-to-ascii.html to find message.*

Blockchain.com (2021a). Network difficulty. Retrieved from: https://www.blockchain.com/charts/difficulty. Accessed: 2021-09-30.

Blockchain.com (2021b). Total hash rate (th/s). Retrieved from: https://www.blockchain.com/charts/hash-rate. Accessed: 2021-09-30.

BLS.gov (2021). Consumer price index summary. Retrieved from: https://www.bls.gov/news.release/cpi.nr0.htm.

Bls.gov (2021). Databases, tables calculators by subject: Unemployment rate. Retrieved from: https://data.bls.gov/timeseries/LNS14000000?amp\%253bdata_tool=XGtable&output_view=data&include_graphs=true. Accessed: 2021-10-10.

Bodie, Z., Kane, A., and Marcus, A. J. (2009). *Investments*. McGraw-Hill/Irwin, Boston.

Carhart, M. M. (1997). On persistence in mutual fund performance. *The Journal ofFinance,* 52(1):57–82. Retrieved from: https://doi.org/10.1111/j.1540-6261.1997.tb03808.x.

CBECI (2021a). Bitcoin mining map. cambridge bitcoin electricity consumption index. Retrieved from: https://cbeci.org/mining_map. Accessed: 2021-10-10.

CBECI (2021b). Bitcoin network power demand. cambridge bitcoin electricity consumption index. Retrieved from: https://ccaf.io/cbeci/index. Accessed: 2021-12-15.

CBOE (2021). Vix volatility suite. Retrieved from: https://www.cboe.com/tradable_products/vix/. Accessed: 2021-10-14.

CEX.IO LTD (2014). Ghash.io press release. Retrieved from: https://pressat.co.uk/media/uploads/deb1b38b9e57088f1bc6998ecc990810.pdf. Accessed: 2021-11-25.

CFI (2021). Dax stock index. Retrieved from: https://corporatefinanceinstitute.com/resources/knowledge/trading-investing/dax-stock-index/. Accessed: 2021-12-01.

CFTC (2021). U.s. commodity futures trading commission: Bitcoin basics. Retrieved from: https://www.cftc.gov/sites/default/files/idc/groups/public/\%40customerprotection/documents/file/oceo_bitcoinbasics0218.pdf. Accessed: 2021-11-22.

Chamberlain, G. (1983). A characterization of the distributions that imply mean—variance utility functions. *Journal of Economic Theory*, 29(1):185–201.

CME Group (2021). Comex. Retrieved from: https://www.cmegroup.com/company/comex.html. Accessed: 2021-11-18.

CoinMarketCap (2021a). About coinmarketcap. Retrieved from: https://coinmarketcap.com/about/. Accessed: 2021-12-06.

CoinMarketCap (2021b). Ethereum. Retrieved from: https://coinmarketcap.com/currencies/ethereum/. Accessed: 2021-12-10.

CoinMarketCap (2021c). Today's cryptocurrency prices by market cap. Retrieved from: https://coinmarketcap.com/. Accessed: 2021-12-18.

Conlon, T. and McGee, R. (2020). Safe haven or risky hazard? bitcoin during the covid-19 bear market. Retrieved from: https://www.sciencedirect.com/science/article/pii/S1544612320304244.

CPI (2019). Corporate finance institute; who is harry markowitz? Retrieved from: https://corporatefinanceinstitute.com/resources/knowledge/trading-investing/harry-markowitz/.

CPI (2021). Fiat money. Retrieved from: https://corporatefinanceinstitute.com/resources/knowledge/economics/fiat-money-currency/. Accessed: 2021-12-11.

Cryptopedia (2021). Crypto hacks and what we can learn from them. Retrieved from: https://www.gemini.com/cryptopedia/mt-gox-bitcoin-exchange-hacked. Accessed: 2021-11-01.

Euronext Paris (2021). Euronext 100 Index. Retrieved from: https://live.euronext.com/en/product/indices/FR0003502079-XPAR. Accessed: 2021-12-01.

Fama, E. F. and French, K. R. (1993). Common risk factors in the returns on stocks

and bonds. *Journal of Financial Economics,* 33(1), pp. 3–56. Retrieved from: https://doi.org/10.1016/0304-405X(93)90023-5.

Fama, E. F. and French, K. R. (2015). A five-factor asset pricing model. Retrieved from: https://www.sciencedirect.com/science/article/abs/pii/S0304405X14002323.

Fantazzini, D. and Kolodin, N. (2020). Does the hashrate affect the bitcoin price? *Journal of Risk and Financial Management*, 13(11).

Federal Reserve Bank of St. Louis (2021a). 5-year, 5-year forward inflation expectation rate [t5yifr]. Retrieved from: https://fred.stlouisfed.org/series/T5YIFR. Accessed: 2021-11-02.

Federal Reserve Bank of St. Louis (2021b). Board of governors of the federal reserve system (us), currency in circulation [currcir]. Retrieved from: https://fred.stlouisfed.org/series/CURRCIR. Accessed: 2021-12-12. Number of 20% calculated by taking money in circulation Nov 2021 divided by Jan 2020.

Federal Reserve Bank of St. Louis (n.d.). Functions of money - the economic lowdown podcast series. Retrieved from: https://www.stlouisfed.org/education/economic-lowdown-podcast-series/episode-9-functions-of-money.

Fisher, L. and Lorie, J. H. (1970). Some studies of variability of returns on investments in common stocks. *The Journal of Business*, 43(2):99–134.

Fox, M. (2021). Proshares' bitcoin futures etf sees the 2nd-heaviest debut volume on record with 24 million shares traded. Retrieved from: https://markets.businessinsider.com/news/currencies/proshares-bitcoin-fund-strong-demand-biggest-etf-launches-ever-2021-10. Accessed: 2021-11-03.

French, K. R. (2021). Current research returns. Retrieved from: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

Granger, C. W., Newbold, P., and Econom, J. (1974). Spurious regressions in econometrics. *Journal of econometrics*, 2:109–118.

Han, E. (2021). Econometrics, honor´s exam review session. Retrieved from: https://scholar.harvard.edu/files/economics/files/final_review_1123.pdf. Accessed: 2021-11-18.

Hertig, A. (2020a). Bitcoin halving, explained. Retrieved from: https://www.coindesk.com/learn/2020/03/24/bitcoin-halving-explained/. Accessed: 2021-10-25.

Hertig, A. (2020b). What is proof-of-work? Retrieved from: https://www.coindesk.com/learn/2020/12/16/what-is-proof-of-work/. Accessed: 2021-11-25.

Investing.com (2021a). Invesco Euro Corporate Bond UCITS ETF (PSFE). Retrieved from: https://za.investing.com/etfs/psfe-holdings. Accessed: 2021-10-18.

Investing.com (2021b). Investing.com Euro Index (inveur). Retrieved from: https://www.investing.com/indices/investing.com-eur-index-components. Accessed: 2021-10-18.

IRS (2021). Frequently asked questions on virtual currency transactions. Retrieved from: https://www.irs.gov/individuals/international-taxpayers/frequently-asked-questions-on-virtual-currency-transactions. Accessed: 2021-11-22.

Jaffer, S. K. S. (2021). The Impact of COVID-19 on Cryptocurrency: The Hedging Behaviour of Bitcoin. Retrieved from: https://ruor.uottawa.ca/handle/10393/41825.

Jain, R. (2021). Crypto roundup, 21 may 2021: Elon musk effect, crypto crash, bitcoin prices, $1 trillion wiped out and more. Retrieved from: https://www.businessinsider.in/cryptocurrency/news/a-massive-crash-in-cryptocurrency-prices-wiped-out-1-trillion-of-wealth-reports-suggest/articleshow/82829155.cms. Accessed: 2021-11-31.

Jensen, M. C. (1968). The performance of mutual funds in the period 1945-1964. *The Journal of Finance,* pp. 23(2):389–416. Retrieved from: http://www.jstor.org/stable/2325404. Accessed: 2021-12-16.

Jones, D. (2021). Global electricity review 2021. *EMBER*. Retrieved from: https://ember-climate.org/wp-content/uploads/2021/03/Global-Electricity-Review-2021.pdf. Accessed: 2021-12-14.

Justetf.com (2021). iShares STOXX Europe 600 UCITS ETF (DE). Retrieved from: https://www.justetf.com/en/etf-profile.html?isin=DE0002635307#overview. Accessed: 2021-12-01.

Kaplan, P. D. (2021). In long history of market crashes, coronavirus crash was the shortest. Retrieved from: https://www.morningstar.com/articles/1028407/in-long-history-of-market-crashes-coronavirus-crash-was-the-shortest. Accessed: 2021-10-18.

Kumar, A. S. (2020). Testing Safe Haven Property of Bitcoin and Gold during Covid-19 : Evidence from Multivariate GARCH analysis. Retrieved from: https://ideas.repec.org/a/ebl/ecbull/eb-20-00540.html. Accessed: 2021-11-25.

Markowitz, H. (1952). Portfolio selection. *Naval Research Logistics Quarterly,* 3(1-2):111–133. Retrieved from: http://www.jstor.org/stable/2975974.

Markowitz, H. (1956). The optimization of a quadratic function subject to linear constraints. *Naval Research Logistics Quarterly,* 3(1-2):111–133. Retrieved from: https://doi.org/10.1002/nav.3800030110.

Markowitz, H. M. (1959). Portfolio selection: Efficient diversification of investments. yale university press. Retrieved from: http://www.jstor.org/stable/j.ctt1bh4c8h. Accessed: 2021-09-30.

McCormick, L. C. (2021). Favorite bond market inflation gauge set to 'cross the rubicon'. Retrieved from: https://www.bnnbloomberg.ca/favorite-bond-market-inflation-gauge-set-to-cross-the-rubicon-1.1664815?fbclid=IwAR10Lb5qNfTyqgyTFixrQhFKNLjEx80UqcTojS5Mj4-nU6ryEay3CnM1B_w. Accessed: 2021-11-11.

Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. Retrieved from: https://bitcoin.org/bitcoin.pdf. Accessed: 2021-10-09.

NobelPrize.org (1990). The nobel prize in economic sciences. Retrieved from: https://www.nobelprize.org/prizes/economic-sciences/1990/press-release/. Accessed: 2021-10-02.

Oosterbaan, E. and Kaloudis, G. (2021). Bitcoin etfs aren't new. here's how they've fared outside the us. Retrieved from: https://www.coindesk.com/markets/2021/10/20/bitcoin-etfs-arent-new-heres-how-theyve-fared-outside-the-us/.

Partz, H. (2021). Two bitcoin funds launched in singapore by mas-regulated fund manager. Retrieved from: https://www.coindesk.com/markets/2021/10/20/bitcoin-etfs-arent-new-heres-how-theyve-fared-outside-the-us/.

Perold, A. F. (2004). The capital asset pricing model. *Journal of Economic Perspectives,* 18 (3): 3-24. Retrieved from: http://www.jstor.org/stable/3216804. Accessed: 2021-10-02.

Presidencia de la República de El Salvador (2021). El presidente nayib bukele impulsa la economía hacia un mejor futuro, más allá de voces anacrónicas que buscan infundir temor en la población. retrieved from: https://www.presidencia.gob.sv/el-presidente-nayib-bukele-impulsa-la-economia-hacia-un-mejor-futuro-mas-alla-de-voces-anacronicas-que-buscan-infundir-temor-en-la-poblacion/. Translated from Spanish to English. Accessed: 2021-10-28.

Ritchie, H., Mathieu, E., Rodés-Guirao, L., Appel, C., Giattino, C., Ortiz-Ospina, E., Hasell, J., Macdonald, B., Beltekian, D., and Roser, M. (2020). Coronavirus pandemic (covid-19). *Our World in Data*. Retrieved from: https://ourworldindata.org/coronavirus. Accessed: 2021-10-15.

River Financial (2021a). How do macroeconomic events affect bitcoin? Retrieved from: https://river.com/learn/how-do-macro-events-affect-bitcoin/. Accessed: 2021-11-10.

River Financial (2021b). Sending and receiving bitcoin. Retrieved from: https://river.com/learn/how-do-i-send-and-receive-bitcoin/. Accessed: 2021-12-02.

River Financial (2021c). What is a blockchain? Retrieved from: https://river.com/learn/what-is-a-blockchain/. Accessed: 2021-11-12.

River Financial (2021d). Why does bitcoin have value? Retrieved from: https://river.com/learn/why-do-bitcoin-have-value/. Accessed: 2021-11-12.

River Financial (2021e). Why should i run a bitcoin node? Retrieved from: https://river.com/learn/why-should-i-run-a-bitcoin-node/. Accessed: 2021-10-25.

SEC (2021). President's working group report on stablecoins. Retrieved from: https://www.sec.gov/news/statement/gensler-statement-presidents-working-group-report-stablecoins-110121.

Sharpe, W. F. (1966). Mutual fund performance. *The Journal of Business,* 39(1):119–138. Retrieved from: http://www.jstor.org/stable/2351741. Accessed: 2021-10-02.

Sortino, F. A. and Van Der Meer, R. (1991). Downside risk. *Journal of portfolio Management,* 17(4), 27. Retrieved from: https://www.proquest.com/openview/9698ae2e5a7f9005e71bb5a931a7ac96/1?pq-origsite=gscholar&cbl=49137. Accessed: 2021-11-02.

S&P 500 Global (2021). S&P 500. Retrieved from: https://www.spglobal.com/spdji/en/indices/equity/sp-500/#overview. Accessed: 2021-12-03.

Statista (2021). Average risk free rate (rf) of investment in germany from 2015 to 2021. Retrieved from: https://www.statista.com/statistics/885774/average-risk-free-rate-germany/. Accessed: 2021-11-01.

Swift, C. (2019). Kurtosis and bitcoin: A quantitative analysis. Retrieved from: https://hackernoon.com/kurtosis-and-bitcoin-uc55n3w5x. Accessed: 2021-10-29.

The People's Bank of China (2021). Notice on further preventing and disposing of the risk of hype in virtual currency trading. Retrieved from: http://www.pbc.gov.cn/goutongjiaoliu/113456/113469/4348521/index.html. Translated from Chinese to English. Accessed: 2021-10-20.

The World Bank (2018). Blockchain distributed ledger technology (dlt). Retrieved from: https://www.worldbank.org/en/topic/financialsector/brief/blockchain-dlt. Accessed: 2021-11-25.

Trading Education (2021). What is modern portfolio theory advantages and disadvantages. Retrieved from: https://trading-education.com/what-is-modern-portfolio-theory-advantages-and-disadvantages. Accessed: 2021-11-08.

Vries, A. and Stoll, C. (2021). Bitcoin's growing e-waste problem. *Resources,Conservation and Recycling, 175:105901.* Retrieved from: https://doi.org/10.1016/j.resconrec.2021.105901. Accessed: 2021-12-15.

Vukovic, D., Maiti, M., Grubisic, Z., Grigorieva, E. M., and Frömmel, M. (2021). Covid-19 pandemic: Is the crypto market a safe haven? the impact of the first wave. Retrieved from: https://www.mdpi.com/2071-1050/13/15/8578/htm. Accessed: 2021-11-22.

Whaley, R. E. (2009). Understanding the vix. *The Journal of Portfolio Management,*35(3):98–105. institutional investor journals umbrella. Retrieved from: https://jpm.pm-research.com/content/35/3/98. Accessed: 2021-10-31.

WHO (2021). Update on omicron. Retrieved from: https://www.who.int/news/item/28-11-2021-update-on-omicron.

Wilks, A. (2021). For the ruined, turkey's crypto crackdown comes too late. Retrieved from: https://www.aljazeera.com/economy/2021/5/5/for-the-ruined-turkeys-crypto-crackdown-comes-too-late. Accessed: 2021-10-27.

Wooldridge, J. M. (2018). *Introductory Econometrics: A Modern Approach.* Cengage learning, Inc.

Yahoo Finance (2021a). Bitcoin USD (BTC-USD). Retrieved from: https://finance.yahoo.com/quote/BTC-USD/. Accessed: 2021-10-14.

Yahoo Finance (2021b). Bitcoin USD (BTC-USD). Retrieved from: https://finance.yahoo.com/quote/BTC-USD/. Accessed: 2021-10-14.

Yahoo Finance (2021c). DAX PERFORMANCE-INDEX (GDAXI). Retrieved from: https://finance.yahoo.com/quote/\%5EGDAXI/. Accessed: 2021-12-01.

Yahoo Finance (2021d). Euronext 100 Index (N100). Retrieved from: https://finance.yahoo.com/quote/\%5EN100?p=^N100&.tsrc=fin-srch. Accessed: 2021-12-01.

Yahoo Finance (2021e). FTSE 100 (FTSE). Retrieved from: https://finance.yahoo.com/quote/\%5EFTSE/. Accessed: 2021-12-01.

Yahoo Finance (2021f). Gold Dec 21 (GC=F). Retrieved from: https://ca.finance.yahoo.com/quote/GC\%3DF?p=GC\%3DF. Accessed: 2021-10-18.

Yahoo Finance (2021g). ishares (de) i - ishares stoxx europe 600 technology ucits etf (de). Retrieved from: https://finance.yahoo.com/quote/EXV3.DE/. Accessed: 2021-11-01.

Yahoo Finance (2021h). iShares MSCI Emerging Markets ETF (EEM). Retrieved from: https://finance.yahoo.com/quote/EEM?p=EEM. Accessed: 2021-11-05.

Yahoo Finance (2021i). iShares STOXX Europe 600 Real Estate UCITS ETF (DE) (EXI5.DE). Retrieved from: https://finance.yahoo.com/quote/EXI5.DE/profile?p=EXI5.DE. Accessed: 2021-12-01.

Yahoo Finance (2021j). iShares STOXX Europe 600 UCITS ETF (DE) (EXSA.DE). Retrieved from: https://finance.yahoo.com/quote/EXSA.DE?p=EXSA.DE&.tsrc=fin-srch. Accessed: 2021-12-01.

Yahoo Finance (2021k). SP 500 (GSPC). Retrieved from: https://finance.yahoo.com/quote/\%5EGSPC?p=\%5EGSPC. Accessed: 2021-12-01.

Yahoo Finance (2021l). US Dollar/USDX - Index - Cash (DX-Y.NYB). Retrieved from: https://finance.yahoo.com/quote/DX-Y.NYB/history?p=DX-Y.NYB. Accessed: 2021-10-08.

Appendix

A1 VIF Test Results

Table A1.1: VIF Test Results

	New_cases	Exp_infl	F&G	VIX	Gold	Dollar
VIF_1	1.001	1.162	1.027	1.210	1.118	1.151
VIF_2	1.085	1.246	1.080	1.142	1.077	1.253
VIF_3	1.022	1.084	1.059	1.082	1.404	1.495
VIF_4	1.045	1.031	1.049	1.198	1.425	1.520

**Note:* This table shows the VIF of all the independent variables.

A2 Breauch-Pagan Test Results

Table A2.1: Breauch-Pagan Test Results

	Period 1	Period 2	Period 3	Period 4
p-value	0.000	0.906	0.332	0.563

**Note:* This table shows the p-value from the Breah-Pagan test in all four periods.

A3 Full Allocation of All Portfolio Optimizations

Table A3.1: Full Portfolio Optimization

Portfolios		BTC	FTSE	DAX	S&P500	Euronext 100	Corporate Bond	Emerging Markets	Forex	Real Estate	EUR600	Technology	Gold	Mean	StdDev	Sharpe Ratio
Tangent	With BTC	4,00 %			2,27 %				80,98 %			6,61 %	6,14 %	0,0361 %	0,2793 %	12,91 %
	Without BTC				4,48 %				80,04 %			7,60 %	7,88 %	0,0256 %	0,2349 %	10,89 %
Resctricted Tangent (20%)	With BTC	14,14 %			11,62 %		14,24 %		20,00 %			20,00 %	20,00 %	0,0820 %	0,7918 %	10,36 %
	Without BTC				20,00 %		20,00 %		20,00 %			20,00 %	20,00 %	0,0411 %	0,5360 %	7,66 %
Semi-restricted BTC (5%) tangent	With BTC	5,00 %			15,00 %		20,00 %		20,00 %			20,00 %	20,00 %	0,0543 %	0,5691 %	9,54 %
	Without BTC				20,00 %		20,00 %		20,00 %			20,00 %	20,00 %	0,0411 %	0,5360 %	7,66 %
Restricted BTC Tangent (1%)	With BTC	1,00 %			19,00 %		20,00 %		20,00 %			20,00 %	20,00 %	0,0437 %	0,5375 %	8,13 %
	Without BTC				20,00 %		20,00 %		20,00 %			20,00 %	20,00 %	0,0411 %	0,5360 %	7,66 %
MVP	With BTC						34,39 %		65,24 %				0,37 %	0,0152 %	0,1719 %	8,86 %
	Without BTC						34,39 %		65,24 %				0,37 %	0,0152 %	0,1719 %	8,86 %
Restricted MVP (20%)	With BTC	13,78 %			7,65 %		20,00 %		20,00 %	14,27 %	4,30 %		20,00 %	0,0266 %	0,4745 %	5,60 %
	Without BTC	13,78 %			7,65 %		20,00 %		20,00 %	14,27 %	4,30 %		20,00 %	0,0266 %	0,4745 %	5,60 %
Short Tangent (+/- 100%)	With BTC	4,95 %	-33,35 %	-12,11 %	22,57 %	34,78 %	-19,12 %	-17,90 %	97,55 %	-2,37 %	-2,27 %	16,66 %	10,63 %	0,0618 %	0,4037 %	15,31 %
	Without BTC		-34,93 %	-14,13 %	24,22 %	34,12 %	-19,79 %	-17,35 %	96,04 %	-1,75 %	4,22 %	16,43 %	12,92 %	0,0484 %	0,3560 %	13,60 %
Short Tangent Restricted +/-(20%)	With BTC	12,76 %	-20,00 %	-13,52 %	20,00 %	17,66 %	20,00 %	-16,92 %	20,00 %	0,94 %	19,09 %	20,00 %	20,00 %	0,0841 %	0,7388 %	11,39 %
	Without BTC		-20,00 %	-13,59 %	20,00 %	19,63 %	20,00 %	-11,37 %	20,00 %	5,33 %	20,00 %	20,00 %	20,00 %	0,0463 %	0,5368 %	8,63 %
Short MVP (+/- 100%)	With BTC	-0,003 %	4,17 %	-1,90 %	0,40 %	-5,97 %	40,57 %	-1,93 %	61,64 %	-3,33 %	5,70 %	0,26 %	0,42 %	0,0129 %	0,1672 %	7,71 %
	Without BTC		4,18 %	-1,88 %	0,39 %	-5,97 %	40,58 %	-1,93 %	61,65 %	-3,33 %	5,66 %	0,26 %	0,41 %	0,0130 %	0,1672 %	7,76 %
Short MVP Restricted (+/- 20%)	With BTC	-0,44 %	20,00 %	-20,00 %	9,56 %	-6,54 %	20,00 %	-1,46 %	20,00 %	17,05 %	20,00 %	1,82 %	20,00 %	0,0228 %	0,4593 %	4,97 %
	Without BTC		20,00 %	-20,00 %	9,37 %	-6,58 %	20,00 %	-1,50 %	20,00 %	16,93 %	20,00 %	1,79 %	20,00 %	0,0241 %	0,4596 %	5,23 %

**Note:* This table shows the full allocation of all the portfolios. The mean, standard deviation, and Sharpe Ratio is also presented on the far right side.