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Bitcoin vs. Traditional Indices

Analysing Performance and Risk Metrics for Long-Term Savings

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Abstract

This thesis compares investment strategies, volatility, correlation, downside risk measures and various risk performance ratios on Bitcoin, S&P 500 and NASDAQ Composite in various timeframes ranging between January 2013 and December 2022. The chosen timeframe is a relatively short period and gives our results some limitations. We considered Bitcoins total market cap to be too low before 2013, so it made sense to start where we did.

We examine various risk-adjusted performance ratios and risk measures of a lump sum investment in Bitcoin compared to S&P 500 and NASDAQ Composite over three periods: 2013-2022, 2018-2022 and 2020-2022. We find that Bitcoin has significantly outperformed both indices in terms of risk-adjusted returns over the 10- and 3-year holding periods but underperformed for the 5-year holding period. The high levels of potential return, however, comes at the cost of a considerably higher risk level, as shown by multiple risk measurements and other risk factors that are unique for cryptocurrencies, which ultimately emphasises the trade-off between risk and reward.

The results seem to fit nice with our correlation findings, where Bitcoin seems to have between none and very weak correlation with the indices based on daily returns for the last ten years.

We further investigated the effectiveness of a monthly dollar-cost averaging strategy for all assets over a 5-, 3- and 1-year timeframe. In this case, Bitcoin outperforms both indices over a 5-year interval but underperforms for the two shortest time horizons. Additionally, our study highlights the trade-off of both investment strategies by comparing them to one another. By only considering Bitcoin and when initiated in 2018, we find that dollar-cost averaging outperforms lump sum investment during bear markets. Conversely, when initiated in 2020, we show that lump sum investment outperforms dollar cost averaging during bull markets.

Preface

This master thesis is the final assignment of our master studies at Oslo Metropolitan University. It has been challenging and stressful at times but also a very rewarding process for both of us.

We first encountered cryptocurrencies at the beginning of 2018, at the top of a bull run where Bitcoin approached a valuation of \$20 000. Since then, our interest in cryptocurrencies and its underlying technology has grown year by year, thus, when we were to choose a topic for our master thesis, we never doubted it should include Bitcoin.

What is fascinating about Bitcoin is its ability to continually recover from several extreme drawdowns. It also seems that everything becomes more digital as time goes by, which makes it easier to believe that cryptocurrencies are here to stay and may perhaps become a permanent part of the financial markets in some way or another.

Another important reason why we chose to write about Bitcoin, is that it relates to a lot of courses from our studies at OsloMet. In this thesis we have used knowledge from courses like Investments, Econometrics, Risk Management and Behavioral Economics.

At last, a special thanks to our supervisor Kizkitza Biguri for all her help and advice. We really appreciate her positive feedback, her guidance as to which direction we could explore, and her help in narrowing our final thesis and research questions.

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1 Introduction

“It might make sense just to get some in case it catches on. If enough people think the same way, that becomes a self-fulfilling prophecy.” (Satoshi Nakamoto, 2009)

In the following chapter we will start by discussing the background and key aspects of our chosen topic. We will further state our research questions before lastly laying out the delimitations.

1.1 Background and motivation

The cryptocurrencies market has captured the interest of millions around the globe. Speculators, retail investors, entrepreneurs, and technologists alike. While the majority are fascinated by the potential of making a quick profit, others are attracted by the possibility of increased portfolio diversification or how the underlying technology can disrupt traditional industries.

Bitcoin has since its release in 2009 sparked a range of discussions and opinions from various stakeholders. On the one hand, some view cryptocurrencies purely as a speculative asset, with little to no intrinsic value. Stakeholders with this view often associate cryptocurrencies with criminal activity, given its anonymity and use in illicit activities. Others, however, view Bitcoin as an investment opportunity that could potentially offer high returns, given its limited supply, decentralized nature, and historical price appreciation. Proponents of this view often emphasize Bitcoin's potential as a hedge against inflation, a store of value, and even a safe-haven asset.

Cryptocurrencies have, over the years, gained popularity as a speculative investment vehicle, often perceived as a high-risk, high-reward opportunity (Seth, 2018). The high degree of uncertainty commonly observed in the cryptocurrency market presents unique challenges for investors seeking to maximize their returns. In this context, the dollar cost averaging strategy has gained attention as a potential investment strategy that could suit the volatile behaviour of Bitcoin.

Though Bitcoin and other cryptocurrencies have witnessed a substantial upswing in research in recent years, the lack of academic research and literature is evident when it comes to determining the optimal investment strategy for this highly volatile asset class. To address this literature gap, this study aims to explore whether Bitcoin is a viable long-term investing asset and the effectiveness of the dollar-cost averaging strategy.

Overall, some investors see Bitcoin as a long-term investment opportunity, whereas critics view it as a speculative bubble, just waiting to burst. Though the future of Bitcoin as a currency, investment or a disruptor remains uncertain, it has without a doubt already significantly impacted the world of finance and technology and will likely continue to do so in the years ahead.



Figure 1: Illustrates the price development of Bitcoin, S&P500 and Nasdaq Composite (2013-2022)

Figure 1 shows the price development of Bitcoin and the two indices from January 2013 to the end of December 2022. The year 2017 was the first time Bitcoin surpassed both indices in terms of price, while also setting a price record, almost reaching \$20,000 in December of 2017. Additionally, the growing interest in Initial Coin Offerings (ICOs) also captured the attention of many, with over 800 ICO’s launching over the year (Kauflin 2018). Despite the price dropping sharply from the 2017 highs, the industry continued to evolve and attract attention from various stakeholders, including investors, regulators, and developers. The last half of 2020 onwards further displays Bitcoin’s extreme volatile nature, with sudden peaks and drops in value. As of today (11.04.2023), Bitcoin has plunged -56.41% since its all-time high (Coinmarketcap.com). Among all the asset classes that exist, Bitcoin’s price history is one of

the most fascinating and volatile the world has ever seen, having since its release undergone several bull-runs and crashes. Because of its dramatic volatility, the question of whether Bitcoin is viable as long-term investment or not remains a highly discussed debate.

1.2 Research question and objectives

The objectives of this master thesis are to assess the past performance and risk-adjusted performance measures of Bitcoin with S&P 500 and NASDAQ Composite by utilizing various risk-adjusted performance measures derived from modern and post-modern portfolio theory. We will also have a look at the correlation between Bitcoin and the indices.

Furthermore, we will investigate the potential benefits and drawbacks of using a dollar cost average strategy when investing in assets over various time horizons and discuss the feasibility of Bitcoin as a long-term saving asset. To answer this, we will take a closer look at a variety of research and discuss its fundamentals, signs of future adoption and risks when investing in this market. Finally, the research will delve into the field of behavioural economics, in the context of investing in the cryptocurrency market. By examining the many psychological and emotional factors that can influence investors, this paper aims to shed light on the most common fallacies that may lead investors to suboptimal investment decisions. Based on this as a background, two research questions are formulated:

***RQ1:** How have the annualized risk-adjusted performance measures of Bitcoin performed in comparison to that of the S&P 500 and NASDAQ Composite over the past 3, 5 and 10 years?*

***RQ2:** What are the benefits and drawbacks of using a dollar cost average strategy to invest in Bitcoin over a time horizon of 1,3 and 5 years, and how has this strategy performed compared to S&P 500 and NASDAQ Composite?*

The first research question will be addressed by calculating multiple risk measures, which will be used in a variety of risk-adjusted performance ratios for the given time periods. To answer the second question, we will analyse the historical performance of Bitcoin, S&P500 and NASDAQ Composite over various time periods and to further compare the returns of a dollar cost averaging strategy with that of a lump sum investment.

Ultimately, the purpose of our thesis is to provide investors with a comprehensive understanding of the potential risks and rewards of investing in Bitcoin, and to further contribute to the academic literature on investment strategies in the cryptocurrency market.

Note: We hereafter refer to Nasdaq Composite as Nasdaq. For the investment strategies we will refer to dollar cost averaging as DCA and lump sum investment as LSI.

1.3 Delimitations

In this study, the period from 2013 to 2022 was chosen, as it represents a significant and well documented period of Bitcoin's price history. Prior to 2013, Bitcoin was a relatively small and unknown asset, mainly used by blockchain enthusiasts and early adopters. Trading volume and price during this time was relatively low. In contrast, 2013-2022 represents a period of growth and mainstream adoption. This is mainly because the market has undergone significant changes since its release, with increased attention and much greater investment flowing into the market. Additionally, the chosen period includes several major events that had an impact on Bitcoin's price, such as several countries banning cryptocurrency trading, the Covid-19 pandemic and more recently the bankruptcy of FTX, the world's third-largest cryptocurrency exchange.

Transaction fees vary from exchange to exchange and could impact the overall returns of an investment strategy, especially when buying frequently. Due to the lack of uniformity in transaction solutions across various exchanges and the unavailability of reliable data on transaction fees over the chosen time periods, transaction fees were not included in our research. Another important analytical delimitation of our research is that we have purely focused on Bitcoin as an investment asset and not investigated the highly discussed topic of whether Bitcoin should be considered as a medium of exchange. This is in line with prior research by Baur, Hong & Lee, which found out that Bitcoin is primarily held for investment purposes rather than being used as a currency.

Another delimitation is the fact that we do not investigate the effects of time value of money, which has seen big impacts in recent years by inflation and the frequent change in the interest rate. This is something to keep in mind when we look at the comparison between the DCA strategy with the LSI strategy over some years.

The last delimitation is the fact that we are looking at Bitcoin from a single-asset portfolio perspective. For research purposes, we wanted to analyse the performance of Bitcoin in isolation, but we acknowledge that a single asset portfolio does not have any diversification effects and will not be efficient compared to a diversified portfolio.

2 Literature Review

2.1 Cryptocurrencies

“I think the internet is going to be one of the major forces for reducing the role of government. The one thing that’s missing but that will soon be developed, is a reliable e-cash” (Milton Friedman, 1999)

As described earlier, the crypto industry is filled with debate. There is yet to be an international unified definition for cryptocurrencies. The definition of a cryptocurrency will differ depending on who you ask. For example, the Norwegian Financial Supervisory Authority defines digital currencies as:

“a digital expression of value, which is not issued by a central bank or public authority, nor necessarily linked to an official currency, and which does not have the legal status as currency or money, but which is accepted as a form of payment, which can be transferred, stored or traded electronically” (Finanstilsynet, 2023).

The largest blockchain-based company in the world, Coinbase defines cryptocurrency as:

“Cryptocurrency is typically decentralized digital money designed to be used over the internet and have grown as digital alternatives to money issued by government” (Coinbase, 2020).

The originator of all cryptocurrencies today is Bitcoin. Bitcoin was first and laid the foundation for all the cryptocurrencies we see today. As of the first of March 2023, more than 9400 different cryptocurrencies are listed on the website CoinMarketCap, where the global market capitalization of all cryptocurrencies is \$1.17 trillion (CoinMarketCap, 2023). Bitcoin, and other digital currencies are purely virtual, meaning that the value is not backed up by any physical commodity or government entity. While traditional currencies and payment systems require a central authority to be operational, cryptocurrencies rely on a distributed ledger technology, nowadays called blockchain technology.

Today, buying and storing digital currencies has become fairly easy. There are various exchanges and online brokers that offer a wide variety of cryptocurrencies to be purchased using fiat currency. In Norway, there are several exchanges such as Norwegian Block Exchange, Firi and Kaupang that are registered and supervised by the Norwegian financial supervisory authority (Finanstilsynet, 2023). However, many also use the world’s largest crypto exchange, Binance, often due to lower fees or access to a wider variety of digital currencies.

Digital currencies can either be stored on an exchange, or by creating a personal wallet. In the last 10 years there have been several instances of exchanges going bankrupt, where investors have lost access to their funds. Therefore, it is recommended that investors create their own personal wallet to obtain complete control over their own digital assets.

2.2 Bitcoin

“If you don’t believe it or don’t get it, I don’t have the time to try to convince you, sorry.” (Satoshi Nakamoto, 2009)

Bitcoin is an ingenious and pioneering technology that was introduced in 2008, through a whitepaper titled “Bitcoin: A Peer-to-Peer Electronic Cash System”. The author went under the pseudonym “Satoshi Nakamoto”, and his paper outlined a solution to the so-called double spending problem. Prior to Bitcoin, the double-spending problem was a fundamental flaw with all digital currencies, where the digital cash could be spent more than once. This was usually countered by implementing a centralized trusted third party that could monitor and verify all the transactions conducted on the network, but Satoshi’s whitepaper solved the problem using a probabilistic risk algorithm called “Proof-Of-Work”, which allowed the Bitcoin network to arrive at a consensus about the state of all bitcoins (Antonopoulos, 2014). The Bitcoin network is operational due to a peer-to-peer network of nodes¹ that are economically incentivised to keep the Bitcoin safe by collecting, validating, and timestamping all the transactions that take place on the network. The name “Bitcoin” has a meaning to it, because when bitcoins are sent and received, a marriage of “bit” (data) is submitted as a packet of data to the network. Bitcoin therefore allows monetary value to be transferred alongside a data transfer (Murray, 2023).

Unlike the legacy banking model, where two parties transact through the service of a financial institution such as a bank, Bitcoin can be exchanged peer-to-peer without the need for an intermediary (Nakamoto, 2008). This is why many call Bitcoin decentralized, namely because the system is maintained by a global network of computers, rather than one single entity, and you can send money to one another without a middleman. Each of these computers is called a node, and through a software they work together to validate transactions and maintain the

¹ In the context of Bitcoin, refers to a computer that participates in the peer-to-peer network, which is owned by a single entity (person) or a group of entities (companies).

integrity of the blockchain. In similar fashion as the internet, it is the decentralized nature of the blockchain that makes it secure, because there is no single point of failure.

In traditional accounting the standard way to check whether money is spent and received is by using a ledger. Likewise, bitcoins are also tracked on a global public ledger that maintains the state of all bitcoins. In more simple terms, it is an immutable record of all transactions on the network. Furthermore, the global ledger is consistently updated and shared with other nodes in the network, where global state is agreed upon by all participants (Murray, 2023). The most important feature here is that the ledger is public to everyone, which contrasts to traditional ledgers where you need to trust that the ledger keeper is honest.

Nakamoto also ensured that the system had a built-in mechanism for controlling the supply of new bitcoins. New bitcoins are created through a process called mining, in which mining nodes use computational power to solve complex mathematical puzzles in order to add new blocks to the blockchain. In exchange, they receive a reward in the form of newly created bitcoin, and the transaction fees that were associated with the block they solved. The block size limit was originally set to 1 megabyte, which you will later see, was one of the major contentions within the Bitcoin community. In essence, a block can be thought of as a book's page with a list of transactions that need to be validated.

The difficulty of the mathematical puzzles is adjusted automatically every 2,016 blocks, to ensure a steady rate of block creation, and the number of bitcoins per block is gradually reduced over time until the maximum supply of 21 million bitcoins is reached (Nakamoto, 2008). Additionally, every four years there is something called the "block halving", which cuts the reward for mining a new block in half. This means when all 21 million bitcoins are mined, mining-nodes will only get rewarded by transaction fees. The creator of Bitcoin, Satoshi Nakamoto disappeared from the bitcoin forums late December 2010, and has not been heard from since. While the identity of Nakamoto remains unknown, it is believed that he mined between 750,000 to 1.1 million bitcoins before leaving the project (Redman, 2021).

2.3 History of Bitcoin

The term "forks" is a widely used word within cryptocurrency terminology, and there are two types of forks that are worth understanding before we look at the history of Bitcoin: hard forks and soft forks. Hearn (2015) defines a hard fork as when the rules of the Bitcoin protocol change such that old nodes refuse to accept blocks created by new nodes. This results in a split in the

blockchain with two separate blockchains, each with their own version of the protocol. One blockchain continues as before, while the other blockchain operates on the new protocol. A soft fork is defined as when the rules of the Bitcoin protocol change such that old nodes don't realise the rules are different but continue to accept blocks created by newer nodes that follow the changed rule set (Hearn, 2015). These can be things that upgrade right away, like gradual software upgrades, bug fixes or new features.

Following Nakamoto's disappearance in 2010, the Bitcoin blockchain has undergone several forks due to disagreements within the Bitcoin community regarding the best way to scale the network and how to accommodate increasing demand and transaction volume. The essence of this conflict started in 2015, when Bitcoin blockchain transaction volume was growing rapidly, and almost reached the limit of what the Bitcoin network could handle. Ultimately, the lack of progress led to a tremendous growth for alternative cryptocurrencies such as the rise of Ethereum, and later thousands of other cryptocurrencies (Knutli, 2021).

The relationship within the Bitcoin community became no less tense when the developers of the Bitcoin code in 2016 tried to address this issue by implementing the soft fork "Replace by fee" (RBF). The introduction of this function allowed unconfirmed transactions that were waiting to be accepted on the blockchain to be replaced by a new transaction with a higher transaction fee to get it accepted faster. The introduction of this feature was met with great disagreement. Those who were in favour of this solution argued that the function was useful because you could pay forward in the "queue", to get your transaction through faster, which was particularly relevant if the network became overloaded and transaction costs increased. The other side argued that this constituted a threat precisely because it violated the "first seen, first safe" principle. This principle states that if the "same" transaction was sent twice, miners would only accept the first transaction (Lee, B. 2022).

The problem with this implementation can easily be illustrated by an example. Let's assume Bob is a merchant who sells digital goods online, and Alice wants to purchase one of his products. Alice sends 5 BTC to Bob, with a low transaction fee, hoping it will take a long time before the transaction is confirmed by the network. Since the transaction is still unconfirmed, Alice simultaneously sends another transaction with a higher fee that sends the same 5 BTC back to her own wallet. Since miners are now incentivized to accept the transaction with the largest fee, Alice will have successfully executed a double spend, and Bob will not receive any payment for the item he already sent to Alice's address. As of this, the opposing side argued that RBF implementation was a weakness to the system, because it could facilitate double

spending attacks, which was a big concern for businesses who wanted to use Bitcoin as a fast and reliable payment system.

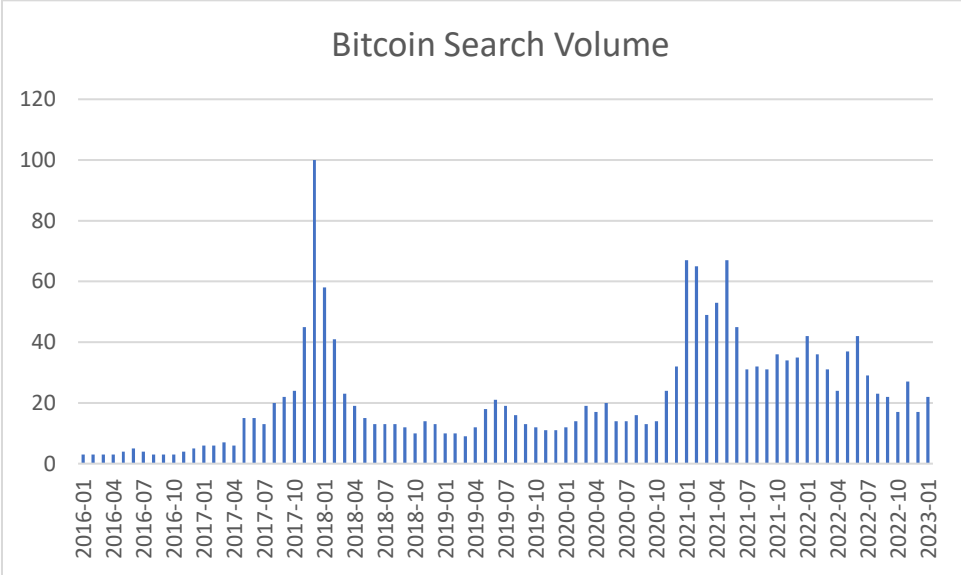


Figure 2: Bitcoin Search Volume, 2016-2023 (Google Trends).

As the interest in Bitcoin and blockchain technology increased and became more mainstream, the network became more and more congested. Figure 2 shows the search interest for “Bitcoin”, where the values on the y-axis represent the search interests relative to the highest point in the chart between January 2016 and January 2023. The highest search interest for Bitcoin was in December of 2017

To resolve the increasing capacity problems, the community proposed two different scaling solutions. The first proposal was put forward by “small blockers” and that was to upgrade the Bitcoin software through a soft fork called Segregated Witness (SegWit) and to later implement a second layer solution called the Lightning Network (Morgan, 2017). On a basic level, the purpose of SegWit was to change the way data was stored, which would make the Bitcoin network more secure and a little bit faster. (Frankenfield, 2022). The Lightning Network on the other hand, was laid out to be a supplementary layer-two solution primarily designed to address the scalability limitations of Bitcoin. The goal of this layer two solution was to enable more, cheaper, and faster transactions off-chain, while also ensuring decentralization (Lin et al., 2020). While this sounded prominent at first, research has shown that the Lightning network is far more centralized than it was supposed to be, and faces challenges in terms of security, liquidity, and complexity (Dasaklis & Malamas, 2023).

The other proposal put forward by “big blockers” argued that the best way to accommodate the issue was to just increase the block size limit. This would allow for increased transaction volume and speed and a lower transaction fee that could compete with payment systems like Visa and PayPal. According to Lin et al (2020), this is a short-term solution because it would increase validation time, storage capacity and bandwidth costs which would lead to increased centralization because fewer nodes would participate in the network. This again would make the system less resilient and more prone to faults and attacks.

To understand the core of the conflict, one must understand that for many people Bitcoin was an ideological battle, where the importance of decentralization and democracy stood central. Opponents of increasing the block size (small blockers) argued that it would result in more centralization, as the cost of running your own node on the network would increase. This was seen by many as a major deviation of what Bitcoin was meant to be, because running your personal node was equated with having a voice in the future development of Bitcoin. The big blockers on the other hand, argued that the implementation of SegWit and Lightning network would in the long run undermine the mining reward system and eventually destroy Bitcoin's economic incentive model.

Despite efforts to find a compromise, the issue was not resolved and on the first of August 2017, a group of bitcoin developers initiated a hard fork of Bitcoin, resulting in the creation of a new cryptocurrency called Bitcoin Cash (BCH), which aimed to increase the block size limit, as well as removing the earlier implemented “Replace-by-fee” function (Andrew, 2018). Another notable hard fork occurred in 2018, when Bitcoin SV (BSV) network split off from the Bitcoin Cash network. The split was driven by disagreement over the future direction of the Bitcoin Cash network, with supporters of BSV advocating for a return to the original vision that was laid out by Satoshi Nakamoto in his whitepaper. Figure 3 showcases the diverging paths of these cryptocurrencies, with BTC representing the original Bitcoin blockchain, BCH representing the chain that forked from Bitcoin, and further BSV who split from Bitcoin Cash.

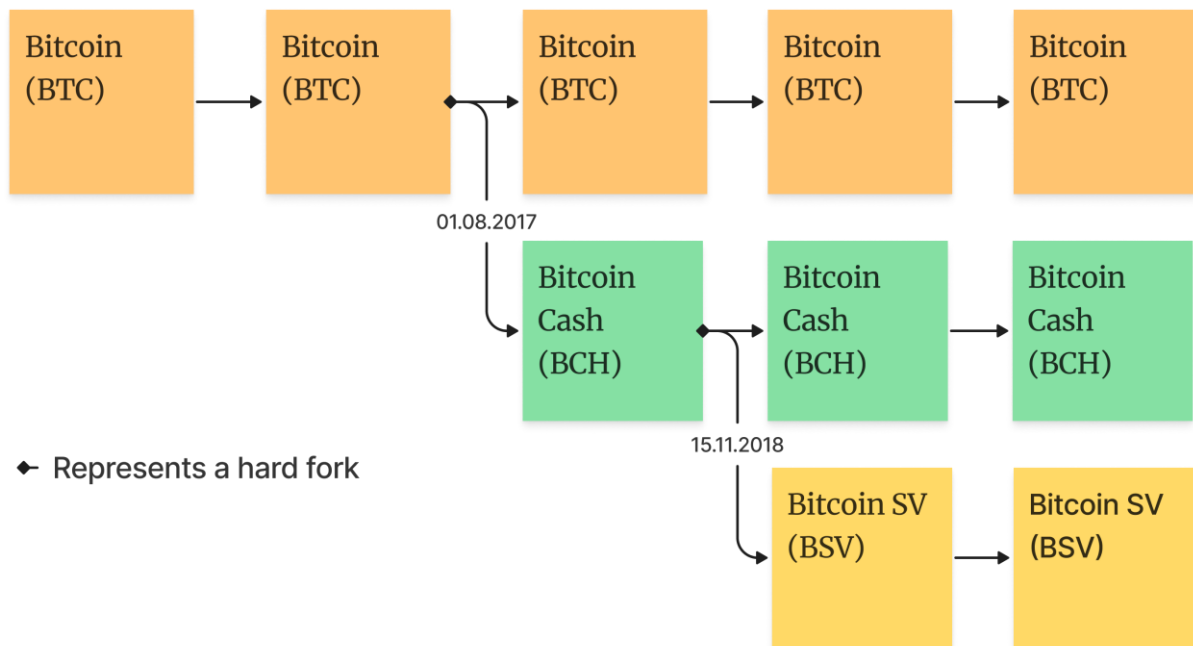


Figure 3: Hard fork between Bitcoin (BTC), Bitcoin Cash (BCH), and Bitcoin SV (BSV). Created using Figma.

Overall, the history of Bitcoin so far has been marked by internal conflicts and forks due to disagreements within the community regarding the best way to scale the network. The ideological battle between small blockers and big blockers was a clash between the importance of decentralization versus the need for increased transaction capacity. This ultimately led to the creation of Bitcoin Cash and Bitcoin SV. Today, Bitcoin (BTC) is the largest, both in terms of price and popularity. While the majority of the community believes Bitcoin to be the true protocol, it is still an open answer as to which version of Bitcoin truly represents the original vision outlined in Satoshi Nakamoto's whitepaper. As the market matures and the technology advances, it remains to be seen whether Bitcoin will maintain its dominant position.

Even though Bitcoin was laid out to be a digital currency that could be used in day-to-day transactions, it has struggled to gain widespread acceptance as a medium of exchange due to its dramatic volatility, slow transaction speed and high transaction costs. While Bitcoin has failed in its stated objectives as a cash system that enables small casual transactions, it has over the years gained attention as a speculative investment vehicle, often perceived as a high-risk, high-reward opportunity (Seth, 2018). The hype and popularity around Bitcoin has for sure been attributed to its perceived potential as a revolutionary technology, and the potential for blockchain technology to disrupt older systems.

2.4 Does Bitcoin have any fundamental value?

Today, Bitcoin's intrinsic value is still a topic of debate, with many differing opinions. One of the most popular arguments for why Bitcoin has value, is related to its scarcity, decentralized nature, and security. Many Bitcoin proponents see value in the network itself, where no government or organization has control over the supply. This mindset may be seen as a counterpoint to the high levels of inflation as seen around the world, where Bitcoin represents a stark departure from the norm. Since the supply of Bitcoin will never exceed 21 million, it is by many perceived as a hedge against inflation, which is quite the contrast to the inflationary pressures that can erode the value of national fiat currencies.

This has led to many Bitcoin proponents mentioning Bitcoin as “digital gold”, and a better store of value than traditional fiat (Kellher, 2022). Although there is currently no empirical evidence that conclusively establishes Bitcoin's fundamental value, there is one study by Hayes (2018) who found that Bitcoin tends to follow the marginal cost of producing one bitcoin, which supports the narrative that Bitcoin may indeed have a fundamental value. Another feature that some value is privacy, or more specifically, pseudonymity. In practice, this means that your real identity is not directly linked to the transactions you make, but your wallet address. Unfortunately, this feature has led Bitcoin, and many other cryptocurrencies, to being used in connection with criminal activity.

Many academics and researchers, however, argue that the value of Bitcoin and other cryptocurrencies is based on pure hype and speculation. Taleb (2021) attacks the “digital gold” narrative by arguing that the comparison between the two lacks elementary financial rigor. The study clarifies through economic reasoning that precious metals, such as gold, are low maintenance, do not deteriorate over time, and do not require regular upkeep to maintain their physical properties. In contrast Bitcoin requires ongoing interest and attention to maintain its value. The research concludes that Bitcoin in its current state can't be a store of value, neither short nor long-term. This is also in line with prior research of Cheah & Fry (2015) who conclude that Bitcoin is prone to speculative bubbles and that its fundamental value is zero.

In comparison, we know that S&P 500 and Nasdaq indirectly have fundamental value because they are composed of a basket of stocks that either produces goods or services. Because of this, the fundamental value in the equity markets is the present value of future cash flows. From a game theory perspective Bitcoin is essentially a zero-sum game, because in its current state, most people only use it for speculative purposes. The gains of one investor come at the expense of others who lose, i.e, the net change in wealth or benefit is zero.

2.5 Price & Adoption of Bitcoin

“Bitcoin is a classic network effect, a positive feedback loop. The more people who use Bitcoin, the more valuable Bitcoin is for everyone who uses it, and the higher the incentive for the next user to start using the technology. Bitcoin shares this network effect property with the telephone system, the web, and popular Internet services like eBay and Facebook.” (Marc Andreessen, entrepreneur & investor, 2014)

While the intrinsic value of Bitcoin is still debatable, the price of Bitcoin is driven by the economic forces of supply and demand. The current circulating supply of Bitcoin (25.04.2023) is 19 355 918. This means that roughly 92% of all bitcoins that will ever be, are already mined (CoinMarketCap, 2023). According to a study performed by a blockchain company it is estimated that 20% of the bitcoin supply has not moved out of their wallets in over 5 years, thus most of these bitcoins are presumably lost (Reiff, 2019).

The price of Bitcoin is also affected by the number of competing cryptocurrencies. At the start of 2013, Bitcoin accounted for over 90% of the total crypto market capitalization due to little competition, but the emergence of new cryptocurrencies has given investors new alternative investment opportunities to choose from. As more and more competition arises, some investors may choose to allocate some of their funds in other cryptocurrencies, which can decrease the demand for Bitcoin. Increased competition can also lead to a shift in investment preferences. For instance, if another cryptocurrency offers more desirable features such as more utility, faster transaction speed or lower fees, investors may prefer that over Bitcoin. As of 1. January 2023, Bitcoin accounts for about 40% of the total market capitalization, which is far less than it did 10 years ago (CoinMarketCap.com).

The price is also affected by media attention in social networks. One study showed that the social media networks have a partial influence on Bitcoins price (Philippas, 2019). Another event study by Ante (2022) also found how Elon Musk’s crypto related twitter posts moves cryptocurrency markets, highlighting the conflict between the ideals of freedom of speech, morals, and investor protection. The findings show that bitcoin related tweets from Musk impacts the price of Bitcoin in the range of -11% to +16.9%, depending on whether the tweet was positive or negative. Because of things like this, many researchers such as Kristoufek (2013), Lehman (2017) and Yang (2018) have suggested that conventional financial theory cannot explain the skyrocketing price of Bitcoin. Traditionally, financial, and economic theory has assumed that humans are rational decision-makers who will always act in their best interest.

However, this assumption has been challenged by the field of behavioural economics, which states that people aren't always rational or optimal, but instead are influenced by emotions and biases.

A couple of years before the Bitcoin genesis block was mined, the world financial systems collapsed during the Global Financial Crisis. During this crisis the central banks all over the world had to bail out several banks because they had taken on too much risk. As an "Easter egg", Satoshi put the following message in the first block: "The Times 03/Jan/2009 Chancellor on brink of second bailout for banks" (Selene, 2017). The message was copied from the London Times who had an article about the British government's failure to stimulate the economy post the Global Financial Crisis. The Global financial Crisis has been seen as a backdrop for the wide adoption we have seen in the last 14 years for Bitcoin. Could it be that the current system wasn't good enough?

A widely used statement about the financial markets is that history never repeats, but it often rhymes. As of April 2023, we have seen several banks both in the US and in Europe with troubles on their balance sheet large enough to have regulators step in to prevent a global contagion. It is at this stage too early to say how this will play out later this year. But for the most speculative Bitcoin investors, it gives them another reason to believe that Bitcoin might be the solution for a modern decentralized financial system and that further adoption will happen.

At the time being, it is said that crypto adoption is around what internet adoption was in 1998. (Wan, 2021) But the adoption is happening faster, so with current trends it is predicted that there will be 1 billion users by 2026/2027. The emerging markets are dominating the adoption of Bitcoin. This is no surprise when we read about inflation rates of 40% in Venezuela and 90,5% in Argentina (Focus Economics, 2023), with citizens trying to find ways to store their wealth in the best possible way. If Bitcoin were to replace gold as a store of value, it still has a long way to go. Gold is currently estimated to have a market cap around 13 trillion dollars and by comparison Bitcoin is trending just above 0,5 trillion dollars.

A global survey conducted by Cointelegraph reveal that public corporations and governments, account for 7.2% of the circulating supply of Bitcoin. It is further reported that on average, 45% of the institutions that took part of the survey, have exposure to cryptocurrencies. According to Cointelegraph's 2022 survey of professional investors, 48 out of 84 respondents reported that they do not hold any cryptocurrencies. Among these, 2/3 stated that they will never invest in

cryptocurrencies, while 1/3 might buy them in the future. The primary reasons for holding cryptocurrencies for investment firms was due to the high risk-return ratio and its properties as a diversifier. (Cointelegraph Research, 2022). The survey also highlights that the lack of regulatory clarity is an obstacle for further institutional adoption.

This clearly shows that there are different attitudes and perspectives towards cryptocurrencies among professional investors. This can also be seen in the context of what was presented earlier between researchers and proponents. The fact that two-thirds of the institutional investors are not invested in cryptocurrencies suggests that there might be some barriers to adoption. The first barrier might be a general scepticism about the long-term value of Bitcoin. On the other hand, the fact that one third of investors might buy them in the future suggests that there might still be interest and potential for growth within the market. Taking into account that most institutional investors hold cryptocurrencies primarily due to the past risk-return ratios suggests that Bitcoin and other digital assets are primarily perceived as investment asset, that could potentially offer high returns.

One of the biggest reasons why so few companies have yet invested in digital assets is regulatory concerns. Institutional investors say they need more clarity when it comes to regulation to speed up the adoption. This is because many institutions are not comfortable investing large amounts into assets with unclear legal implications. Several risk factors are also a big barrier for many institutions. One of the greatest risk factors is related to the total market size of cryptocurrencies, which is still quite small in comparison to equity markets, thus there is also a fear of too much liquidity risk.

The capabilities and advancements of blockchain technology have over the years attracted many institutions since it has proven to be more effective in many areas of use. For instance, many blockchain based payment systems have shown to be superior in terms of transaction speed and costs, compared to traditional systems. Several big worldwide companies, such as KPMG, EY, and Deloitte, are investigating how the underlying technology can disrupt various industries such as life sciences, banking and capital markets and manufacturing and supply chain sector (Pawczuk, 2020).

In Norway we have seen articles about DNB cooperating with other big banks to use blockchain as a more efficient system to transfer value across borders and between banks. The Central Bank of Norway is also exploring the benefits and utilization of blockchain technology, in the means of creating a central bank digital currency, that could improve cross border payments

(Hægeland, 2023). Additionally, the technology has the potential to create new business models and revenue streams. For instance, a Norwegian company called SeaFoodChain has utilized the blockchain technology to enhance the traceability and transparency of seafood to distributors and consumers.

To conclude, it is the potential cost reductions and efficiency gains associated with the technology that attracts institutional interest. As blockchain technology continues to evolve and mature, there is expected to be an increase in institutional demand and investments in the years ahead.

2.6 Dollar-cost averaging (DCA)

An investment strategy is a set of principles that guide investors regarding their investment decisions (Taylor, 2022). One of these investment strategies is called dollar cost averaging (DCA), and is a strategy that is widely used, and often recommended by investment advisors. The strategy has however been largely ignored by academic theorists, contemporary academic texts, and textbook writers (Brennan, 2005).

The strategy suggest that the investor should invest a fixed amount of money on a regular basis over a given time interval, rather than investing the whole amount at time zero. For instance, an investor who follows this strategy and wishes to invest \$20 000 in Bitcoin, could invest \$1 000 per month for 20 months, rather than investing the whole \$20 000 in a lump sum. The intuition here is that the DCA strategy allows the investor to purchase Bitcoin at an average price which is below the average of the prices prevailing on the purchase dates, because the fixed periodic dollar investment purchases more bitcoin when the price is low (Brennan, 2005).By spreading the investment out over time, one can mitigate (but not avoid) the risk of market fluctuations without relying on market timing (Merlone, 2015).

Even though in retrospect, a lump sum investment was lucrative for early investors, timing the today's market is extremely difficult, because the extreme volatility makes it hard to determine an optimal entry point. By not relying on one single large investment, investors reduce the risk of entering the market at an unfavourable time, often referred to as "buying at the top". Instead, the strategy spreads the investments across multiple time periods, which can capture both market lows and highs. A declining market can be viewed as a buying opportunity, and in such cases the DCA can significantly boost long-term portfolio returns, when (and if) the market turns.

Another benefit of adopting a DCA strategy, which is especially true for investments in the cryptocurrency market, is the reduction of irrational and emotional decision making. By having a systematic and structured investment plan investors can to some extent get rid of the emotional component of when to actually buy (Hayes, 2023). This can be crucial when investing in Bitcoin which fluctuates a lot and is often trending in the news when the price is at all-time-high or at rock bottom. Therefore, the psychological aspect of investing will probably be more present when investing in Bitcoin, and as we will see in paragraph 2.7 about investment behaviour this can be hard to overcome regarding loss aversion. Compared to many other strategies, the DCA strategy is a disciplined approach to investing, because it encourages regular investing habits with a long-term investment mindset.

Another important aspect is the fact that it is a much more budget friendly strategy that doesn't affect the monthly household budget as much, and it might be more suitable for retail investors with limited initial capital. By investing smaller amounts more frequently, investors are committed over time, both in terms of staying updated on the market information, while also having opportunity to reconsider the investment and adjust the portfolio if necessary.

The DCA strategy also comes with downsides worth mentioning. One of the key features of a DCA-strategy is partly to mitigate drawdown risk by investing frequently. However, this may also limit the upside potential through higher transaction costs and smaller amount invested in the asset, in the event of a longer bull market. Thus, a DCA-strategy is more likely to miss out greater gains in a bull run than a lump-sum investment. A study published by Vanguard, a US registered investment adviser firm, found that 2/3 of the times a lump-sum investment outperformed a DCA investment over a 10-year time horizon for a 60% /40% equity-bond portfolio. However, the study also reveals that a DCA strategy outperforms an LSI during market downturns (Shtekman et al., 2012). One could therefore argue that these strategies are quite intuitive. If markets are going up, one should invest the whole sum immediately to gain full advantage of the market growth, but if markets are down trending, a DCA strategy is more appropriate due to the increased accumulation over time.

The S&P 500 index have given an annual compounded growth rate of roughly 10% over the past 30 years (Lake, R, 2023). Bitcoin has given a much higher annual compounded return the last 10 years as we will present in the result section, but it has a much shorter history. But the main problem is that Bitcoin can still go to zero, no one knows. The probability that the stock market will crash all the way to zero is highly unlikely.

The Bitcoin market has evolved through some large boom-and-bust cycles for the last decade. With the halving of Bitcoin's flow into the market from the mining process, approximately every four years, the cycles are likely to continue for many years (Aijiboye et al, 2019). These cycles have brought the price of Bitcoin down over 70% from each cycle's top several times. This is a big disadvantage for investors, should they need to cash out their investment at the wrong time. This problem is not avoided by investing in the S&P 500. For instance, the S&P 500 index fell over 56% during the global financial crisis in 2007-2009 and over 34% during the Covid crash. But it does not happen nearly as often as it does with the Bitcoin market.

2.7 Investment behaviour

The field of behavioural economics offers valuable insights into investment behaviour and the phenomena observed in financial markets that cannot fully be explained by conventional financial theory (Boyer et al., 2015). With this in mind, we have chosen to include some of the most common investment fallacies we feel are related to the cryptocurrency market.

Two popular terms within the cryptocurrency space are "FOMO", the fear of missing out and "HODL", hold on for dear life. One could argue that these are closely related to the field of behavioural economics. The extreme returns within the cryptocurrency market have made many retail investors use the term fear of missing out (FOMO) on social media platforms. This refers to the fear of missing out on a potential gain from an investment. By not having a proper investment strategy, one can easily fall for such fallacies, because it can, in the worst-case scenario, lead to impulsive investing, which is more based on emotions around short-term market fluctuations, rather than safe and sound investment strategies.

The term hold on for dear life "HODL", is actually a typo of "hold", which originated from a Bitcoin forum post in 2013, where a retail investor admitted to having bought bitcoin at a high price, but refused to sell it, despite a significant drawdown (Rosen, 2023). It has since become a widely adopted term within the Bitcoin community, referring to the strategy of holding Bitcoin for the long-term no matter what happens to its price. Ironically as it is, this type of mentality is explained by behavioural economists as the sunk cost fallacy. From an investment perspective, the sunk cost fallacy refers to the tendency for investors to irrationally follow through an investment that is not meeting their goals (Downey, 2022). Being emotionally attached to an investment is never a good strategy, and investors should always set strict

investment goals, either it be a performance target or benchmark, and re-evaluate their portfolio accordingly if the investment does not meet the set goals.

Another aspect also from behavioural economics which we would like to address is the endowment effect, where people value goods more highly when they have some ownership over it (Cartwright, 2018). Once they have it in their possession, they don't want to trade it for something else. This can help long-term investors stay the course during periods of high volatility, and as we shall see later, by comparing volatility for Bitcoin and the chosen indices, it might save them for some of the psychological stress.

Then there is loss aversion. This refers to how outcomes are interpreted as gains and losses, where losses are subject to more sensitivity in people's responses compared to equivalent gains acquired (Cartwright, 2018). Originally proposed by Amos Tversky and Daniel Kahneman in their articles about the utility function shape, they found out that losses can be twice as powerful, psychologically as gains. The concept is increasingly applied within finance and economic analysis and can be an important factor to consider when it comes to investing in Bitcoin, which has had some large drawdowns from time to time.

In the context of institutional adoption, it is anticipated that large institutions, such as mutual funds, pension funds and insurance companies might invest in blockchain technology. This category of investors brings us into a famous puzzle of finance and behavioural economics, namely the "Equity Premium Puzzle", originally researched in 1985 by R. Mehra and E. C. Prescott. The main point in their paper was to investigate why funds like mutual and pension funds hold bonds in their portfolio, when stocks have had annual real return 6 percentage points higher all the way since 1926 (Benartzi & Thaler, 1995). In other words, the equity premium has been on average 6% annually. In Benartzi & Thalers article from 1995, called Myopic Loss Aversion and the Equity Premium Puzzle, they try to explain the phenomena by using the concept of loss aversion. They found that when decision-makers are loss averse, they will be more willing to take risks if they evaluate their performance (or have their performance evaluated) infrequently. And that the longer the holding period for the investment becomes, the attractiveness of risky assets rises. A typical pension fund is likely to exist "forever" if the company remains in business. This is not the case for the manager of the fund. Since he is evaluated frequently, at least every year and maybe more often, he cannot have large drawdowns in the fund because loss aversion of the investors in the fund will make them choose another fund with better risk-adjusted returns. As we will see under the result section, this is a

big issue when it comes to Bitcoin's volatility and is most likely a large hurdle for institutional adoption.

Today, Bitcoin is still a highly risky asset with a very short time frame of existence compared to the overall stock market. Historically the stock market has bounced back after every big correction, which can also relate to the mean reversion hypothesis (Chen, J, 2021). Even though Bitcoin has also bounced back from every large drawdown, it is still in its infancy as an investment class, and it could still go to zero. The probability that the stock market goes to zero is very low at the time being.

Another issue about Bitcoin is the volatility, which is problematic for an investor regarding loss aversion. Bitcoin dropped as much as 53% in May 2021 and approximately 77% from the top in 2021. These kinds of declines are far too big for most investors, especially for those saving for retirement in a pension fund. Thus, lower volatility is probably necessary for the next adoption step, but as we shall see under the result section, this is not the case for now.

2.8 Risk

“Stay away from it. It's a mirage, basically. In terms of cryptocurrencies, generally, I can say almost with certainty that they will come to a bad ending.” (Warren Buffet, CEO of Berkshire Hathaway, 2018)

Investing in general exposes an investor to two types of risk. As such, it is common to separate systematic and unsystematic risk. Systematic risk, or often called market risk is the risk of losing investments due to the inherent risk in the overall market. This can for instance be political or macro-economic factors (Nickolas, 2022). Canh et al. (2019) found evidence suggesting that there is an own systematic risk within the cryptocurrency market. Unsystematic risk on the other hand is unique to a specific company or industry and is therefore diversifiable.

One form of unsystematic risk aspect to consider when investing in the cryptocurrency market is the operational risk. Operational risk is defined as the risk of loss resulting from inadequate or failed internal processes, people, and systems or from external event (Baker & Filbeck, 2015). In contrast to other forms of risk, operational risk represents only a downside risk for investors, without any upside potential.

The rapid collapse of the third world largest cryptocurrency exchange FTX in November 2022, has sparked a big discussion on the corporate control exercised by such exchanges. In the light of FTX's bankruptcy filing, it has become apparent that the exchange has accumulated over 8 billion in liabilities owed to more than one million creditors (Smith, 2023). Additionally, the collapse caused a sudden decline in the overall cryptocurrency market, and based on our own data Bitcoin experienced a decline of -22.84% between Nov. 8 and Nov. 10, 2022. Another notable bankruptcy within this space was the downfall of the exchange Mt. Gox in 2014, which was the largest Bitcoin trading platform at the time. During its lifetime, the exchange experienced multiple security breaches and hacking incidents, leading to a loss between 650 000 and 850 000 bitcoin (Frankenfield, 2022). Similarly, the exchanges Cryptopia and QuadrigaCX also went bankrupt due to funds lost from inadequate and failed internal processes (Vidrih, 2019). The lack of regulatory oversight and corporate control has made financial regulators suspicious of many platforms across the world, and hopefully such cases will decrease when regulation tightens.

The incidents mentioned above, highlights the vulnerability of operational risk for both exchanges and investors who store their funds on the exchange. The broad and widespread access of digital asset platforms across the globe, combined with patchy regulatory guidance, renders the space highly susceptible to investor abuse (Deloitte, 2021). This further emphasizes the importance of robust regulatory frameworks as essential for investor protection and to ensure market integrity. The problem in the last decade is that the development and ecosystem around cryptocurrencies has outpaced legislation in many cases, which has made the crypto-markets a perfect place for price manipulation. Misleading market information, pump and dump schemes, insider trading and rug pulls are prevalent, especially among new and emerging cryptocurrencies. However, there is now a growing focus on this in Europe by the European Union and in the US by the Securities and Exchange Commission. For example, the Markets in crypto-assets regulation (MiCA) which formally comes into effect from July 2023, aims to ensure financial stability in the crypto markets and protect both retail and institutional investors from risks (Ribe, 2023). Banks and other financial institutions have for a long time been waiting for increased regulatory clarity, and the introduction of MiCA is therefore likely to drive increased institutional interest and adoption within this industry.

Another operational risk that is unique to Bitcoin and other digital currencies is related to its system/technology. This type of risk is called a 51% attack and occurs when a single entity or a group of entities control over 50% of the networks mining power (Frankenfield, 2022). This

can give the malicious actors power to manipulate or even reverse transactions that have already been confirmed. Since miners are incentivised to keep the network secure and operational, the likelihood of such an attack is minimal. However, it still poses a significant risk for investors, especially for investment funds who trade on the behalf of customers.

Another important type of risk that is highlighted in the recent events of FTX, is liquidity risk. Liquidity is the lifeblood of financial markets and is critical for the smooth operation of an economy. In short, liquidity risk can be divided into two parts: market and funding liquidity. The market liquidity refers to the ease with which investors can trade an asset or a security, whereas the funding liquidity refers to the ease with investors or traders obtaining capital (Baker & Filbeck, 2015). In the context of our thesis, liquidity risk arises when a seller of Bitcoin cannot sell it because nobody is willing to buy. The cryptocurrency market is still very illiquid in comparison to the stock and forex market, A study from Bitwise (Cointelegraph, 2023) showed that out of 6 billion in average daily bitcoin volume, only 5% was real, the rest was hoax volume trying to boost the exchanges popularity. By comparison the S&P 500 index has an average daily volume of 4,2 billion as of May 2023 (Yahoo Finance, 2023)

Since the creator of Bitcoin, Satoshi Nakamoto, allegedly is believed to own approximately 1.1 million bitcoins, which is 5,23% of the total supply, he is also a potential source of liquidity risk. A scenario where Nakamoto were to sell all his bitcoins, would lead to a significant and sudden collapse in price, before eventually creating a liquidity crisis. This is also mentioned in an interview with the CEO of Coinbase, Brian Armstrong who argues that *“The entire crypto market could be destabilized if Bitcoin’s anonymous creator is ever revealed or sells their \$64 billion stake”* (Kay, 2021). This risk is particularly concerning for everyone who holds any cryptocurrencies, namely because Bitcoin and other cryptocurrencies are extremely correlated in bear markets (Gkillas, 2018).

3 Methodical Approach

In this chapter, we will first present our chosen research design, followed by a description of our data collection methods and techniques. Furthermore, we will examine the distribution of the data, introduce the risk-performance measures that were used in our analysis, and lastly provide an assessment of the research quality.

3.1 Choice of Research Design

A common distinction in research methodology is the division between qualitative and quantitative method. The quantitative approach involves counting phenomena and mapping their extent, while qualitative methods focus on the characteristics of the phenomenon under study (Johannesen et al., 2011).

In this master thesis, the quantitative approach was necessary, because we wanted to calculate the risk-adjusted returns of Bitcoin compared to two other indices. This involved calculating, measuring, and analysing the data set we downloaded. We used Microsoft Excel to compare the annualized returns, the risk adjusted performance measures and the investing strategies. The statistics software Stata was used to visualize the distributions, and to conduct formal normality tests.

In this study we conducted a literature review as a supplement to our quantitative approach, which can be described as the process of using different types of documents as empirical material, such as books, research articles, news articles or survey reports. It involves going through various documents to find answers to the topic one desires. These sources may cover historical events and public documents, where documents are considered as secondary data (Høivik, 1974). A literature review was primarily used to get an overview of previous research and findings, to understand whether Bitcoin can be viable as a long-term saving asset. Another purpose was to get a broader understanding of the driving factors of adoption and institutional demand, and to understand whether behavioural biases might be an explaining variable in the price appreciation of Bitcoin.

3.2 Data collection: Methods & Techniques

When it comes to data collection, we have primarily used two different data sets: quantitative price data and literature review. The price data gave us the opportunity to analyse and calculate the risk-adjusted returns and to compare the performance of Bitcoin with S&P 500 and Nasdaq. Since the data is retrieved from two different databases, it is considered as secondary data. Other

notable secondary data sources that are frequently used in this study are books, research papers, surveys, and financial and economic journals.

Historical price data was collected from 1. January 2013 to the end of December in 2022 on Bitcoin, S&P 500 and Nasdaq. The data was downloaded from Investing.com, a website that provides credible price data information for various assets. To ensure that our data was reliable we cross-checked the price data with various websites. The data was downloaded in both monthly and daily frequency, to check whether the increased frequency increased the accuracy of our calculations. We saw the advantages of using daily data as it captured both daily ups and downs for Bitcoin, which can swing a lot in just a day. While most calculations we used were daily data, we also used monthly data in some cases as it provided a more aggregated view of the price fluctuations.

We chose to use the S&P 500 as a proxy for the overall market. This is because this index is often referenced both in international and Norwegian financial press, so anyone interested in finance have most likely heard about it and can relate to it. The index is a market-capitalization-weighted index of the 500 largest publicly traded companies in the U.S.

The Nasdaq index is a broad index heavily weighted toward the important technology sector and is seen as an index of companies that have a large potential for growth in the future and is therefore a more volatile index compared to S&P 500. It contains more than 3700 stocks from all around the world.

By comparing Bitcoin to S&P 500 and Nasdaq indices we can bring in the psychological aspect of investing long-term, where we see S&P 500 as the safest choice and then Nasdaq and Bitcoin further out on the risk curve.

Comparing daily data sets consisting of both Bitcoin price data and stock market data comes with one specific implication. Since Bitcoin and other cryptocurrencies are traded 24/7 and 7 days a week, we had more data on Bitcoin than the two other indices. To address this issue, we standardized the data sets by removing bitcoin data during the weekends to achieve a common time interval. This resulted in all three data sets having 2517 observations, which is relatively close in alignment with 252 trading days per year, using a standard calendar of 365 days. We believe this approach was important to ensure consistent and comparable data, which was an important step since we wanted to compare investment strategies to one another on various time horizons.

In addition, the risk-free rate for the same periods was obtained from FRED.com. We used the Market Yield on U.S. Treasury securities at a 10-year constant maturity (DGS10) as a benchmark for our calculations. This risk-free rate was chosen as the aim of the research is to view Bitcoin and traditional indices from a long-term investment perspective. We believe this risk-free rate is reliable and reflects an appropriate benchmark for long-term investment analysis. For calculations purposes, we converted the risk-free rate to both monthly and daily format for the different data sets. We chose a US interest rate as everything we calculated was valued in US Dollars.

3.3 Distribution of the data

Checking for normality is an important step in quantitative research. This was an integral to our research because many of the risk-adjusted performance measures we utilized assume normality. This is a significant acknowledgement, because if the data set is not normally distributed, it decreases the validity of those risk metrics that rely on the assumption of normality. In other words, if normality is not met, it will lead to either upwards or downwards biased estimates in our risk metrics, which again makes it difficult to draw any meaningful conclusions.

Not surprisingly, the dataset was non-normally distributed, as confirmed by visual inspection through a histogram, and two statistical tests, the Jarque-Bera test and a skewness and kurtosis test. We tested for normality on all assets in the three time periods. Since formal normality tests are highly sensitive to sample size, they are optimal and should always be interpreted alongside histograms (Sainani, 2012)

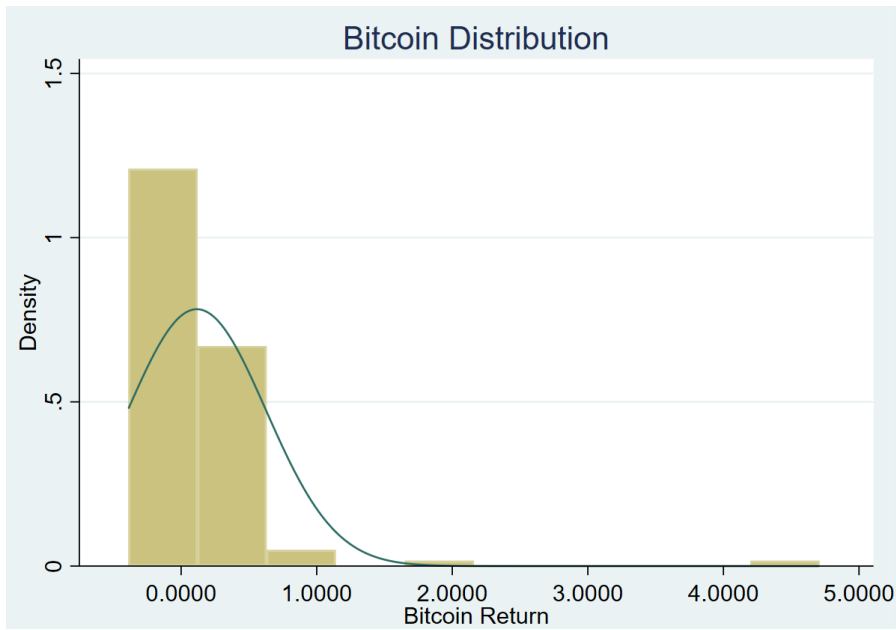


Figure 4: Histogram of Bitcoin's return distribution. (2013-2022)

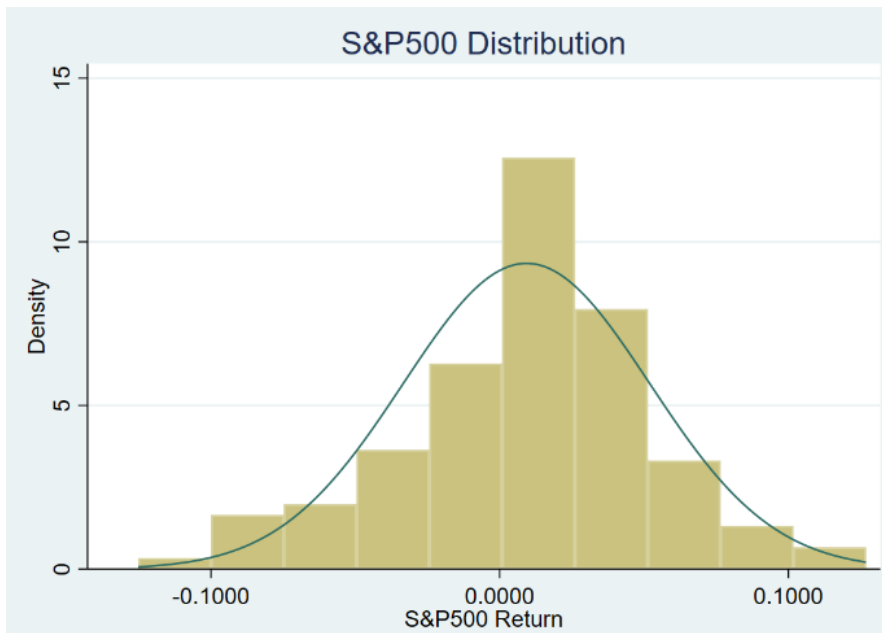


Figure 5: Histogram of S&P500 return distribution. (2013-2022)

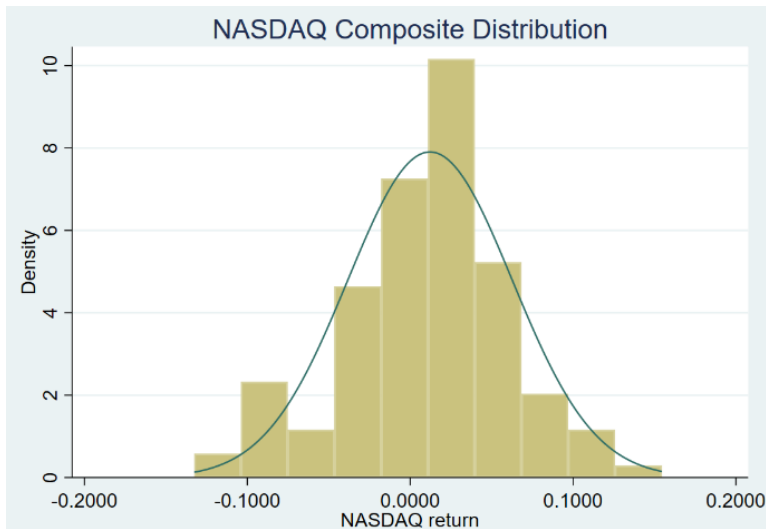


Figure 6: Histogram of NASDAQ Composite's return distribution. (2013-2022)

Table 1: Summary statistics and Jarque-Bera Test of the daily returns.

Summary Statistics	Bitcoin	S&P500	NASDAQ Composite
Mean	0,005490	0,000445	0,000567
Median	0,0019	0,00064	0,00107
Minimum Value	-0,57	-0,12	-0,12
Maximum Value	3,37	0,09	0,09
Standard Deviation	0,093796	0,0110743	0,013007715
Skewness	20,8535	-0,548837	-0,490182729
Excess Kurtosis	2,224138	-0,649746	-0,566737363
Observations	2517	2517	2517
Jarque Bera	182946	170,6379	134,482017
P-Value	0,00 %	0,00 %	0,00 %

Table 2: Skewness & Kurtosis test on daily returns. Test conducted in statistics program Stata.

```
. sktest BitcoinReturn
Skewness and kurtosis tests for normality
----- Joint test -----
Variable | Obs Pr(skewness) Pr(kurtosis) Adj chi2(2) Prob>chi2
-----|-----
BitcoinReturn | 2,517 0.0000 0.0000 . .

. sktest SP500Return
Skewness and kurtosis tests for normality
----- Joint test -----
Variable | Obs Pr(skewness) Pr(kurtosis) Adj chi2(2) Prob>chi2
-----|-----
SP500Return | 2,517 0.0000 0.0000 530.33 0.0000

. sktest NASDAQReturn
Skewness and kurtosis tests for normality
----- Joint test -----
Variable | Obs Pr(skewness) Pr(kurtosis) Adj chi2(2) Prob>chi2
-----|-----
NASDAQReturn | 2,517 0.0000 0.0000 395.24 0.0000
```


As shown in Figures 4 to 6, Bitcoin exhibit a heavily right tailed distribution over the 10-year period from 2013 to 2022. This suggests that the daily data is not normally distributed. This is also supported by Table 1, where we can see that Bitcoin, S&P 500 and Nasdaq have a skewness of respectively 20.85, -0.54 and -0.49. Although many financial theories and models assume the normality of returns, empirical evidence has shown that return distributions are usually skewed (Taylor, 2023). To further check for normality, two formal normality tests were conducted: The Jarque-Bera test and the skewness and kurtosis test.

The Jarque-Bera test is a common test for normality, where the null hypothesis is that the data follows a normal distribution. Table 1 shows that the p-value for all assets is less than 5%, and we conclude that the returns are not normally distributed. Table 2 shows the skewness and kurtosis test, which also suggests that the returns do not follow a normal distribution. Based on everything above, it is reasonable to conclude that the daily returns of all the assets are non-normally distributed.

3.4 Risk-adjusted performance metrics

Assessing risk-adjusted performance measures is a key component and an important aspect of investment and performance analysis. This subchapter provides an overview of the risk metrics we have used in this thesis. For each risk metric, we discuss its theoretical underpinnings, the formula, as well as their benefits and limitations. How Bitcoin and the two indices performed in relation to these metrics will be presented in annualized form in the next chapter. The use of annualized returns and ratios is a common benchmark within investment analysis as it provides a standardized measure of performance that enables a fair comparison of the assets. Despite risk measures being a useful tool to evaluate the risk adjusted return over a given time, it is important to acknowledge the fact that these measures are calculated based on historical data and that past performance is no guarantee for future returns. This is especially true for speculative markets, characterized by high levels of risk and uncertainty. Therefore, it is important to also evaluate other factors that may impact an investment, such as the overall market conditions or the underlying fundamentals of the asset.

Though some of the risk-adjusted performance measures we have calculated assume normality, we have tried to mitigate the potential impact of non-normality and measurement bias, by utilizing alternative risk measures such as the Sortino Ratio, Calmar Ratio, Sterling Ratio, Value at Risk and Expected Shortfall which does not assume normality of returns.

3.4.1 Sharpe Ratio

The Sharpe ratio was first introduced by William Sharpe as a measure to compare the performance of mutual funds. Since its inception, however, it has become widely accepted within finance as a metric of how to measure the reward to-volatility ratio provided by a portfolio (Berk & DeMarzo, 2020). This can be interpreted as the number of standard deviations the portfolio's return must fall to underperform the risk-free investment.

Sharpe ratio, however, relies on the fact that the returns are normally distributed, which is not the case for most financial assets, nor for this study. Another important point here is that the Sharpe ratio does not distinguish between upside and downside volatility, and thus the effect of high outlier returns will increase the standard deviation, thereby actually lowering the value of the ratio (Rollinger & Hoffman, 2015). This is particularly true for positively skewed return distributions such as what we have for Bitcoin. Ironically, the Sharpe ratio can be improved by removing the largest positive returns, which is illogical from an investment perspective. Overall, we can conclude that the Sharpe ratio falls short in events of non-normal return distributions. One must therefore carefully consider the validity of this measure when interpreting the results in the next chapter.

$$\text{Sharpe Ratio} = \frac{\text{Excess Return}}{\text{Portfolio Volatility}} = \frac{E[R_p] - r_f}{\sigma(R_p)}$$

3.4.2 Treynor Ratio

The Treynor ratio is yet another risk-performance measure that is commonly used when measuring the risk adjusted returns of investments. Though the formula is quite like the Sharpe ratio, the Treynor ratio differs because it utilizes systematic risk in the denominator, rather than standard deviation. The systematic risk is also known as the market risk and is defined as beta in the equation below. The advantage of this ratio is that it considers the market risk rather than just the past volatility of the investment. In similar fashion as the Sharpe ratio, the Treynor ratio also suffers from assuming normality of returns. Additionally, the accuracy of the ratio heavily relies on the use of an appropriate benchmark to correctly measure the beta (Kenton, 2020). The calculations of the beta were conducted using the slope function in Microsoft Excel. In retrospect, we understand that S&P 500 isn't really a good benchmark that reflects the

cryptocurrency market. Nonetheless, the Treynor ratio is a common benchmark used in investment analysis and we chose to keep it even though the ratio gets exaggerated.

$$\text{Treynor Ratio} = \frac{\text{Excess Return}}{\text{Portfolio Beta}} = \frac{E[R_p] - r_f}{\beta_p}$$

Where;

$$\beta = \frac{\text{Cov}(R_i, R_m)}{\text{Var}(R_m)}$$

3.4.3 Sortino ratio

The Sortino ratio was introduced in the early 1980s by Dr Frank Sortino and was a modification of the Sharpe ratio. However, it differs because it only considers downside risk, defined as the standard deviation of returns below a certain threshold (Kenton, 2020). The risk-free rate was used as the minimum accepted return threshold for this ratio. Since many risky investments exhibit a high degree of both upside and downside volatility, this ratio will help us see the true risk adjusted performance, as upside deviation is a benefit.

Arguably, the Sortino ratio is a better risk-adjusted performance measure, especially when measuring the performance of returns that exhibit non-normal distributions. Even the originator of the modern portfolio theory, Harry Markowitz, recognized in 1959 that it would be more appropriate to use downside deviation as a measure of risk. Although his pioneering work on modern portfolio theory relied on variance, this was largely due to computational constraints that precluded the use of downside deviation at the time (Rollinger & Hoffman, 2015).

$$\text{Sortino Ratio} = \frac{\text{Excess Return}}{\text{Semi deviation}} = \frac{E[R_p] - r_f}{\sigma(R_D)}$$

Where;

$$\sigma(R_D) = \sqrt{\frac{1}{n} * \sum_{r_t < Avg.}^n (\text{Average} - r_t)^2}$$

3.4.5 Sterling ratio

The Sterling ratio is yet another risk-adjusted investment measure, often used to define how efficiently risk capital is being allocated. The Sterling ratio differs because the risk in the denominator is defined as the investment's average maximum drawdown. To fully understand the Sterling and Calmar ratio, one needs to understand the concept of drawdown. Drawdown is

a measure of downside volatility, typically quoted as a percentage, that refers to how much an investment has declined from its peak before it recovers back to the peak (Mitchell, 2022). Essentially the Sterling ratio can be interpreted as the risk premium compared to the risk-free rate per unit of average drawdown.

To derive to this metric, we calculated the drawdowns in one column, and then used the AVERAGEIF function in excel to calculate the average drawdown which represents the average magnitude of the declines experienced for the three time periods.

$$\text{Sterling Ratio} = \frac{\text{Annualized Return} - \text{Annual risk free rate}}{\text{Average Max Drawdowns}} = \frac{E [R_p] - r_f}{\text{Avg. MDD}}$$

Where;

$$\text{Avg. MDD} = \frac{\sum_{i=1}^n DD}{n}$$

3.4.6 Calmar Ratio

The Calmar ratio was introduced by Terry W. Young in 1991 as a modified version of the Sterling ratio. The Calmar ratio utilizes the maximum drawdown as a measure of risk, which is defined as the maximum sustained percentage decline from a high point to a low point, before a new peak is achieved (Hayes, 2022). This means that the Calmar ratio is more sensitive to large drawdowns, and less sensitive to small drawdowns compared to the Sterling ratio. The maximum drawdown can both be interpreted as a measure of its own, or as an input into other risk metrics. From an investor's standpoint, one would therefore look for a low maximum drawdown and a high Calmar ratio.

The max drawdown was simply calculated by using the -MIN function on the identified drawdowns, which gave us the maximum drawdown for the given period.

$$\text{Calmar Ratio} = \frac{\text{Annualized Return} - \text{Annual risk free rate}}{\text{Max Drawdown}} = \frac{E [R_p] - r_f}{MDD}$$

Where;

$$MDD = \frac{\text{Trough Value} - \text{Peak Value}}{\text{Peak Value}}$$

3.4.7 Value at Risk (VaR) and Expected Shortfall (ES)

Value at Risk (VaR) and expected shortfall (ES) are the last statistical measures of downside risk we have calculated. These differs from the previous risk metrics since it only looks at the size of bad outcomes that can occur within a specified probability in a specific time interval (Elton et al., 2014). The Value at Risk can be calculated in three different ways: Parametric VaR model, Monte Carlo Simulation or Historical VaR model. The historical VaR method was used as it does not assume the normality of returns, and we had experience with calculating it in the course “Risk Management”. The Historical VaR was calculated by looking at the daily and monthly returns, and then sorting the returns from worst to best. For example, for the whole period we had 2517 daily return observations. The 1 percentile then is either the 25th or the 26th worst outcome. The advantages of VaR and ES are that it is easy to understand and captures an important aspect of downside risk in a single number. In essence, these statistical measures ask the simple question of how bad things can get. The historical expected shortfall was also included because it is a more conservative risk measure that captures the tail risk more efficiently. The expected shortfall is the expected loss given that the loss is greater than the VaR level (Reindl, 2022). We therefore calculated average of the losses above the VaR level to find the expected shortfall.

3.3 Limitations

All research has limitations to some degree, and our research is no exception. Our study only examines the historical price data from 2013 to 2022 on Bitcoin, S&P 500 and Nasdaq and we acknowledge that the daily volatility of Bitcoin is so high that the investment strategy might have played out differently in practice.

Exploring the fundamentals of Bitcoin and assessing its long-term viability as a savings asset, comes with certain limitations that should be acknowledged. One limitation of literature reviews is how researchers have interpreted the different research and literature. In some cases, this can lead to bias and might cause the researcher to select evidence that supports his viewpoint. In this thesis, this is mitigated by analysing multiple research articles and perspectives, and we have aimed to provide a rounded literature review by looking at both sides of the debate, satisfying internal validity. We have also tried our best to avoid any biases that can stem from interpretations of results and analysis by showing both the positive and negative aspects of each investment class. In retrospect we acknowledge that choosing a random time horizon when investigating the investment strategies might be more beneficial.

4 Results & Analysis

4.1 Comparison of Returns and Risk Metrics

The following chapter presents a three-table overview of various risk metrics as discussed earlier. Each table represents its own period, namely: 2013-2022, 2018-2022 and 2020-2022. The calculated risk and performance metrics for all tables provide insights into the outcome of utilizing a lump sum investment strategy. The results assume that the investment took place on the first day in the year of the specified timeframe and was held until the last day of December 2022. The first table, spanning from 2013 to 2022, provides a long-term perspective, showcasing the enormous gains of an early investment. The second table, from 2018 to 2022, provides a more recent and mid to short-term perspective, whereas the last table is a much shorter timeframe ranging from 2020 to 2022.

Table 3: Annualized Risk-performance measures, (2013-2022)

Risk Metrics (2013-2022)	Bitcoin	S&P500	NASDAQ
Annualized return	104,22 %	10,15 %	12,91 %
Annualized Risk	148,90 %	17,58 %	20,65 %
Risk Free rate 10 year	1,86 %	1,86 %	1,86 %
Sharpe Ratio	0,69	0,47	0,54
Beta	0,098	1	1,112
Treynor Ratio	1048,52%		9,9%
Downsides	1198	1173	1123
Semi variance	0,31 %	0,01 %	0,02 %
Semi deviation	88,18 %	18,61 %	22,37 %
Max Drawdown	90,96 %	33,92 %	36,40 %
Average drawdown	50,42 %	4,59 %	6,21 %
Sortino Ratio	1,161	0,445	0,494
Calmar Ratio	1,125	0,244	0,304
Sterling Ratio	2,030	1,806	1,779

Table 3 presents the annualized risk adjusted-performance measures of a lump sum investment in Bitcoin, S&P 500 and Nasdaq over the ten-year period from Jan. 2013 to Dec. 2022. The risk-adjusted measures will show how lucrative Bitcoin was for early investors. The U.S Treasury securities at 10-year constant maturity (DGS10) were used as a risk-free rate, as it is a widely accepted proxy for long term investments.

Over the 10-year period, Bitcoin yielded an annualized return of 104,22%, compared to S&P 500 and Nasdaq with an annualized return of 10,15% and 12,91% respectively. However, the lucrative returns of investing in Bitcoin come at the cost of significantly higher volatility, with

an annualized risk of 148,9%. In contrast, the two indices exhibit much lower levels of risk, with an annualized risk of just 17.58% and 20.65% respectively.

The Sharpe ratio for Bitcoin, S&P 500 and Nasdaq is 0.69, 0.47 and 0.54 respectively. The Sharpe ratio for Bitcoin indicates that the investment generated a return that was 0.69 times greater than the risk-free rate for each unit of standard deviation. However, as presented earlier, this metric assumes the normality of returns, and since the Sharpe ratio does not distinguish between upside and downside volatility, the effect of high outlier returns will increase the standard deviation, thereby decreasing the overall ratio.

The Treynor ratio is yet another metric that assumes normality, where the S&P 500 was used as a benchmark for Bitcoin and Nasdaq. Bitcoin yields a Treynor ratio of 1048%, which means an investment in Bitcoin in the start of January 2013 has generated an excess return of 1048% per unit of systematic risk (beta) relative to the risk-free rate of 1.86%. However, this is not correct because this is the biggest shortcoming of beta and the Treynor ratio. The Treynor ratio assumes that you have a benchmark that matches the same market. This is because Bitcoin is more exposed to the cryptocurrency market, rather than the overall stock market, and therefore the Treynor ratio gets exaggerated. In other words, the fluctuations of Bitcoin are idiosyncratic, i.e., unexplainable by S&P 500 as a beta. In comparison, Nasdaq only yielded a Treynor ratio of 9,9%. As a result, the Treynor ratio is a misleading and unreliable estimate for Bitcoin in this case.

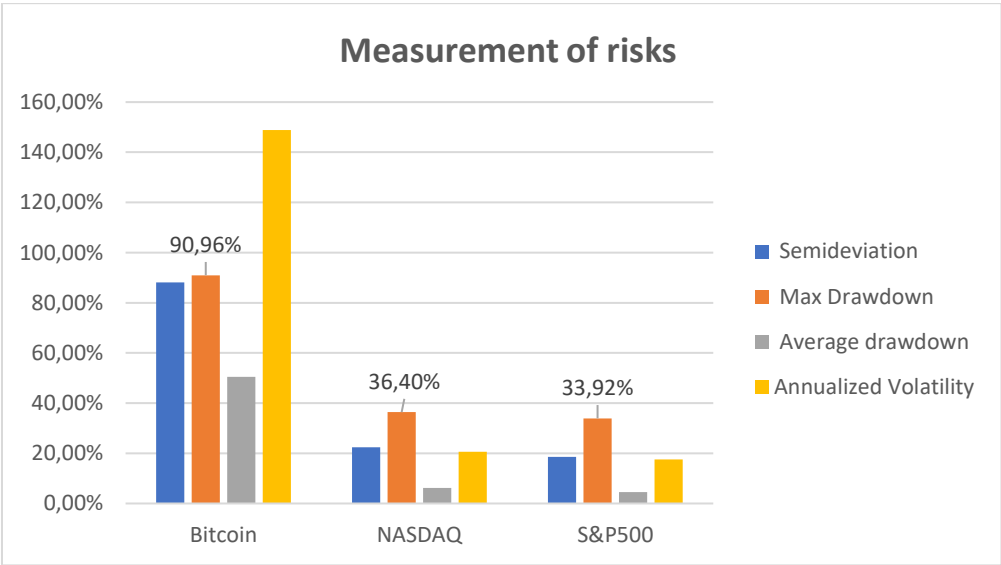


Figure 7: Measurements of Risks, Annualized. (2013-2022)

Where Bitcoin falls short is in terms of risk toleration, and this is clearly highlighted by figure 7. Looking at the different risk measures in isolation gives us another perspective of investing

in Bitcoin. During the 10-year period, a Bitcoin investor would have experienced an annualized standard deviation of 148.8%, which is over seven times more than the annualized volatility of Nasdaq of 20.65% and over eight times more than S&P 500 of 17.58%. Additionally, Bitcoin has an average maximum drawdown of 50.42%, which means that on average, Bitcoin has experienced a decline in value of 50.54% from its previous high over the 10-year period. This is quite the contrast to the index's average drawdowns of only 4.6% and 6.2% for S&P 500 and Nasdaq. Over the 10-year period, the maximum drawdown for Bitcoin, S&P 500 and Nasdaq was 90.96%, 33.92% and 36.4% respectively. Lastly the semi deviation, or also known as the volatility of negative returns for this time interval is over 88% for Bitcoin, 18% for S&P 500 and 22% for Nasdaq.

Looking at the different risk measurements in isolation, the findings suggest that Bitcoin is a highly risky investment compared to the two indices. Assuming that a normal investor is risk-averse, Bitcoin is unlikely to be a beneficial medium of storing money over a longer time horizon. Experiencing a maximum drawdown of 90.96%, as exemplified by Bitcoin in this case, also highlights the risks with a lump sum strategy, because you are fully invested, and a drawdown of such a magnitude highlights the importance of understanding one's risk tolerance. The high volatility combined with the extreme drawdowns, makes it difficult for an investor to know when it would be wise to buy in. Therefore, the findings suggest that Bitcoin resembles a speculative investment object, which is in line with previous research that has pointed out that Bitcoin can be a high-risk high-reward investment. Although it may be tempting to jump on the Bitcoin bandwagon when its value is increasing rapidly, it may be important to consider whether one has the necessary risk tolerance to handle potential significant losses if the market turns.

The visual presentation of the Value at Risk results is another way to show how risky Bitcoin is as an investment, and it's easy to compare it with the two indices. We chose to look at confidence level of both 1% and 5%, because these two are what we have most often looked at during our studies and we believe that readers of this thesis can relate to them.

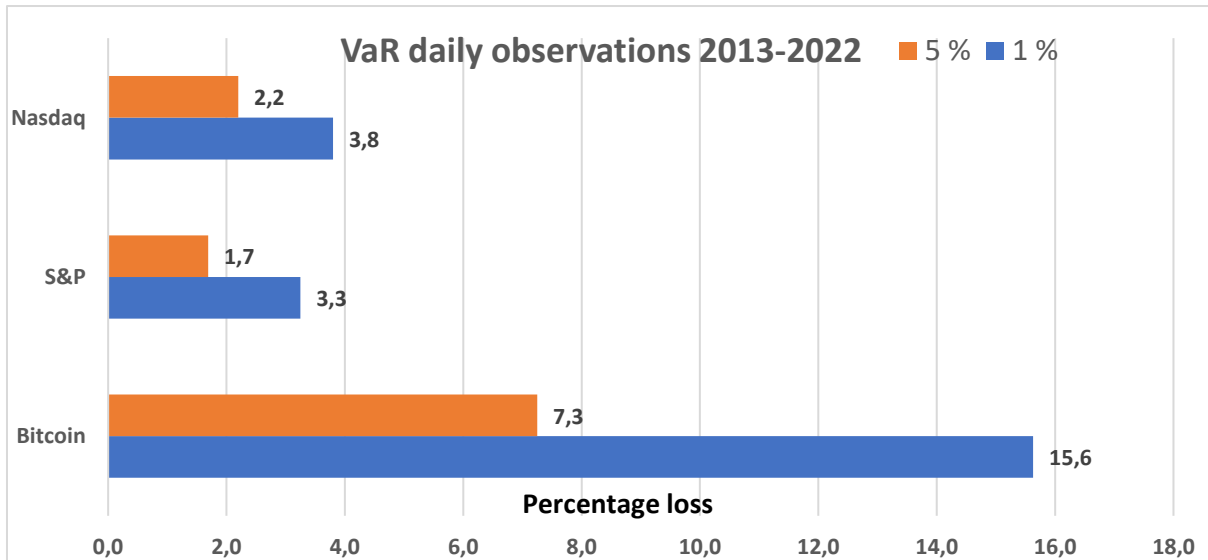


Figure 8: Daily Value at Risk, (2013-2022)

Using observations from our whole period we can see that Bitcoin clearly has the highest potential for a daily loss in both confidence levels. We had 2517 daily observations of returns, so at the 1% level this is the 26th largest loss. For the 5% level we used the 126th largest loss.

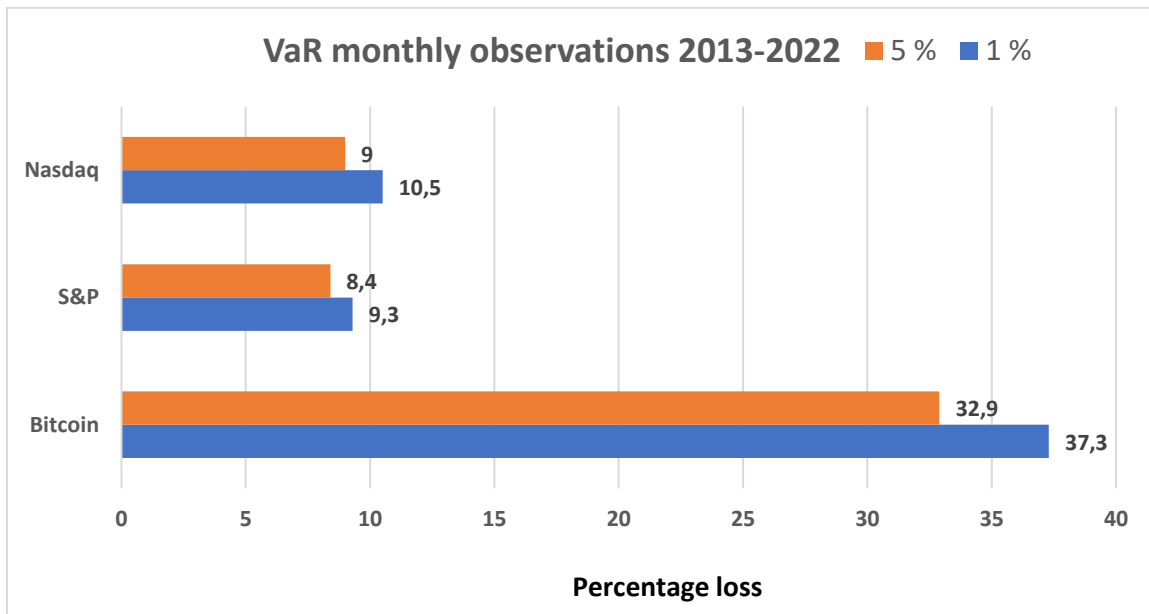


Figure 9: Monthly Value at Risk, (2013-2022).

Since we are investigating whether saving monthly in Bitcoin could be a good idea, its logical to have a look at the monthly Value at Risk as well. Here we have just 120 observations, which means that for the 1% confidence level we have chosen to use the second largest loss and for the 5% confidence level we have used the 6th largest loss. Here we can correlate to the psychological aspect of investing. If a risk averse investor sees the numbers from Bitcoin here, it is hard to believe that he would put any of his portfolio into Bitcoin. Imagine if the loss

happened in December, it would be catastrophic for a portfolio manager’s performance for that particular year. Even though Bitcoin has recovered from many large drawdowns in the past decade, the numbers here are quite extreme. The expected shortfall values for the same period are even more devastating, which can be seen from **Table 6**.

One could therefore argue, it may be wise to invest in more traditional indices for risk averse investors, because the indices have shown less volatility and a more stable development over time compared to Bitcoin. Additionally, the two indices gain the diversification effect, which is not the case for Bitcoin as a single asset investment. The probability for an index to vanish is unimaginable, but for Bitcoin to lose its “momentum” or so to speak is a possibility. This is because Bitcoin is competing against many other cryptocurrencies, and the industry is still in an early stage, so no one knows what is going to happen next. Another factor is that Bitcoin is more fragile regarding regulation, which can impact the future of Bitcoin and the overall industry.

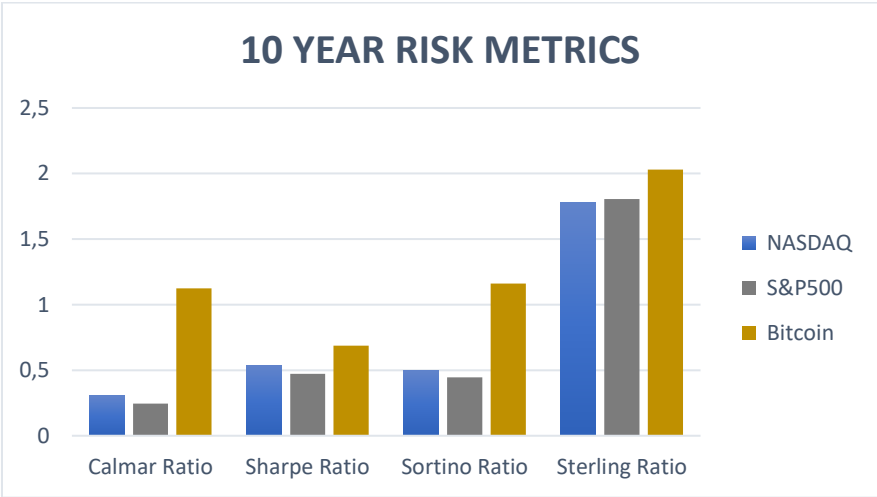


Figure 10: Annualized Risk Metrics Chart (2013-2022)

Despite Bitcoin being extremely volatile, the risk-adjusted performance measures show that Bitcoin performed way better in terms of risk-adjusted returns. All the relevant metrics can be seen from figure 7, which shows how dominant Bitcoin was in comparison during the last 10 years. One counterargument to this is that Bitcoin wasn’t widely known in 2013, and those who bought probably didn’t see it as a serious investment at the time. However, its risk adjusted returns have still been some of its major selling points for many investors. The appeal of very high returns still attracts investors to speculate on its price.

Table 4: Annualized Risk-performance measures. (2018-2022)

Risk Metrics (2018-2022)	Bitcoin	S&P500	NASDAQ
Annualized return	2,93 %	7,51 %	8,69 %
Annualized Risk	73,07 %	21,86 %	25,67 %
Risk Free rate 5 year	2,39 %	2,39 %	2,39 %
Sharpe Ratio	0,01	0,23	0,25
Beta	-0,130	1	1,115
Treynor	-0,042		0,056
Downsides	635	586	573
Semi variance	0,21 %	0,02 %	0,03 %
Semi deviation	72,16 %	23,30 %	27,65 %
Max Drawdown	82,96 %	33,92 %	36,40 %
Average drawdown	49,82 %	6,92 %	9,27 %
Sortino Ratio	0,008	0,220	0,228
Calmar Ratio	0,007	0,151	0,173
Sterling Ratio	0,011	0,740	0,679

Table 4 shows the annualized risk and performance measurements for investors who took a lump sum investment in Bitcoin, S&P 500 and Nasdaq on 1. January 2018. In contrast to the previous table, we now see that Bitcoin yields worse annualized returns than the two indices. This is also evident when we examine risk measures alone. Bitcoins annualized volatility, semi deviation, max drawdown, average drawdown, and number of downside events ultimately indicates that Bitcoin carries a higher level of risk, and the potential for large losses.

From a long-term saving perspective, the risk profile of Bitcoin is considerably higher compared to the two other indices. The high levels of risk combined with low returns also affects the risk performance measures, making Bitcoin the worst performing investment of all three, during this period. This further supports our assumption that timing the market is extremely difficult, and that some investors may be better off with a DCA-strategy to reduce some of the downside deviation.

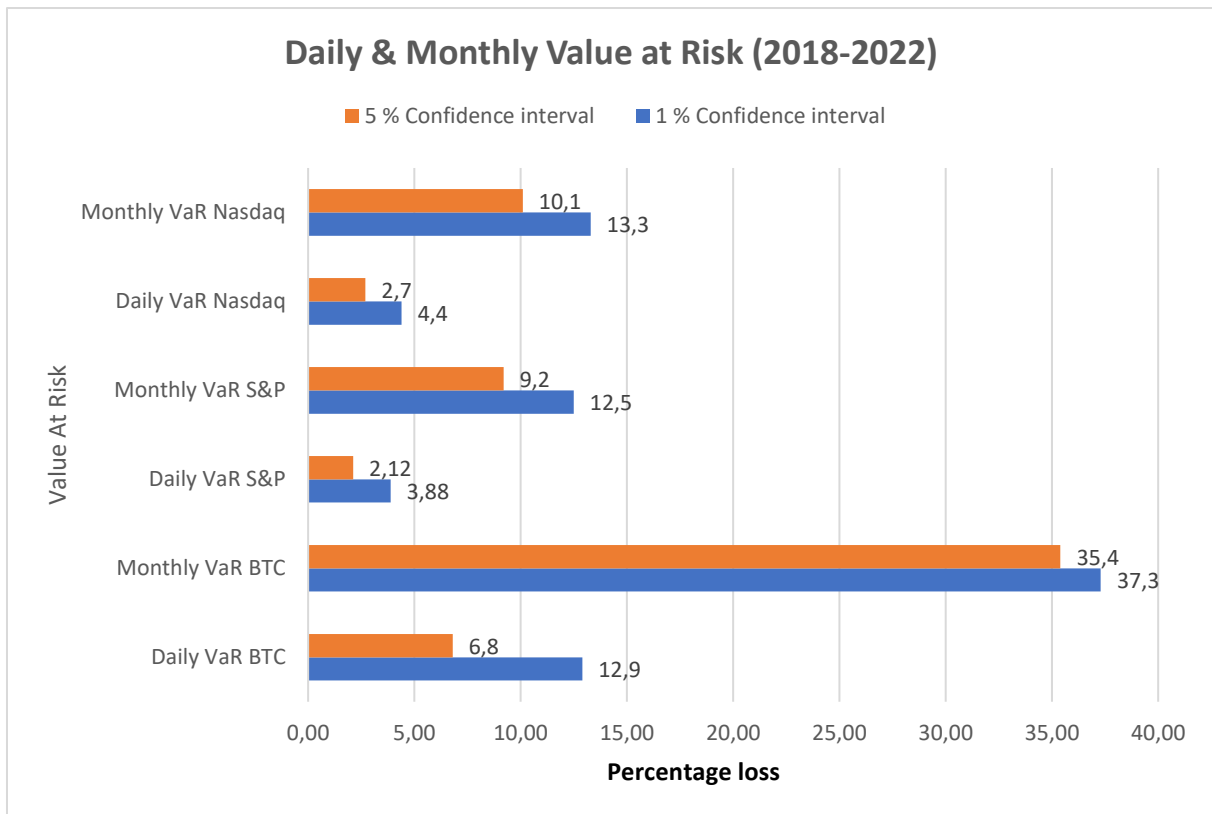


Figure 11: Monthly and daily Value at Risk. (2018-2022)

By looking at the last 5 years in figure 11 we can see that the daily Value at Risk for Bitcoin has decreased for both confidence levels, and that the opposite has happened for both Nasdaq and the S&P 500. This could be of interest for those investors preaching the store of value narrative for Bitcoin since its Value at Risk drops during period of turbulence in the overall market. A deeper analysis on this specific matter is needed to conclude on this, however, and as we can see, Bitcoin is still way above both indices. When we look at the observations from the last 5 years, we see that all potential losses have increased, except for Bitcoin on a 1% level which is still at the same level as it was when we looked at the past 10 years. The period might be a little short when we are using monthly observations, but it gives us some perspective on losses in the overall market compared to Bitcoin, when the interest rate has changed as much as it has in the last 5 years. For instance, on the 5% confidence level Bitcoin has increased 7,6% while Nasdaq has increased by over 26% when we compare the numbers from the last 10 years with the last 5 years. The expected shortfall from this period can be seen in [Table 7](#).

Table 5: Annualized risk performance measures. (2020-2022)

Risk Metrics (2020-2022)	Bitcoin	S&P500	NASDAQ
Annualized return	31,83 %	5,92 %	5,27 %
Annualized Risk	73,19 %	25,45 %	29,51 %
Risk Free rate 3 year	1,90 %	1,90 %	1,90 %
Sharpe Ratio	0,41	0,16	0,11
Beta	-0,20	1	0,82
Treynor	-1,50		0,04
Downsides	372	360	349
Semi variance	0,22 %	0,03 %	0,04 %
Semi deviation	74,11 %	26,70 %	31,53 %
Max Drawdown	76,64 %	33,92 %	36,40 %
Average drawdown	42,25 %	8,70 %	12,16 %
Sortino Ratio	0,404	0,151	0,107
Calmar Ratio	0,391	0,119	0,093
Sterling Ratio	0,708	0,463	0,277

Table 5 shows the annualized risk and performance measurements for all three assets using a lump sum investment over the three-year period, from January 2020 to December 2022. The annualized return of Bitcoin now yields 31.83%, which is larger than it was if you invested in 2018. This further shows that Bitcoin exhibits a high degree of uncertainty, which again indicates that timing a market buy-in is extremely challenging, if not impossible. Comparing the two traditional indices, however, shows that S&P 500 actually yielded higher annualized returns than Nasdaq during this investment period.

4.2 Dollar Cost Averaging: Bitcoin, S&P 500 and Nasdaq

In this part, we will present a comparative analysis of the dollar cost averaging (DCA) on Bitcoin, S&P 500 and Nasdaq. We have chosen to show the results for the last five, three and one year. The reason behind this is that Bitcoin gained mainstream attention during the bull run and we believe became an alternative investment in 2017-2018. Therefore, we can justify that someone might have seen an opportunity to start investing on a regular basis in this new and risky investment class. We have created various graphs and diagrams to visualize the comparison between the different periods and strategies.

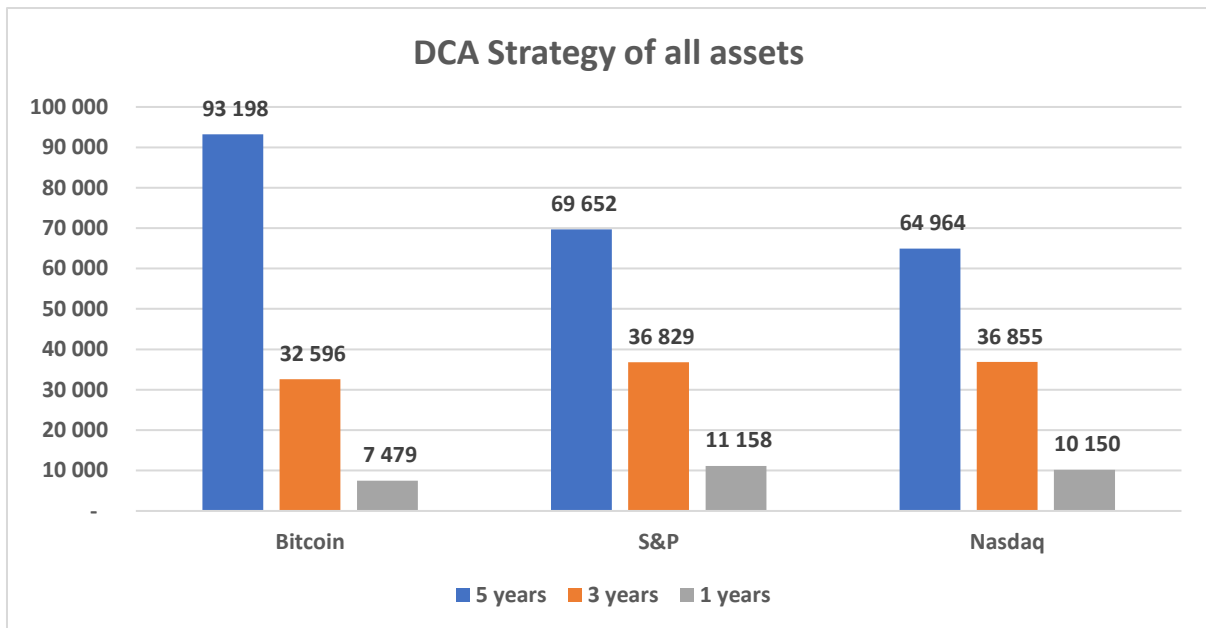


Figure 12: The dollar cost averaging strategy of Bitcoin, S&P500 and Nasdaq Composite.

When we look at the 5-year period we can see that Bitcoin has performed well compared to S&P 500 and Nasdaq indices, even though Bitcoin had massive drawdowns in both 2018 and 2022. For the shorter time frames, Bitcoin has underperformed the indices for both 3- and 1-year periods. But these two periods are quite short when we want to look at long-term investing. For a risk seeking investor, this performance might not be that frightening after all, considering that Bitcoin dropped over 75% from its all-time high in 2021. It is also worth mentioning that both the indices had several months with almost 10% drawdowns in 2021-2022, so it has been unusually volatile in the overall market as well.

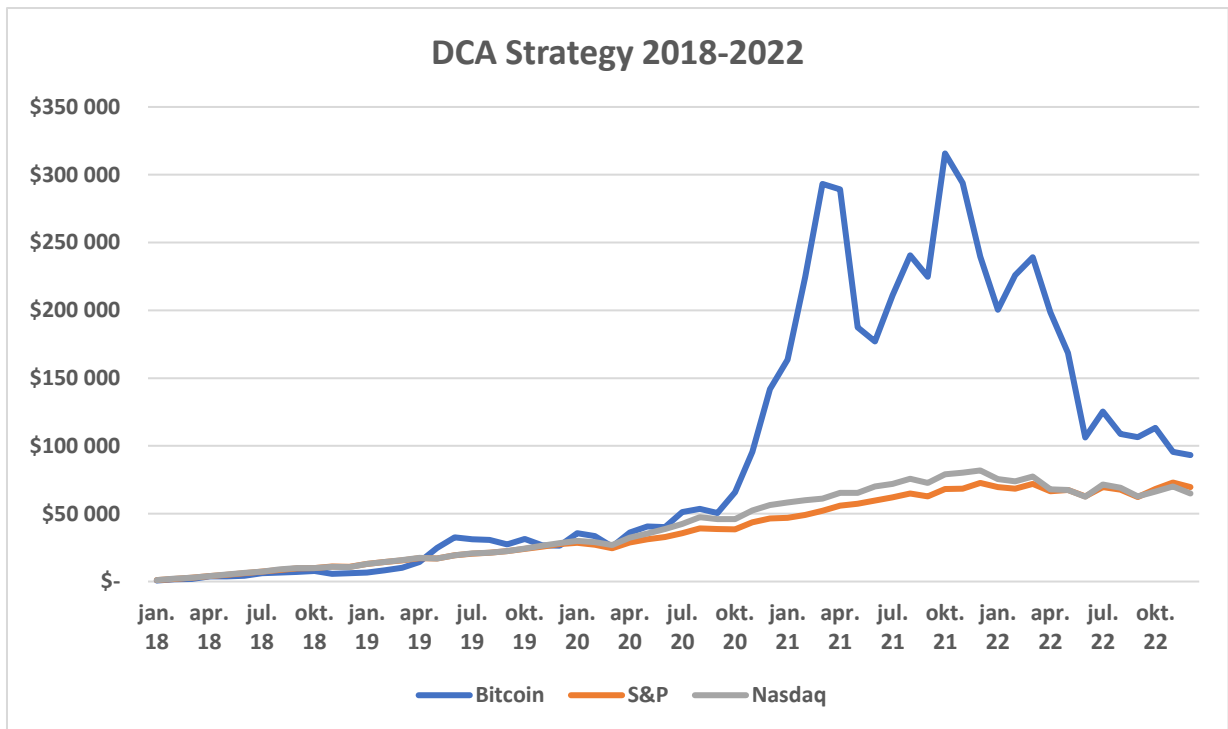


Figure 13: Illustrates a single asset portfolio using the dollar cost-averaging strategy for Bitcoin, S&P500 and Nasdaq composite. Investment horizon (jan. 2018 - des 2022)

In figure 13 we can see how the portfolios have fluctuated with a dollar cost averaging strategy starting at the beginning of 2018. Since the Covid lockdown in March 2020, the Bitcoin strategy has stayed above the indices. Even though a DCA strategy is supposed to get rid of some of the stress from the volatility in Bitcoins price, it is highly likely that it would affect an investors stress level when the price rises as much as it did both in 2020 and 2021. Should the investor sell at any point because of unimaginable short-term returns, or could the price go even further? The large drawdowns will then feel like a big loss if he didn't sell. In other words, the investor needs to be risk seeking or have the ability to completely shut out the short-term swings.

4.3 Dollar Cost Averaging vs. Lump Sum: Bitcoin

In this part, we will present a comparative analysis of the dollar cost averaging (DCA) with a lump sum investment (LSI) by only looking at Bitcoin as the investment asset. The purpose of this analysis is to shed light on the advantages and disadvantages of both investment strategies. We have chosen to compare the last 5- and 3-years, as these distinct time frames will give us valuable insights into the suitability of each investment approach.

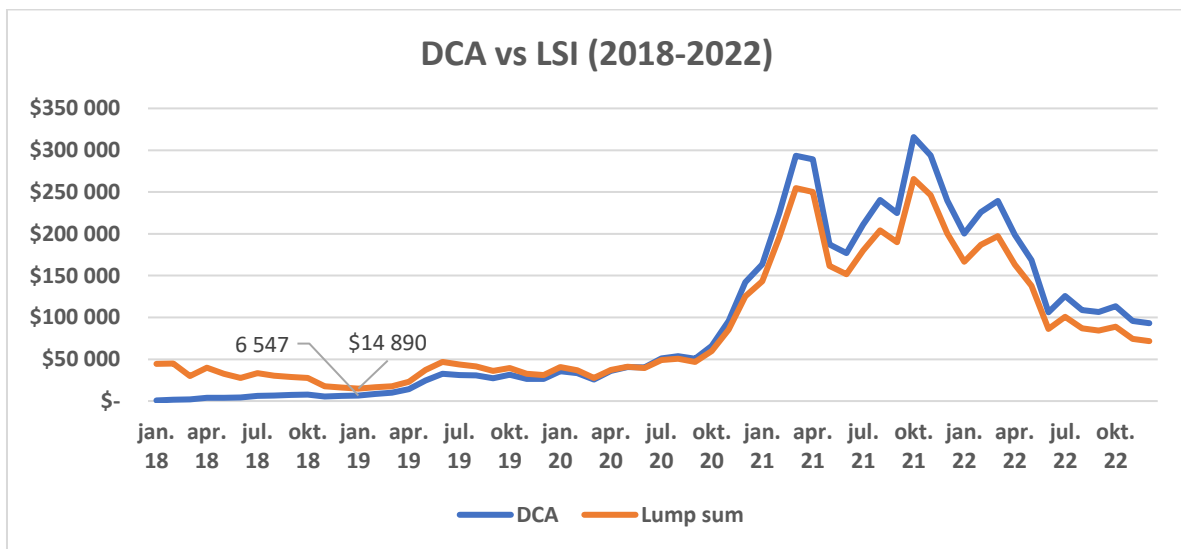


Figure 14: Illustrates the portfolio value over time for a DCA-strategy and a lump-sum strategy. (2018-2022)

Figure 14 compares the historical performance of a DCA strategy with that of a lump-sum investment (LSI) starting at the first day of 2018. To illustrate the comparison between the two strategies, we assume that \$60 000 is immediately invested for LSI. For DCA, we assume a fixed amount of \$1 000 is invested at the beginning of every month until the total of \$60 000 is allocated into Bitcoin. Once the DCA investment is complete, both portfolios have equal amounts of cash allocated. Since the investment is immediately made for LSI, it actually reflects the price movement of Bitcoin during this period. As can be seen from the graph above, Bitcoin decreased in value throughout 2018, and then fluctuated sideways until October 2020.

In the case above, the advantages of the DCA strategy come into effect. Due to its systematic investment approach, it mitigates timing risk, and the DCA-portfolio manages to buy Bitcoin at relatively lower price levels for over half of the 5-year period. At the end of 2022 the DCA portfolio was valued at \$93 198, while the LSI portfolio had a value of \$71 640, giving the DCA strategy a 30% higher return for this period. Another important aspect that isn't captured by numbers is the psychological and emotional problems that can arise from a lump sum investment. The initial investment of \$60 000 for LSI, was one year later worth \$14 890 (as marked in the figure above), which is a portfolio loss equal to -75%. In comparison the invested

amount at the time for DCA was \$13 000, and the portfolio was valued at \$6 547 which results in a loss of 49.64%. In terms of loss aversion this is much worse for the LSI approach, since the total investment is at risk, while for DCA only \$13 000 out of the total \$60 000 is invested. Based on the above, we can conclude that a DCA-strategy 1) outperforms an LSI strategy during bear markets, 2) mitigates timing risk as opposed to LSI and 3) reduces the emotional impact of losses.

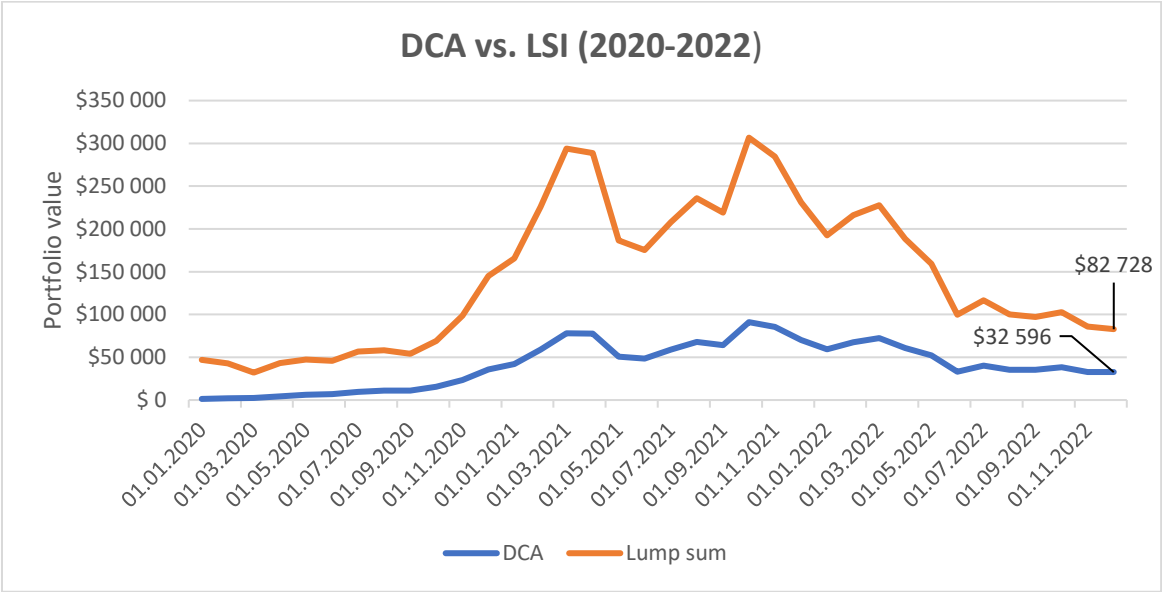


Figure 15: Illustrates the portfolio value over time for a DCA-strategy and a lump-sum investment (2020-2022)

Figure 15 also illustrates a comparison between LSI and DCA, but for the period from January 1, 2020, to December 31, 2022. For LSI, an initial investment of \$36 000 is put into Bitcoin in January 2020 and for DCA a fixed amount of \$1 000 is invested at the beginning of each month.

In this case, the advantage of LSI comes into effect. By placing all your money to “work” immediately in a rising market, makes the full investment amount increase in value due to the price appreciation of Bitcoin. A DCA on the contrary, only gets a smaller portion of the total investment (2.778% each month) exposed to the rising market. While the DCA strategy mitigates the timing risk, it comes with a particular downside, namely that the total investment wont fully benefits from the upwards trending market. The portfolio value for each strategy is shown above, and LSI outperforms DCA by a large margin. We can therefore conclude that an LSI outperforms a DCA-strategy during bull runs.

Ultimately, the choice between these strategies is an individual preference which depends on the goal of the investment, risk tolerance and market outlook. Additionally, one must not forget the many inherent risks within this market, and whether the choice falls on DCA, LSI or any

other investment strategy for that matter, one must remember the extreme risk measures as presented earlier.

Further research that compares these investment strategies with randomized starting dates would be needed to draw any conclusions on which strategy outperforms the other in the long run. Randomized starting dates would eliminate biases and provide a more robust assessment than has been done in this study.

4.4 Rolling Standard Deviation and Correlation

To get a better view of how risky Bitcoin is as an investment compared to S&P 500 and Nasdaq indices, we have chosen to visualize the standard deviation for the daily returns with both one year rolling intervals and then monthly rolling intervals for both a 5- and 10-year period. This lets us observe if there have been any ongoing trends for Bitcoin's volatility during the ten-year period. The 1-year and monthly rolling standard deviation for all assets during the period 2013 to 2022 can be observed from **Figure 20** and **Figure 21** respectively.

By inspecting figure 20 and 21, it becomes evident that Bitcoin has over the 10-year period experienced a significantly higher volatility in comparison to the two indices. The 1-month rolling average volatility for Bitcoin is 24.1%, which is significantly higher than S&P 500 and Nasdaq's average of 4.2% and 5.1%. Another notable finding, which is easily observed by inspecting the figures, is the extreme volatility for Bitcoin during 2013 and 2014, which exhibited volatility over 400%. Given these extreme values, we have also chosen to present the volatility for the more recent period, 2018-2022.

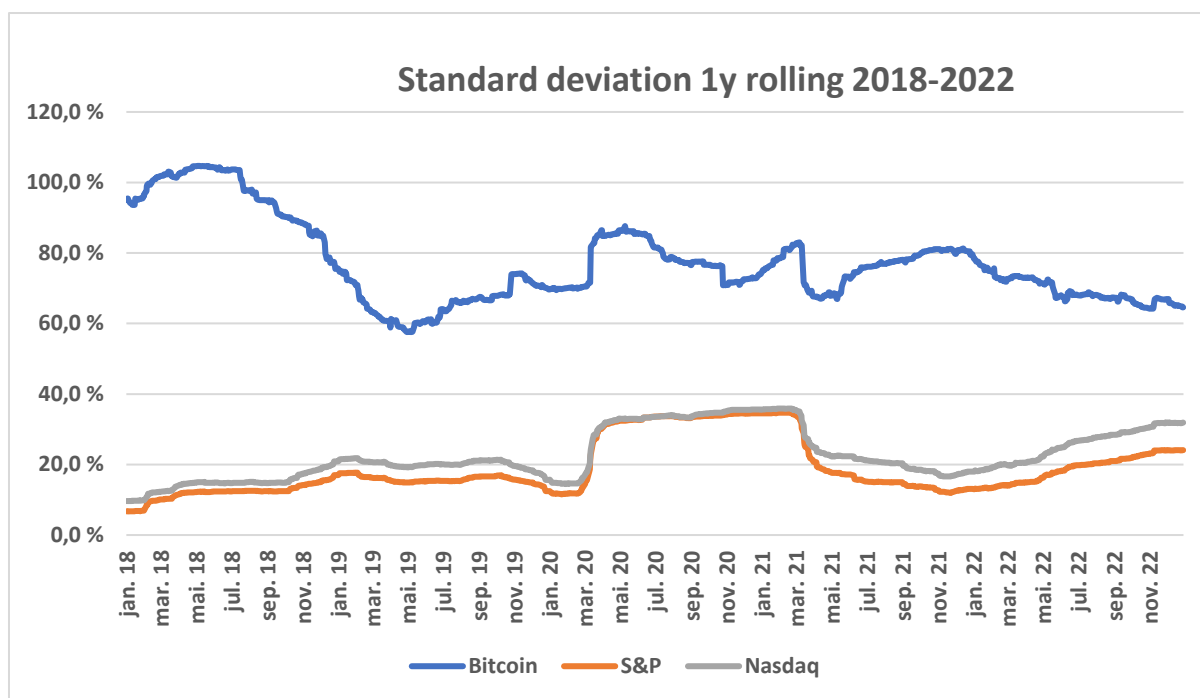


Figure 16: Standard deviations are calculated consecutively by using returns from the last 252 trading days.

Figure 16 shows a much more interesting period, because Bitcoin’s volume and adoption has come a long way since its inception and there were some major events that influenced the stock market in extreme directions as well. For example, Covid 19, inflation and frequent rate changes up and down.

The Covid-19 pandemic brought a lot of volatility to the stock market, increasing from under 20% all the way up to almost 40%. Bitcoin also increased a lot in the beginning of the Covid 19 crash in March 2020, but it didn’t stay there for the same amount of time as S&P 500 and Nasdaq did.

Another interesting thing to notice is that Bitcoin’s volatility decreased in 2022, while the other two indices went in the opposite direction. The stock market became more volatile with increasing interest rates, which Bitcoin did not. But overall Bitcoin still has a volatility way higher than the indices we have looked at, and this can delay further institutional adoption as we discussed in the literature review.

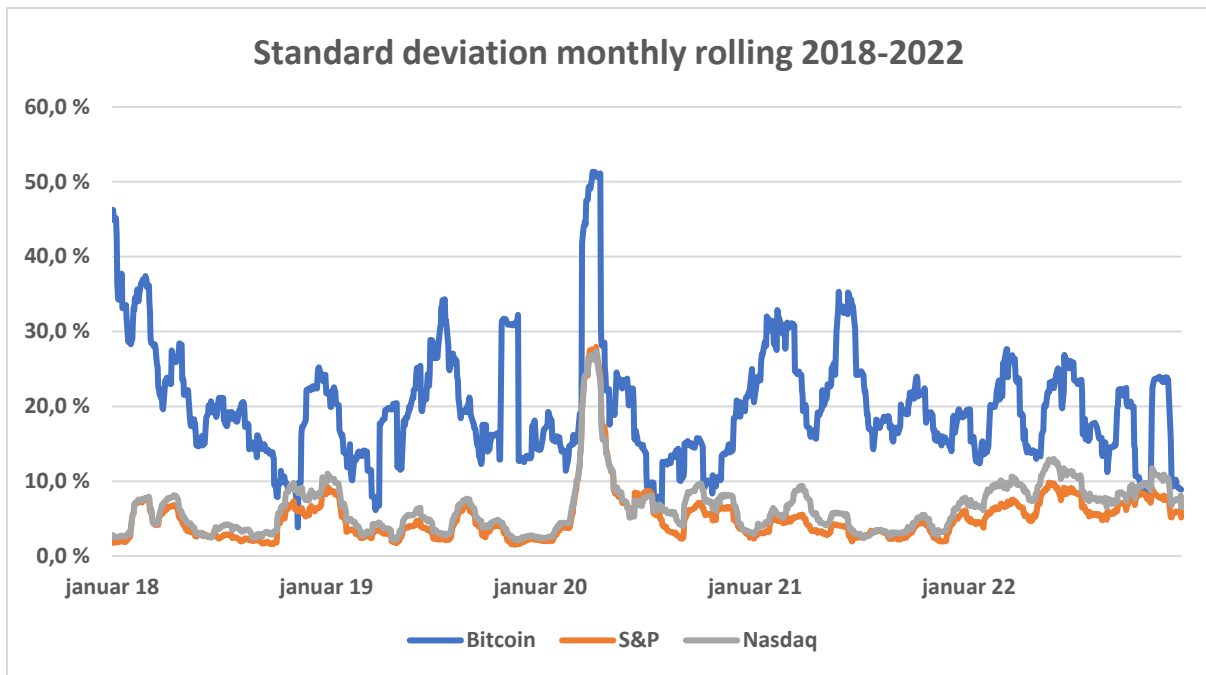


Figure 17: Standard deviations are calculated consecutively by using returns from the last 21 trading days.

We can clearly see a spike in volatility for S&P 500 and Nasdaq in approximately March 2020 during the Covid 19 pandemic. But here we can also see that Bitcoin spiked a lot more during the same period.

An interesting thing to notice is Bitcoin's drop after that big spike, with volatility under 10%. Maybe caused by investors leaving Bitcoin for safer assets during a time of crisis. Though, it is still hard to find evidence of Bitcoins volatility to stay lower at longer time periods. A biased view may see a positive trend from January 2021 regarding volatility, but it still has quite a few spikes during the last year.

In our study, we wanted to look at the correlation between Bitcoin and S&P 500, as well as between Bitcoin and Nasdaq, to see if there is any trend or development during the ten-year period. We achieved this by calculating a one year rolling correlation and a monthly rolling correlation based on daily returns.

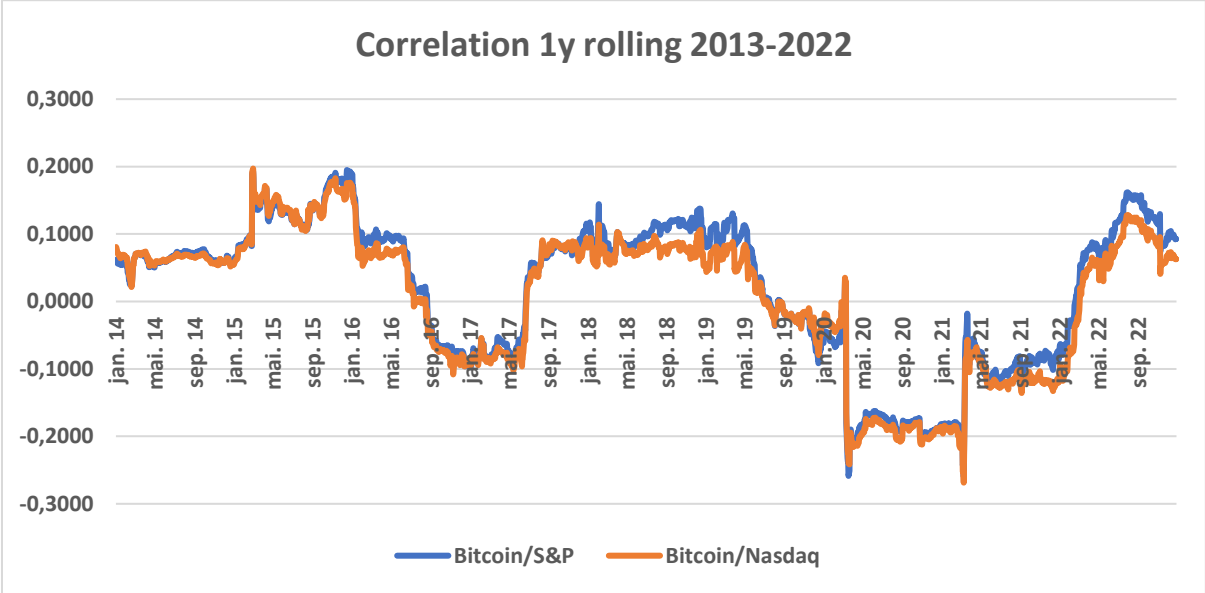


Figure 18: Correlations are calculated at all points by using returns from the last 252 trading days.

By looking at the one year rolling correlation for Bitcoin we can see that, for most of the period, the correlation lies between 0.2 and -0.2 for both the S&P 500 and Nasdaq. We can also see that there seems to be a strong correlation between S&P 500 and Nasdaq.

Historically gold has had a near-zero correlation with the S&P 500. Since Bitcoin is swirling around zero correlation with the S&P 500 it could be interesting to look at Bitcoins correlation with gold, to see if there could be anything in the store of value narrative for Bitcoin by comparing the two.

One mentionable finding is that the correlation dropped during Covid 19. But for the overall period it's hard to find a strong pattern, other than that the correlation remains at very low levels throughout the whole period. If the correlation value is below 0.3, the correlation is none or very weak.

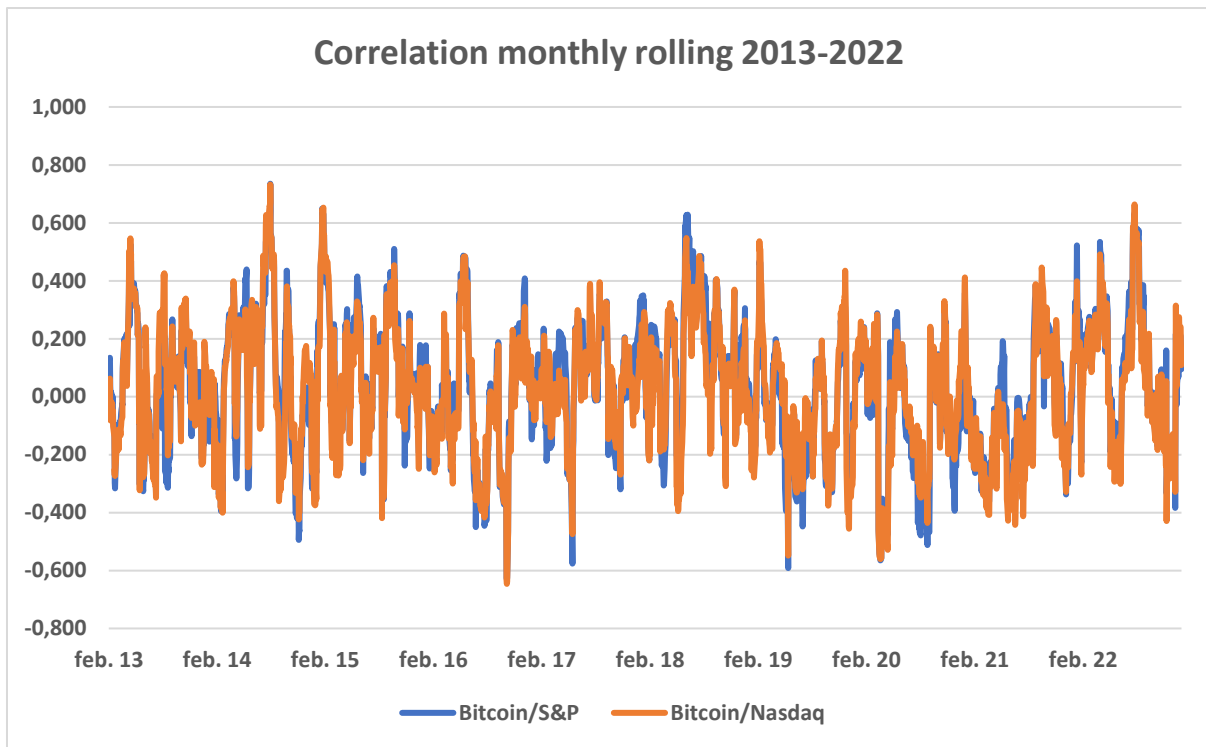


Figure 19: Correlations are calculated at all points by using returns from the last 21 trading days.

The correlation for monthly rolling Bitcoin returns has a much wider spread for both the correlation with S&P 500 and Nasdaq. We can also see here that there is a high probability that S&P 500 and Nasdaq have a strong correlation. The correlation goes much higher and lower for the monthly rolling compared to the yearly rolling. From this we can tell that for certain monthly periods the correlation between Bitcoin and S&P 500 and Nasdaq hits a moderate level of correlation, which is between 0.5-0.7. It also seems like a stationary process, where the mean is probably somewhere close to zero and it's hard to see if it is trending up or down in the long run.

5 Concluding remarks

In this thesis we show that Bitcoin has performed better than S&P 500 and Nasdaq the for the 10- and 3-year holding period. However, for the five-year holding period, Bitcoin has underperformed the indices. Due to the high risks associated with Bitcoin, as evidenced by its value at risk, expected shortfall, downside deviation, and other industry-specific risk factors such as low liquidity and high operational risk, it is reasonable to conclude that investing in traditional established indices is much wiser choice for a normal risk-averse investor. Whereas the cryptocurrency market can be compared to the internet in 1998, the indices have a long-standing track record, consisting of hundreds of well-established companies. We also find that Bitcoins standard deviation was much higher than for the indices, resulting in a much higher Value at Risk and Expected Shortfall. Neither did we find any solid evidence supporting a downwards trend in volatility for Bitcoin. Thus, Bitcoin still seems to remain an investment opportunity for the risk seeking investor.

When it comes to investment strategies, we reveal that the DCA strategy outperforms LSI when initiated in 2018, showing its effectiveness during a market downturn, and its benefits regarding loss aversion compared to LSI. However, for 2020, we found that an LSI outperformed DCA, reflecting its advantage during bull markets. We advise others to conduct further research with randomized starting points to draw more conclusive findings on which strategy outperforms the other for Bitcoin in the long run. Further research could also investigate including Bitcoin as part of a portfolio.

Our research also shows that Bitcoin has a very low correlation with the indices throughout the investigated period. This characteristic suggests that Bitcoin may have the potential to act as a hedge against the stock market, but additional research is necessary to conclude on this. Since S&P 500 and Nasdaq seemed to be very correlated it could have been interesting to use a more speculative investment object instead of the Nasdaq index to get a wider spectre of investments regarding risk.

While the potential of blockchain technology has been widely recognized as a disruptor by many institutions, only time will tell whether Bitcoin can maintain its dominant position, or if another cryptocurrency will prevail as a formidable contender. We therefore argue that to reduce the reliance and dependency on only Bitcoin, investors who primarily seeks to speculate and profit (but not use cryptocurrencies) should explore blockchain exchange-traded funds (ETFs) to achieve a more diversified exposure to this rapid evolving market.

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Attachments

Table 6: Expected shortfall for all assets (2013-2022).

Expected shortfall (2013-2022)	Daily ES 1%	Daily ES 5%	Monthly ES 1%	Monthly ES 5%
Bitcoin	24,07 %	13,24 %	38,87 %	36,25 %
S&P	4,67 %	2,74 %	12,51 %	9,65 %
Nasdaq	5,04 %	3,23 %	13,26 %	10,51 %

Historical Expected shortfall for all assets from 2013 to 2022. Table shows both daily and monthly expected shortfall, both on 1% and 5% confidence intervals. As an example, the interpretation for the daily expected shortfall is that in 1% of the daily returns we could see an expected shortfall of 24,07% in daily return.

Table 7: Expected shortfall for all assets (2018-2022).

Expected shortfall (2018-2022)	Daily ES (1%)	Daily ES (5%)	Monthly ES (1%)	Monthly ES (5%)
Bitcoin	16,55 %	10,89 %	37,30 %	36,42 %
S&P	5,89 %	3,42 %	12,50 %	10,34 %
Nasdaq	6,07 %	3,92 %	13,30 %	11,29 %

Historical Expected shortfall for all assets from 2018 to 2022. Table shows both daily and monthly expected shortfall, both on 1% and 5% confidence intervals. Similarly, as above, the monthly expected shortfall can be interpreted as in 5% of the monthly returns, the average shortfall is 36.42%

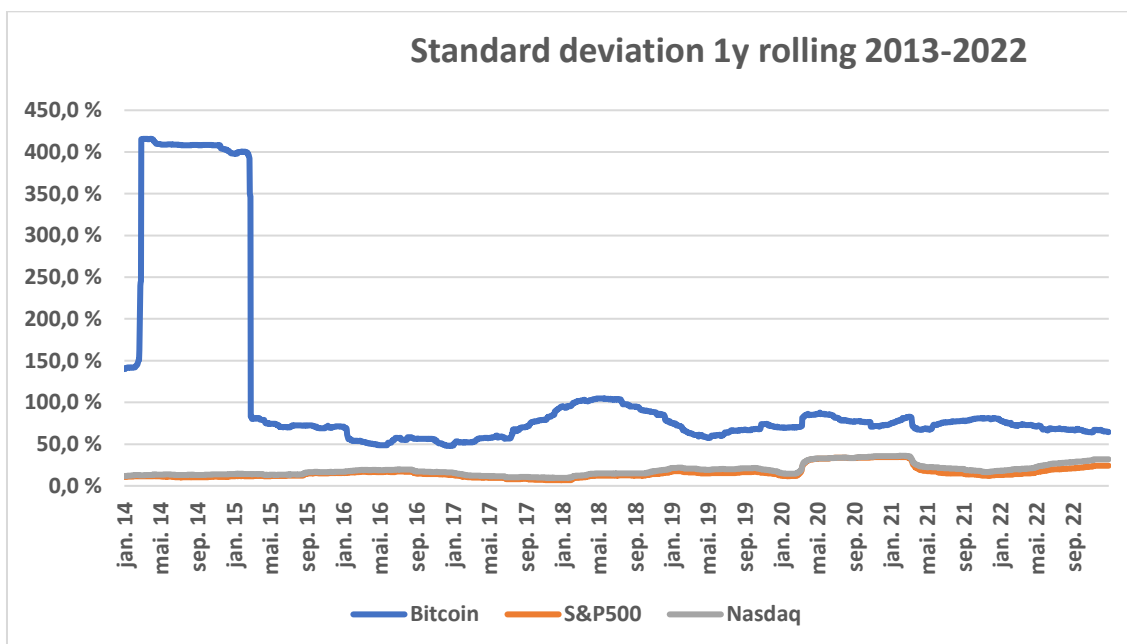


Figure 20: Standard deviation 1-year rolling for all assets, (2013-2022).

Figure 16 shows 1-year rolling Standard deviation, which are calculated at all points by using the last 252 trading days.

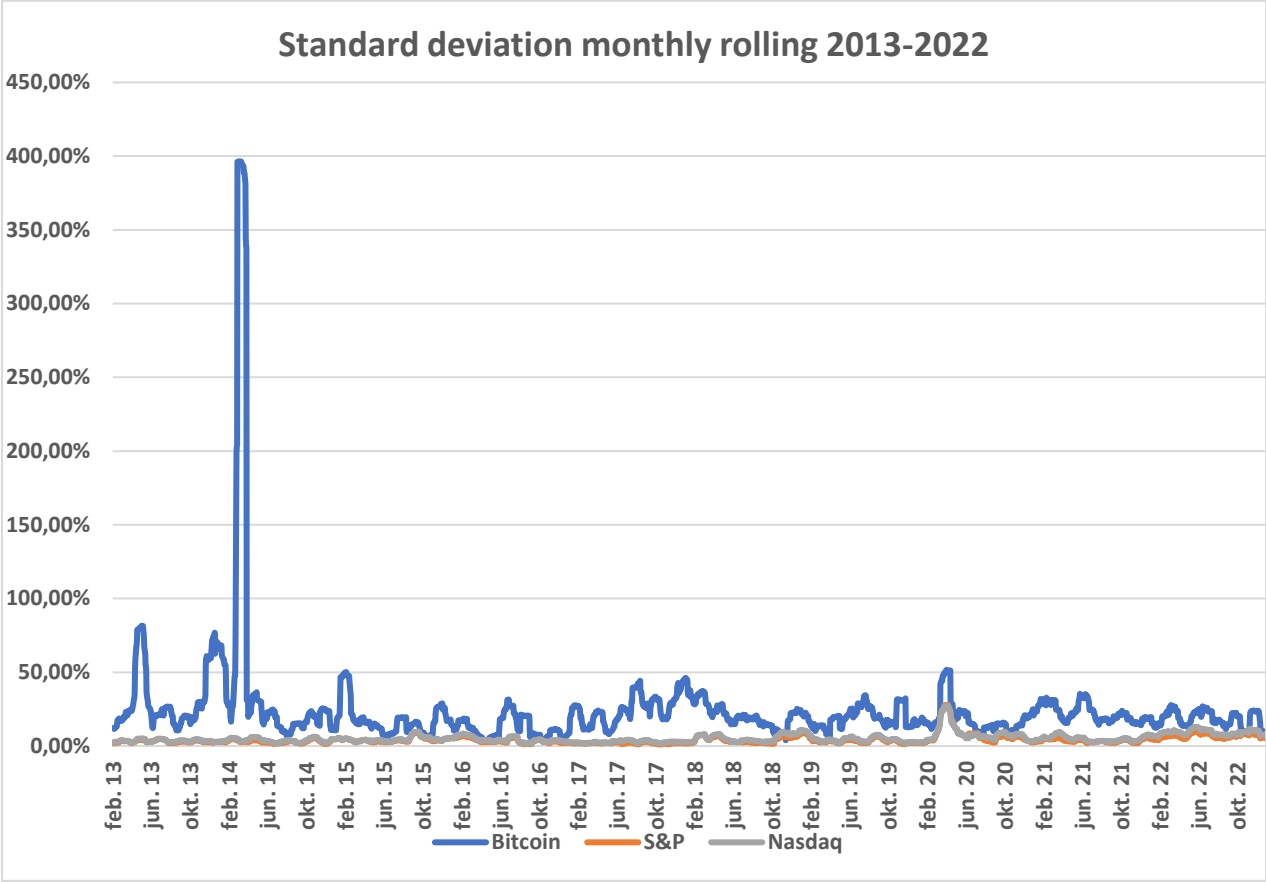


Figure 21: Standard deviation monthly rolling for all assets, (2013-2022).

Figure 18 shows the monthly rolling standard deviation for all assets, which are calculated at all points by using returns from the last 21 trading days.