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DEPARTMENT OF INTELLIGENT SYSTEMS
ÚSTAV INTELIGENTNÍCH SYSTÉMŮ

IMPROVING PREDICTION OF AUTOMATED TRADING STRATEGIES BASED ON DISPARATE EXTERNAL SOURCES

ZLEPŠENÍ PREDIKCE AUTOMATIZOVANÝCH OBCHODNÍCH STRATEGIÍ NA ZÁKLADĚ RŮZNÝCH EXTERNÍCH ZDROJŮ

BACHELOR'S THESIS
BAKALÁŘSKÁ PRÁCE

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Bachelor's Thesis Assignment

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Institut:	Department of Intelligent Systems (DITS)
Student:	**Říčný Matěj**
Programme:	Information Technology
Title:	**Improving Prediction of Automated Trading Strategies Based on Disparate External Sources**
Category:	Data Mining
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Assignment:

1. Study existing trading strategies and approaches for various financial instruments (including cryptocurrencies). Analyze the claimed results of the studied strategies, their assumptions, and data sources.
2. Study existing simulation tools suitable for testing trading strategies and compare them.
3. Analyze the backlog of chosen financial instruments and analyze observed external events.
4. Implement a simulation tool for a comparison of various trading strategies and test it with at least 3 existing strategies.
5. Propose at least one improvement of existing strategies and test it on your simulation tool.
6. Evaluate your improveement and compare it with other supported strategies in your simulation tool.
7. Discuss further improvements and limitations of the practical deployment.

Literature:

- Bankless: "How to make money trading stablecoins", https://newsletter.banklesshq.com/p/how-to-make-money-trading-stablecoins
- HodlBlog: "When Does Portfolio Rebalancing Improve Returns?", https://www.hodlbot.io/blog/when-does-portfolio-rebalancing-improve-returns
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- The Shrimpy Team: "Crypto Users who Diversify Perform Better", https://hackernoon.com/crypto-users-who-diversify-perform-better-new-research-ebf775d348dd
- The Shrimpy Team: "Portfolio Diversity: A Technical Analysis" https://hackernoon.com/portfolio-diversity-a-technical-analysis-c2c49f4d3a77

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Points 1-3.

Detailed formal requirements can be found at https://www.fit.vut.cz/study/theses/

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Abstract

This thesis aims to enhance long-term investment strategies by improving capital efficiency and risk management. The analysis initially focused on two major cryptocurrencies: Bitcoin and Ethereum. Three strategies were tested: HODL, Dollar-Cost Averaging, and Hourly Rebalancing. After conducting tests, the Dollar-Cost Averaging strategy was chosen for further development. The Improved DCA approach dynamically adjusts investment amounts based on sentiment-driven external indicators, which were found to be more relevant for Bitcoin. This sentiment-driven adjustment allows investors to allocate capital more effectively while avoiding overheated market conditions. The final results demonstrate that the improved DCA strategy achieved higher returns with less invested capital, providing a more efficient alternative to traditional long-term investment methods.

Abstrakt

Cíl této práce je vylepšit dlouhodobé investiční strategie zvýšením efektivity investovaného kapitálu a snížením rizik. Analýza byla zpočátku zaměřena na dvě hlavní kryptoměny: Bitcoin a Ethereum. Byly testovány tři strategie: HODL, DCA a Hodinové Rebalancování. Na základě provedených testů byla pro další rozvoj vybrána strategie DCA. Vylepšená DCA strategie dynamicky upravuje výši investic na základě externích sentimentálních indikátorů, které se ukázaly jako více relevantní pro Bitcoin. Tento přístup umožňuje efektivnější alokaci kapitálu a zároveň pomáhá vyhnout se přehřátým tržním podmínkám. Závěrečné výsledky ukazují, že vylepšená strategie DCA dosáhla vyšších zisků s nižším objemem investovaného kapitálu, a nabízí tak efektivnější alternativu k tradičním dlouhodobým investičním přístupům.

Keywords

Cryptocurrency, Long-Term Investing, Sentiment Analysis, DCA, HODL, Rebalancing, Backtesting, Simulation Tool, Capital Efficiency, Investment Strategies

Klíčová slova

Kryptoměny, Dlouhodobé investování, Sentimentální analýza, DCA, HODL, Rebalancování, Backtesting, Simulační nástroj, Efektivita kapitálu, Investiční strategie

Reference

ŘÍČNÝ, Matěj. *Improving Prediction of Automated Trading Strategies Based on Disparate External Sources*. Brno, 2025. Bachelor's thesis. Brno University of Technology, Faculty of Information Technology. Supervisor Ing. Ivan Homoliak, Ph.D.

Rozšířený abstrakt

Oblast investování a obchodování na finančních trzích, zejména pak s kryptoměnami, se v posledních letech stala velmi populární. Oproti tradičním investičním nástrojům, jako jsou například akcie, jsou však kryptoměny výrazně volatilnější. Tato extrémní volatilita představuje výzvu jak pro běžné investory, tak i pro zkušené obchodníky a vyžaduje efektivní řízení rizik a použití dobře promyšlené a otestované investiční strategie.

Jednou z možností, jak čelit této nejistotě, je využití dlouhodobých investičních přístupů, které snižují dopad krátkodobých výkyvů na celkový výsledek portfolia. Tato práce se zaměřuje právě na dlouhodobé investování kryptoměn, především dvou nejznámějších: Bitcoinu a Etherea. Cílem bylo vylepšit některou z již existujících dlouhodobých strategií. Pro testování byly vybrány tři různé strategie – HODL (držení kryptoměny bez ohledu na vývoj ceny), DCA (pravidelné investování stejné částky) a Hodinové Rebalancování portfolia (vyvažování investic každou hodinu dle alokace).

Pro efektivní testování všech strategií byl navržen a implementován vlastní simulační nástroj v jazyce Python, který umožňuje načíst historická tržní data, otestovat tyto investiční strategie na širokém spektru časových období a generovat grafy a statistiky výkonnosti.

Na základě výsledků těchto testů byla pro další rozvoj zvolena strategie DCA, která vykazovala nejstabilnější a nejpředvídatelnější výsledky z hlediska výnosnosti i řízení rizik. HODL sice v některých obdobích dosahoval vyšších zisků, avšak kvůli nevhodnému načasování vstupu na trh často zaznamenával i výraznější ztráty, což mohlo vést k dlouhodobě nevýhodné výkonnosti portfolia.

Tradiční strategie DCA byla následně upravena do podoby vylepšené DCA, jejímž cílem je zefektivnit alokaci kapitálu v závislosti na aktuální situaci na trhu. Namísto investování pevné částky každý měsíc strategie dynamicky upravuje výši investice na základě externích dat, která by mohla ovlivnit kryptoměnový trh. V rámci této práce byly shromážděny a analyzovány různé typy dat: makroekonomické ukazatele (např. úrokové sazby, inflace), indikátory tržního sentimentu (FNG a CBBI) a tweety (např. Elon Musk, Michael Saylor).

Z následných analýz však vyplynulo, že největší korelaci s cenovým vývojem Bitcoinu mají právě sentimentální indikátory. Ty se proto staly klíčovým prvkem pro rozhodování o tom, jaká výše částky bude investována.

Pokud byl trh ve "strachu", tedy když hodnoty indikátorů jako Fear & Greed Index (FNG) nebo CBBI klesly pod zvolenou prahovou hodnotu, strategie investovala vyšší částku, aby využila příznivějších nákupních podmínek. Naopak v obdobích "chamtivosti", kdy byly indikátory na vysokých hodnotách, investice byla redukována, čímž se předešlo neefektivnímu nákupu v přehřátém trhu.

V rámci testování byly porovnány různé přístupy, jak s těmito sentimentálními indikátory pracovat: hodnoty v den investice, minimální, maximální, průměrná nebo medián měsíčních hodnot indikátorů. Jako nejefektivnější se ukázala práce s hodnotou v den investice. Strategie byla dále testována s různými násobky investice, aby bylo dosaženo nejefektivnější práce s kapitálem.

Závěrečné výsledky potvrdily, že vylepšená DCA strategie dosáhla vyšších výnosů s nižším objemem investovaného kapitálu a zároveň vykazovala menší riziko ve srovnání s klasickými přístupy HODL a tradiční DCA. Tím prokázala, že za využití tržního sentimentu lze dosáhnout efektivnějšího dlouhodobého investování kryptoměn.

Improving Prediction of Automated Trading Strategies Based on Disparate External Sources

Declaration

I hereby declare that this Bachelor's thesis was prepared as an original work by the author under the supervision of Mr. Ing. Ivan Homoliak, Ph.D. I have listed all the literary sources, publications and other sources, which were used during the preparation of this thesis.

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Matěj Říčný

May 9, 2025

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Chapter 1

Introduction

Automated trading strategies have transformed the financial markets by enabling faster, data-driven decisions and eliminating the emotional biases often affecting human traders. By using predefined algorithms to execute trades, these strategies can monitor multiple markets at once, identify opportunities in real-time, and optimize the execution of trades with precision.

These strategies are tested on historical data and continuously adjusted based on market conditions, making them essential tools in modern finance. However, while automated systems excel at processing large volumes of historical data and technical indicators, their effectiveness can be significantly limited if they do not account for external events that can dramatically impact asset prices.

In today's interconnected world, external factors shape market dynamics. Economic announcements, global conflicts, and even social media posts can lead to sharp price movements within seconds. For instance, a single tweet from a prominent figure can cause significant fluctuations in the prices of cryptocurrencies or stocks, potentially disrupting even the most sophisticated technical trading models. If automated trading systems fail to incorporate these external influences, they may react too late or incorrectly interpret sudden market changes, leading to significant financial losses.

Incorporating external events into automated trading strategies is essential for improving risk management and profitability. A strategy that relies solely on price momentum may struggle when faced with a sudden market reversal triggered by negative news.

This thesis aims to improve predictive accuracy in volatile markets by integrating external events. The goal is to connect existing trading strategies with the fundamental market forces influenced by these external events.

Chapter 2

Basics

This chapter overviews the fundamental concepts needed to understand automated trading strategies. It starts by defining trading strategies, explaining their purpose, and exploring various approaches to identify profitable market opportunities. The chapter then introduces financial assets, describing the different types of instruments, such as stocks, bonds, and commodities, that can be traded. Furthermore, it discusses technical and fundamental analysis, the two primary methods used to evaluate market trends and asset values.

2.1 Trading Strategy

To anticipate the market, traders can buy or sell financial assets, such as stocks, cryptocurrencies, or commodities, to make a profit. To make a profit, traders aim to predict where the market is heading and capitalize on its price movement. If the trader expects the market price to increase, he can enter a long position (buy an asset) and capitalize. If he expects the market price to decrease, he can enter a short position (sell an asset) and then wait for the market movement. The market can be very volatile, and it might be challenging to predict where it is heading. A trader must develop a trading strategy to navigate the complexities of the market effectively. A trading strategy is a plan a trader should follow that includes technical analysis, fundamental analysis, or both. The trading strategy should consist of market analysis as a whole and key elements like where to enter a trade (buy or sell an asset) and where to exit a trade to take profit or reduce risks in losing positions. This depends on the trader. Some are looking for long-term goals and might buy and hold an investment for an extended period, but traders can also capitalize on small market movements.

2.2 Financial Assets

A financial asset is an intangible asset representing value from a claim of ownership or contractual claim on an underlying asset, which can be either tangible or intangible. Financial assets are commonly used in investment and trading. Tangible assets, such as a company, financial institution, or commodity, typically back these assets. However, some financial assets may not supported by anything physical and may not hold intrinsic value [22]. Here are some common examples of financial assets that can be traded:

Cryptocurrencies

Cryptocurrency is a virtual currency that uses cryptography for secured transactions. Most cryptocurrencies are typically using blockchain technology, which is a decentralized system that saves every transaction. The digital payment method doesn't require banks to verify transactions, allowing for a peer-to-peer system where individuals can send and receive payments anywhere in the world.

In the blockchain, all transactions are publicly available (e.g., Bitcoin, Ethereum), but enterprises with restricted access can use private blockchains. Cryptocurrency holders do not own anything physical. They can buy currencies from brokers, store them in a digital wallet, and spend them as they wish.

Traders who want to invest in cryptocurrency should be prepared for high volatility, as prices can experience significant fluctuations [15]. Some of the most well-known cryptocurrencies:

Bitcoin

Bitcoin (BTC) is the first cryptocurrency and remains the most valuable one. It was created in 2008 by an anonymous individual or group using the pseudonym Satoshi Nakamoto, who has never been publicly identified. Bitcoin was introduced to the public in 2009 [7]. On January 3rd, 2009, the first Bitcoin block, Block 0 or Genesis block, was mined. Bitcoin mining rewards are halved every 210,000 blocks, which is about every four years, reducing the block reward by 50 %. This reduces the supply of bitcoins entering the market, creating scarcity that helps limit inflation and encourages long-term value preservation [5]. On April 19, 2024, the Bitcoin miners' block reward was halved from 6.25 BTC per mined block to 3.125 BTC. As mining rewards decrease over time, Bitcoin's inflation rate drops, contributing to its status as „digital gold“ [6].

Consensus Mechanism of Bitcoin

Bitcoin operates on a consensus mechanism called Proof of Work (PoW). In this system, participants in the network, called miners, compete to solve complex encryption puzzles. Solving these puzzles allows them to verify cryptocurrency transactions and add them to the blockchain.

Miners repeat attempts to find a solution that meets the difficulty target. As of May 17, 2024, this target required 83.148 trillion attempts per second per miner. The successful hash proves that the miner did the work, allowing the new block to be added to the blockchain.

Each miner validates the newly added blocks and proposes new ones. New blocks contain the header hash of the previous block, creating a chain of proofs that ensures consensus across the network. This entire process guarantees the security and decentralization of the network [41].

Ethereum

Ethereum (ETH) is similar to Bitcoin, but the key difference is in their supplies. Bitcoin has a limited total supply, while the amount of ETH that can be created is not restricted.

In 2021, non-fungible tokens (NFTs) became extremely popular. Most early NFTs were created on the Ethereum blockchain, which remains one of the most popular platforms for NFTs. An NFT is a digital asset with an identifying token and private key, which

gives access only to its owner. The NFT can also be traded and recorded as a blockchain transaction [20].

Consensus Mechanism of Ethereum

Ethereum initially used a competitive Proof of Work (PoW) validation process. In this system, miners were rewarded with block rewards for validating transactions. There was no cap on the issuance of ETH, and mining rewards were consistent, which made the system inherently inflationary. This system issued approximately 13,000 ETH daily, leading to an annualized inflation rate of 4.09%. In 2022, after years of development, it transitioned to Proof of Stake (PoS). PoS differs from PoW by eliminating energy-intensive mining and relying on validators who stake ETH to propose and validate blocks. New blocks are finalized and closed once multiple validators confirm their accuracy.

Solo validators must stake a minimum of 32 ETH to activate their role, or they can join staking pools with smaller amounts. A validator proposes a block, which is then verified and voted on by a committee of other validators through attestation. Validators receive staking rewards instead of mining rewards. The consensus mechanism, Gasper, rewards honest validators and penalizes dishonest ones by burning their staked ETH, effectively removing it from circulation [20]. This transition has made Ethereum potentially deflationary, especially during periods of high network activity when more ETH is burned than issued. Daily issuance of ETH has significantly decreased to about 1,600 ETH per day, resulting in an annual inflation rate of approximately 0.52% [21].

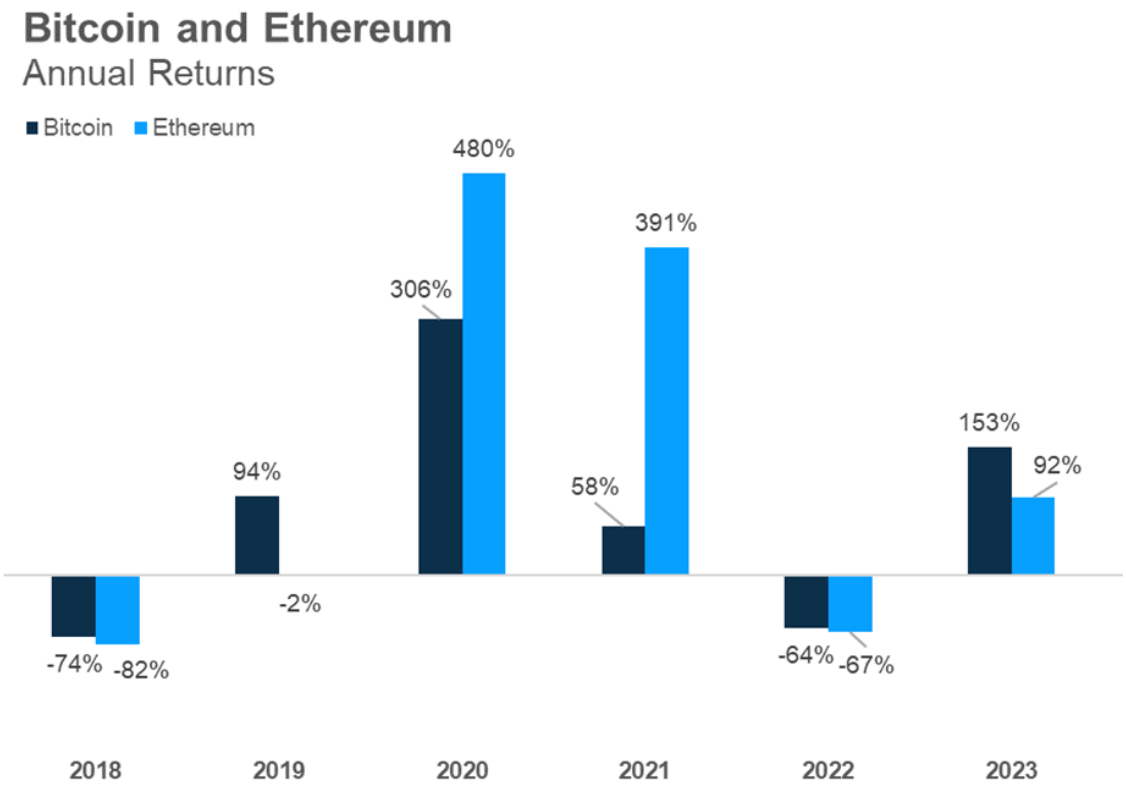

Figure 2.1: Annual returns of Bitcoin and Ethereum from 2018 to 2023 [10].

Tether

Unlike Bitcoin and Ethereum, known for their high volatility, Tether (USDT) is the largest stablecoin in the cryptocurrency market. Stablecoins are designed to have stable prices and avoid substantial market fluctuations. USDT is a cryptocurrency tied to the value of the U.S. dollar and is backed by Tether, a company owned by iFinex. Long-term investors of BTC or ETH may choose to convert their holdings into USDT to preserve their capital in stable assets, especially during extreme market volatility or if they are expecting a significant price drop [57].

Stocks

Stocks are financial instruments that represent company ownership, commonly called shares. Buying stocks is purchasing a small ownership share of the company. The shareholders benefit if the stock price increases and some companies distribute dividends. Dividends allow shareholders to earn returns on their investments without selling their shares. These payments are typically distributed quarterly, but some companies can also schedule dividends monthly or annually. Well-known companies like Apple, Microsoft, and Johnson & Johnson provide regular dividend payments to their shareholders.

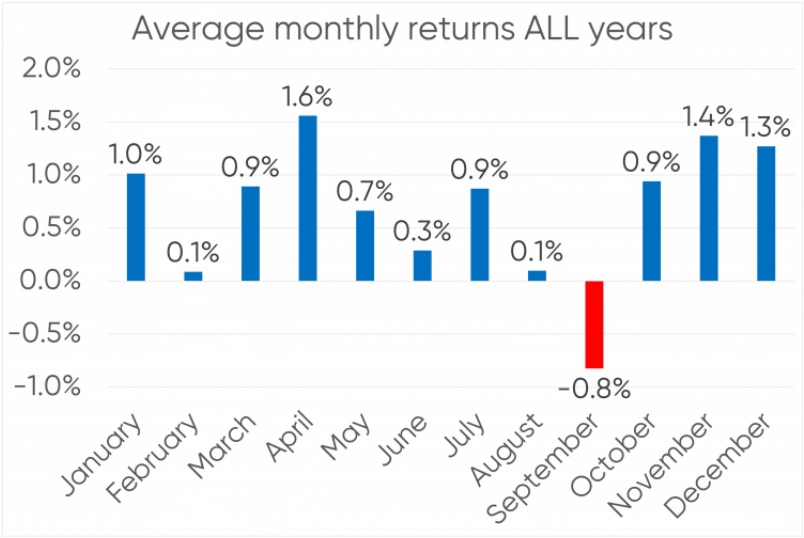

Figure 2.2: Average Monthly Returns of the S&P 500 Over All Years [52].

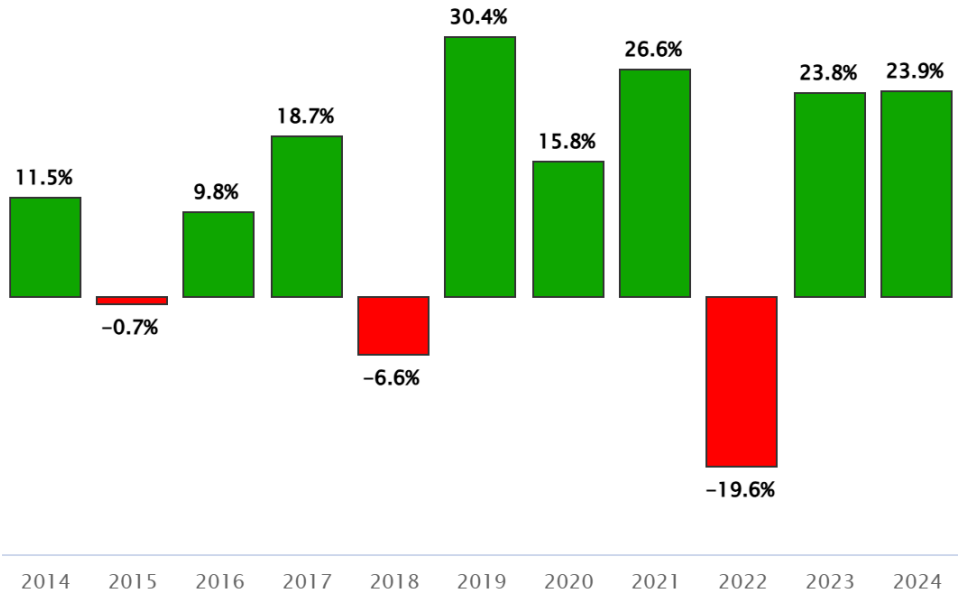

Figure 2.3: S&P 500 Yearly Performance Over the Last 10 Years (2014–2024) [50].

Commodity Markets

Commodity markets enable the trading of products sourced from the earth. Commodities are divided into two primary categories: hard commodities and soft commodities. Hard commodities, such as gold, silver, and oil, include natural resources that must be mined or extracted. Soft commodities refer to agricultural products or livestock, including corn, coffee, and sugar.

Trading commodities has existed since ancient societies, where communities and tribes exchanged food, supplies, and essential goods through bartering. Today, commodities are traded globally but with much more sophistication. The establishment of exchanges and derivative markets has improved the trading of commodities. These exchanges standardize and regulate transactions, creating a more reliable and streamlined system for trading goods and contracts.

Trading commodities can involve more risk than stocks due to their inherent volatility and various risk factors, including geopolitical events, natural disasters, and weather conditions. Traders should consider these elements when developing their market strategies [14].

2.3 Market Participants

Understanding the participants in financial markets and their roles is crucial for anyone looking to trade or invest. This section explores the key participants in financial markets and their impact on trading and investment strategies.

Retail Trader

A retail trader or investor is an individual who buys and sells financial assets for their accounts rather than for an organization. Retail traders typically enter the market with smaller amounts of capital than institutional investors, which means they have less impact on market prices [32].

Brokers

Retail traders cannot directly trade on the Stock Exchange. They need a broker to execute their trades. Brokers are intermediaries who execute trades on behalf of retail traders. Some brokers also trade on their accounts, known as broker-dealers. Most brokers offer online platforms allowing traders to execute their trades directly [32].

Institutional Investors

Institutional investors or traders operate in financial markets at a significantly larger scale than retail traders. They manage large pools of capital for individual investors or organizations. Institutional investors can significantly impact market prices because of the size of their trades. Institutional traders include banks, pension funds, and hedge funds [38].

High-frequency Trading

High-frequency trading (HFT) is a type of institutional trading that relies on advanced technology. HFT firms use algorithms to detect patterns automatically and take advantage of small fluctuations in the market. They execute multiple trades at speeds beyond human capability, often within seconds or milliseconds. These trades are executed in large volumes to capture small profits from each transaction. Unlike retail or institutional investors, HFT firms do not hold positions overnight or build portfolios. Instead, they capitalize on small market fluctuations [38].

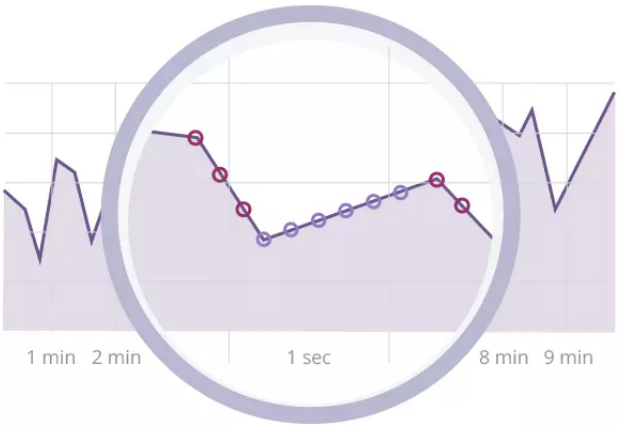

Figure 2.4: Automatically opens multiple positions within a second [38].

2.4 Technical Analysis

Technical analysis is a method for evaluating and predicting future price movements of financial assets based on historical price data and trading volume. Unlike fundamental analysis, which focuses on a company's financial health, industry position, and economic factors, technical analysis focuses solely on price and volume patterns displayed on charts. It assumes that all public and private information is already reflected in price movements and that historical trends will likely repeat.

Market Trend

One of the core principles of technical analysis is that prices tend to move in trends. A trend is defined as the overall direction in which the market moves. There are three main types of trends. The first is the uptrend, characterized by higher highs and higher lows. This shows that the market has strong buying power, leading to a price increase. On the other hand, the downtrend is characterized by lower highs and lower lows. This indicates that sellers are in control, leading to a price decline. The third trend, the sideways trend, is when the price of an asset moves within a narrow range without showing significant upward or downward momentum. Unlike uptrends or downtrends, a sideways trend indicates a balance between buyers and sellers, with no clear direction for the price movement.

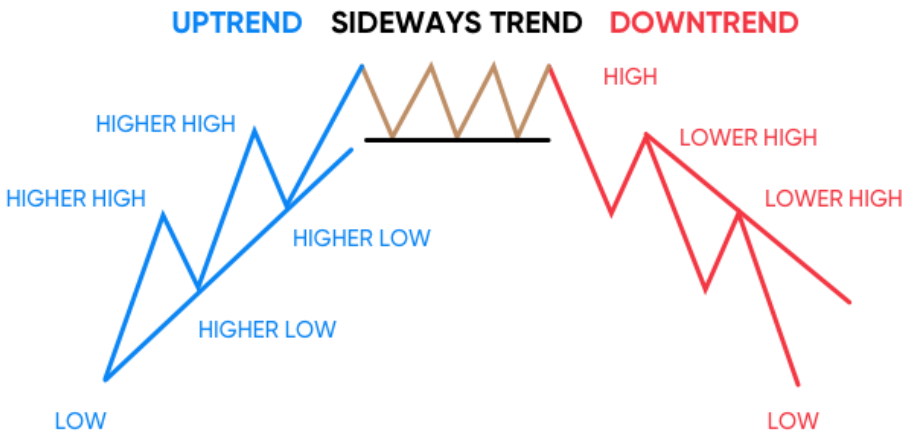

Figure 2.5: The market trend is determined by observing higher highs and lower lows [13].

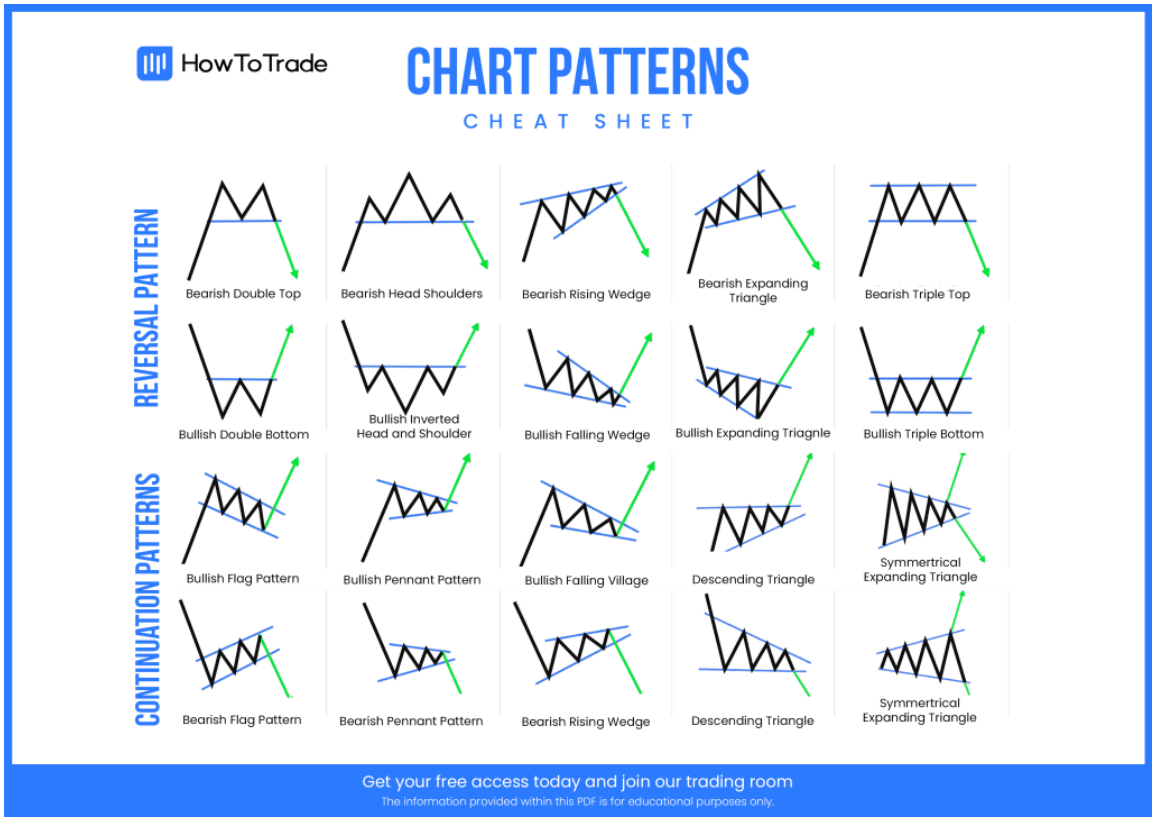

Figure 2.6: Examples of known reversal and continuation patterns [39].

Chart Patterns

Identifying market trends is a key aspect of technical analysis, as they are the foundation for chart patterns. Trends indicate the general direction in which a financial asset is moving over time. Chart patterns provide traders with visual tools to identify potential reversals or continuations of these trends. Price movements create patterns that reflect market psychology and the forces between buyers and sellers. By recognizing chart patterns, traders can predict future price movements based on historical data, allowing them to align their trades with the current market condition.

Chart patterns fall into two main categories: reversal and continuation patterns. Each type of pattern indicates a different potential outcome for the trend, either indicating that it is likely to reverse or will continue in the same direction.

2.5 Fundamental Analysis

Market movements are influenced by more than just technical analysis. Fundamental analysis aims to determine the actual value of an asset, whereas technical analysis focuses on predicting price movements based on historical data. Fundamental analysis involves analyzing various macroeconomic and microeconomic factors. By analyzing multiple macroeconomic factors, like interest rates, inflation, and gross domestic product (GDP) levels, an investor determines the economy's overall direction, which he can integrate with technical analysis [26].

Chapter 3

Investment and Trading Strategies

This chapter presents two approaches to the market: investment and trading strategies.

Investment strategies have been used to buy and hold an asset over extended periods, typically a year or more. Investors usually focus on long-term goals, paying less attention to short-term market fluctuations.

Trading strategies instead focus on a short-term approach, looking to capitalize on small price movements over days, weeks, or months. Traders typically concentrate more on technical analysis, observing chart patterns and market trends. They may also utilize technical indicators to help them identify market trends or determine if the market is overbought or oversold, like moving averages (MA) or the Relative Strength Index (RSI).

3.1 HODL

This straightforward long-term investment strategy refers to „hold on for dear life, “ which advises other crypto investors not to sell and to keep holding the asset in the highly volatile cryptocurrency market. This term was first used by a user named GameKyuubi, who posted on the crypto forum Bitcointalk in 2013 with the title „I AM HODLING. “ Since then, other crypto investors have frequently used it [28].

Since the original HODL was posted, this simple strategy had incredible outcomes. In 2013, the price of Bitcoin was around $750. Today, it's at approximately $90,000, and even if investors bought at the start of the 2024 year, bitcoin prices are up about 100 %. It might benefit investors to deal with emotions as they are not actively managing the asset based on high market volatility and instead focus on the long-term goal.

3.2 DCA

Dollar-cost averaging (DCA) can help investors answer one of the most fundamental and essential questions: „When should I invest in an asset?“ With DCA, there's no need to time the best price in the market. Instead, this strategy involves regularly investing the same amount of money into a desired asset regardless of its price at the time of investment.

Unlike a HODL strategy, which can have the risk of investing all the money at the wrong time, DCA spreads the investment over time [18].

For example, imagine an investment of $1000 every two weeks. When the market is down, the $1000 investment will lead to getting more units of the asset. However, if the

price rises over time, the investment may lead to fever units on average, where HODL would perform better.

DCA involves investing fixed amounts at regular intervals, regardless of market conditions. This approach can cause a miss of potential gains during favorable markets and won't effectively reduce risks during unfavorable conditions.

A study [19] introduced a variation called DCA Plus, which employed a machine learning algorithm to assess market risk. When the algorithm identifies a lower-than-average risk, it increases the investment amount and reduces the investment when a higher risk is identified. This strategy was backtested from 2020 to 2022, including the bear and bull market for Bitcoin.

The analysis compared regular investments over 180, 90, and 30 days. From 2020 to 2021, DCA Plus provided, on average, 50 % higher returns than standard DCA and, at its best, outperformed by over 100 %. When the risk was computed as high between August 2021 and February 2022, the worst loss experienced by standard DCA was nearly 60 %, while the worst loss by DCA Plus was 56.4 %, achieved by buying less at the top.

3.3 Portfolio Rebalance

Portfolio rebalancing is a strategy that investors use to maintain desired asset allocation when holding multiple assets. This strategy ensures that the portfolio aligns with the investor's goals and risk management. Investors determine the percentage of their portfolio to allocate to each asset. When an asset performs better than others, rebalancing will help restore the value of each asset to its original portions by redistributing the gains from the outperforming investment [48]. The two most common rebalancing strategies:

Periodic Rebalance

This strategy is based on rebalancing portfolios at fixed time intervals, regardless of asset value. For example, consider a portfolio of $1,000 containing four assets. We want to check every 24 hours if the assets are invested equally. Initially, the assets are worth $200, $300, $230, and $270. Every 24 hours after rebalancing, each investment will be worth the same, as shown in 3.1.

To show the potential of this strategy, a study [27] on cryptocurrencies found that increasing the number of assets can improve investment outcomes. The study also found that the best fixed period for rebalance was one hour. The tested portfolios contained a random number of assets in the range of 2-10, where the assets were also selected randomly. When comparing a random rebalancing period in the one-hour and one-month range, the results showed that rebalancing over one year of data outperformed a HODL strategy by a median of 64 %.

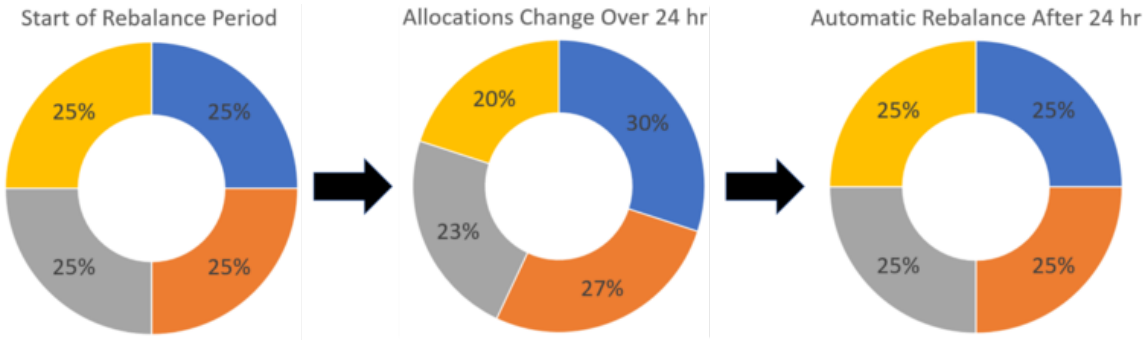

Figure 3.1: Periodic rebalance after 24 hours. [48]

Threshold Rebalance

In this approach, the portfolio is not managed according to time. Rebalancing does not occur at fixed intervals. Instead, rebalancing occurs when some assets reach the set threshold [48].

Let's use the example from a periodic portfolio where each asset was allocated with the same percentage and additionally set the threshold at 5 %. Rebalancing occurs only when some assets reach 5 % more or less from their original allocation. Figure 3.2 shows that rebalance takes place when an asset exceeds 30 % or falls below 20 % of the total portfolio. This means that rebalance is unnecessary if all assets are performing similarly.

A study [58] compared threshold rebalancing to the HODL strategy in cryptocurrency portfolios over three years, which included the bull market of 2020-2021 and the bear market of 2022. The thresholds tested were 1 %, 5 %, 10 %, 15 %, 20 %, 25 %, and 30 %. These thresholds were backtested on a portfolio containing ten randomly selected assets. The average performance of all threshold rebalancing strategies versus HODL was 60 %. Among the various thresholds, the 15 % threshold rebalancing gained the highest returns, achieving 77 %.

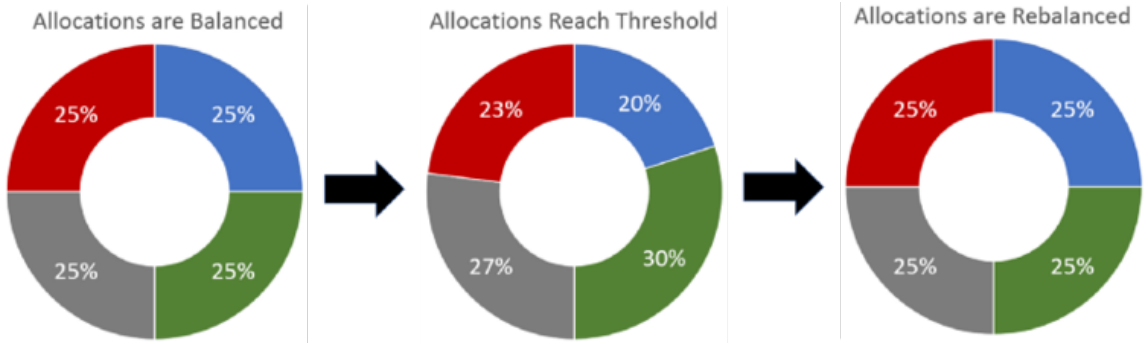

Figure 3.2: Threshold rebalancing happens after the asset reaches the set threshold [48].

3.4 Day Trading

Day trading is about capitalizing from small movements in the market by executing multiple trades within the same day. Day traders focus on technical analysis to detect patterns and identify signals for entering and exiting trades.

It is very common for day traders to use leverage to increase gains from a minor movement in the market. However, there is also a potentially higher risk of taking more significant losses. Therefore, a trader needs to have strict risk management rules for their strategy and adhere to them. Additionally, managing emotions is an essential aspect of this approach [17].

3.5 Swing Trading

Swing trading focuses on more significant moves in the market that can take over days or weeks. Unlike day trading, swing traders seek to capitalize on more substantial price changes rather than small fluctuations. They must first identify the market trend to capture significant price movements in the desired direction.

Open positions in swing trading don't need to be actively managed, which can help traders with their emotions. Traders can automate their strategies by setting orders to execute on the desired price, setting a stop loss, and taking profit orders. This automation allows traders to anticipate no longer the trade, which may help execute the strategy and prevent emotions from occurring [17].

3.6 Support and Resistance

Support and resistance are vital for technical analysis, helping traders identify potential price levels where the market might pause or reverse [54].

Support

Support is a price level at which the market stops falling and starts attracting buyers, preventing prices from slipping and potentially reversing a downtrend into an uptrend [54].

Figure 3.3: The market wholly reversed after testing the support level four times [55].

Resistance

Resistance refers to a price level where upward movement ceases, as selling power becomes stronger than buying power, preventing the price from rising above that level [54].

Figure 3.4: In this example, the price stopped two times at the same resistance level before continuing its downward trend. We can expect a similar outcome if the price tests this level again [55].

Figure 3.5: When the price approaches the upper resistance level of 141.533, the trader has the opportunity to sell and expects the market to return to the lower support level of 140.614, which might be an opportunity to buy [43].

3.7 Range Trading

This strategy doesn't follow market trends, allowing traders to capitalize on movements in both directions. A trading range exists when a market fails to break through two significant price levels, leading to consistent movement between these levels (support and resistance). In Figure 3.5, the market struggles to breach these two important levels, allowing range trading [43].

3.8 Break and Retest

Break and retest is a popular strategy that allows traders to profit from price movements in both upward and downward directions, taking advantage of short-term and long-term trends. Firstly, the trader must spot the market range with solid support and resistance levels and then wait for a breakout.

Breakout might occur in either direction: the market can break below a support level or above the resistance level. When the price breaks below support, it often signals the beginning of a downtrend, known as a bearish breakout. But if the price breaks above a resistance level, the market signals a potential uptrend, a bullish breakout.

After the bullish or bearish breakout, the next step is to wait for a retest. A retest happens when the market returns to the previously identified support or resistance levels and sees if the price respects this level without breaking through. The need for retracement

Figure 3.6: The price failed to break the resistance 3 times before the bullish breakout, which signals a strong resistance level. After the breakout price returns to the broken resistance level and respects it, the trader can buy the asset and expect the price to increase [9].

is to confirm whether the broken level has become a new support or resistance level. Once the trader spots this whole break and retest pattern, they can decide to buy or sell the asset, which depends on what type of breakout happened [9]. Figure 3.6 shows a perfect example of what to look for in the market.

3.9 Technical Indicators

Technical indicators are valuable tools for analyzing market data. They provide insight into an asset's ongoing supply, demand, and other important metrics. These indicators help identify market trends, momentum, and potential reversal points. Using various indicators, traders can gain perspective on what to expect from the market and determine whether a trend will continue or reverse [56].

On-Balance Volume

The on-balance volume (OBV) is a technical indicator that measures trading volume to show the buying and selling power over time. It calculates progressive volume by adding the volume on days when the price increases and subtracting the volume when it decreases. The OBV value helps traders identify the overall flow of volume in the market [56].

When OBV is increasing, it says that buying power is strong, and the market is attracting more traders to buy. This pushes the price higher and can be used to confirm a bullish trend, as the upward movement is supported by rising buying volume.

When OBV decreases, it indicates higher seller volume, which might indicate a weakening uptrend or a continuing downtrend.

Moving Average

Moving average (MA) smooths price data over a specified period. The purpose is to show the overall trend of how the price moves and remove the short-term fluctuations.

Simple moving averages (SMAs) are types of MA computed by calculating the arithmetic mean of prices over a defined time frame. To demonstrate how to calculate SMA [34]:

$$SMA = \frac{A_1 + A_2 + ... + A_n}{n}$$

$$\begin{aligned} A &= \text{Average in period n} \\ n &= \text{Period in days} \end{aligned}$$

SMA might not be so accurate in the short term because it weighs every value equally. The exponential moving average (EMA) assigns more weight to recent prices, which can help identify market trends earlier How is EMA calculated [34]:

$$EMA_t = [V_t * (\frac{s}{1+d})] + EMA_y * [1 - (\frac{s}{1+d})]$$

$$\begin{aligned} EMA_t &= \text{Today's EMA} \\ V_t &= \text{Today's value} \\ s &= \text{Smoothing} \\ d &= \text{Period in days} \\ EMA_y &= \text{Yesterday's EMA} \end{aligned}$$

Moving Average Convergence/Divergence

Moving Average Convergence/Divergence (MACD) is used to identify market trends. It displays the relationship between two exponential moving averages (EMAs) of an asset's price action, which can also be used for trade entry points.

MACD line is calculated by subtracting the 26-day EMA from the 12-day EMA. The signal line is created from the MACD line by taking a 9-day EMA of the MACD line itself. The signal line is a potential entry point to buy or sell an asset. The market is bullish if the MACD line is above the signal line, indicating a possible buy opportunity. The market is bearish when the MACD line is below the signal line, and the trader can look for selling [31].

Relative Strength Index

The Relative Strength Index (RSI) is a momentum oscillator for technical analysis to measure the rate of recent price changes. It helps traders identify when the market is potentially overbought or oversold and can also signal when an asset might experience trend reversal or price corrections. J. Welles Wilder Jr. developed the RSI, first introduced in his book „New Concepts in Technical Trading Systems, "published in 1978. Since then, it has become a popular tool for traders.

The RSI is displayed as a line graph on a scale of 0 to 100. When the index is above 70, the market is overbought, while reading below 30 indicates that the market is oversold. These signals can be helpful in various market conditions and may provide buy or sell signals for traders [47].

Stochastic Oscillator

The stochastic oscillator is a price momentum oscillator, often used with the Relative Strength Index (RSI). It operates on the prediction that the closing price (the price of

the last transacted price before the market closes for regular trading [12]) should move in the same direction as the prevailing market trend.

This oscillator is also used to signal when the market is overbought or oversold, using values ranging from 0 to 100. The value is calculated by subtracting the period's low from the current closing price, dividing the result by the range for that period, and then multiplying by 100 to get a whole number. A value above 80 indicates an overbought condition, while a value below 20 indicates an oversold condition. When the market is strongly trending, the oscillator can remain in an overbought or oversold state for a long time.

While the RSI is particularly effective in trending markets, the stochastic oscillator performs better in trading ranges [53].

3.10 External Events Influencing the Market

The cryptocurrency market can be impacted by external events, triggering significant price movements in either direction. Influential factors such as social media activity, regulatory decisions, and macroeconomic changes often play a critical role in market volatility. This section explores examples of such events to demonstrate their impact on the cryptocurrency market.

Elon Musk's Tweets

Elon Musk has become a significant figure in the cryptocurrency space, often influencing prices through his activity on X. His public involvement with crypto began in February 2021 when Tesla announced a $1.5 billion investment in Bitcoin, which pushed its price to over $58,000. However, in May 2021, Musk tweeted that Tesla would stop accepting Bitcoin due to environmental concerns, causing a 10 % drop in value.

Musk's also had a significant impact on Dogecoin price. In early 2021, Dogecoin surged over 20 % after Musk tweeted, "Dogecoin might be my fav cryptocurrency. It's pretty cool." Another price spike occurred in April 2021 when Musk tweeted, "SpaceX is going to put a literal Dogecoin on the literal moon," leading to a 16 % price increase.

Musk's tweets have influenced the prices of major cryptocurrencies and lesser-known tokens like OP. In November 2023, his tweet, "Optimism is always better," was interpreted as support for the OP token, causing its price to increase over 12 % within just a few hours [35].

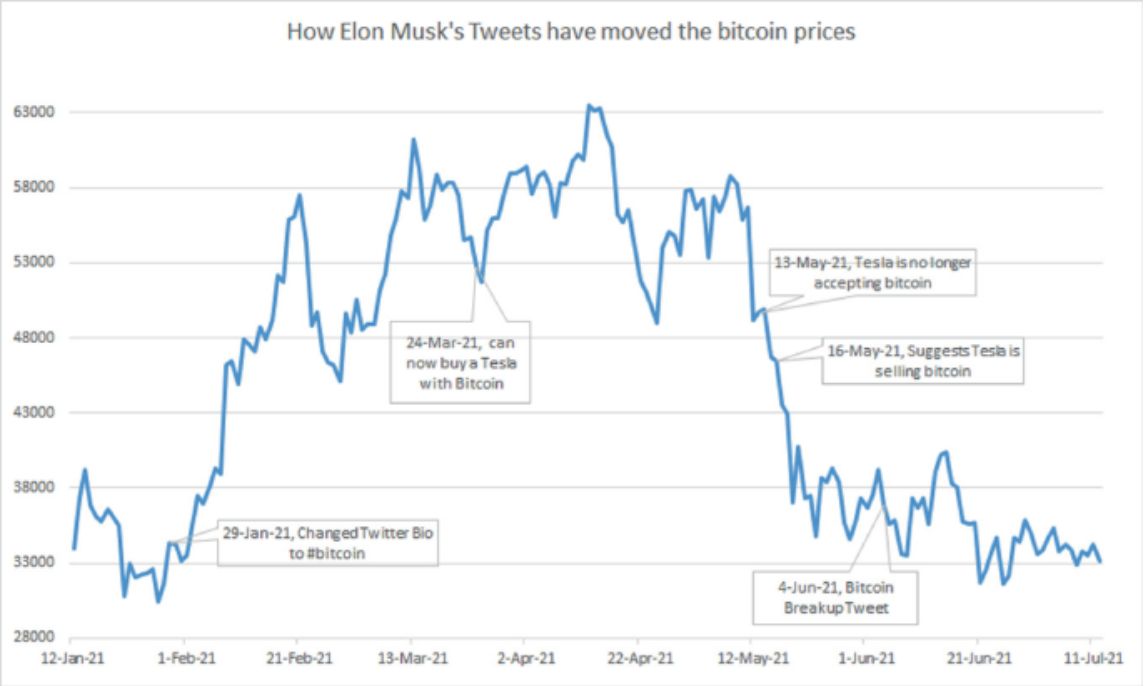

Figure 3.7: The graph shows how Elon Musk's tweets affected Bitcoin prices from January to July 2021 [36].

Tornado Cash Victory Case

In 2022, the U.S. Treasury sanctioned Tornado Cash after accusing it of laundering over $7 billion worth of cryptocurrency since its creation in 2019. In response, six Tornado Cash users, supported by Coinbase, filed a lawsuit against the Treasury. They contended that adding 44 Tornado Cash smart contract addresses to the sanctions list was unlawful.

On November 26, 2023, a U.S. appeals court ruled that the Office of Foreign Assets Control (OFAC) had overstepped its authority by sanctioning the immutable smart contracts of Tornado Cash. Following this ruling, Coinbase's Chief Legal Officer, Paul Grewal, posted on X, stating, "These smart contracts must now be removed from the sanctions list, and US persons will once again be allowed to use this privacy-protecting protocol." As a result of this announcement, Tornado Cash's governance token (TORN) surged nearly 866 %, hitting a two-year high of $34.98 [60].

Travala's AVA Token Soars After Zhao's Tweet

Travala is a travel platform allowing users to book hotels, flights, and activities using over 100 cryptocurrencies as payment options.

On December 12, 2024, former Binance CEO Changpeng Zhao tweeted about Binance's early investment in Travala. The tweet immediately caught the attention of the crypto market, leading to a 300 % surge in Travala's AVA token. The token's price increased from $0.80 to $3.38, demonstrating the significant impact of social media posts by influential figures [2].

Interest Rates

While cryptocurrencies operate outside the traditional banking system, they can still be influenced by changes in interest rates. Lower interest rates tend to make traditional investments less appealing, which can prompt investors to consider volatile assets like cryptocurrencies.

The financial crisis 2008 led to central banks slashing interest rates to stimulate economic recovery. This low interest rate encouraged investors to explore alternative assets, which coincided with the launch and rise of Bitcoin. As a result, Bitcoin's price dramatically increased from under $1 in 2009 to nearly $20,000 by late 2017, driven by growing interest in cryptocurrencies.

However, in 2017, the Federal Reserve began raising interest rates in response to a strengthening U.S. economy and inflationary pressures. Increased interest rates made cryptocurrencies appear riskier, and traditional investments became more attractive. By December 2018, Bitcoin's price had dropped from its 2017 peak of $20,000 to around $3,200, highlighting the impact of rising interest rates towards cryptocurrencies.

In 2020, the COVID-19 pandemic led central banks to adopt unprecedented monetary policy, which included slashing interest rates to near zero and implementing massive stimulus measures. These low interest rates and abundant liquidity contributed to a new cryptocurrency rally. Bitcoin reached an all-time high of over $60,000 in 2021, as the combination of low interest rates, increased liquidity, and economic uncertainty attracted investors to cryptocurrencies [29].

During the FOMC meeting on December 18, 2024, the Federal Reserve decided to lower the federal funds rate by a quarter percentage point, reducing it to a range of 4.25 % to 4.5 %, the lowest rate since February 2023 [24]. The projected federal funds target rate increased from 3.5 % to 3.9 % following the September meeting. This change in projection led to a more than 3 % drop in the S&P 500, which was closely correlated with a 5 % decline in Bitcoin's value [51].

Market Liquidations

The cryptocurrency market can experience large liquidations when it becomes overheated due to excessively leveraged positions. On December 9, 2024, a major liquidation event occurred with Bitcoin, causing its price to drop from $103,647 to $92,092 within hours, although it quickly recovered afterward.

These rapid price drops are typically caused by the automatic liquidation of overleveraged positions, creating a cascading effect where forced selling pushes prices even lower. This event also impacted the broader market, leading to significant losses for altcoins and causing over $1.7 billion in losses from nearly 584,000 traders within 24 hours.

When the market becomes overbought and prices are unsustainably high, exchanges and large players may take advantage of this imbalance by lowering prices to liquidate these positions, which can quickly erase billions in market value [30].

Whale Activity

Whales in the cryptocurrency market are considered entities or individuals holding large amounts of cryptocurrency, which enables them to influence market trends and impact liquidity. A Bitcoin whale is a holder of over 10,000 BTC. Whale movements, whether through large purchases, sales, or transfers, draw attention due to their potential to impact market prices.

For example, in 2021, a mysterious whale executed a transaction involving approximately 40,000 BTC, valued at over $2 billion. In 2020, Strategy purchased 21,454 BTC in two transactions, totaling over $250 million. This move boosted market confidence and drove the price even higher. While some transactions, like those to cold wallets, may not indicate the intent to trade, others, especially those from old and long-inactive wallets, can signal future market trends [63].

The transparency of blockchain technology allows these actions to be tracked, providing insights into their potential impact. Whales can manipulate markets through various strategies. One example is the pump-and-dump strategy, where whales drive prices up through coordinated buying and then sell at the peak, leaving smaller investors at a loss. Another method is short-selling, which involves borrowing and selling the cryptocurrency with plans to repurchase it at a lower price.

Whales can also manipulate markets by trade washing. This involves simultaneously buying and selling the same asset, creating a false impression of increased market activity. They may place large buy or sell limits to make massive „walls“ to influence trader behavior, as seen in Figure 3.8. It's important to note that not all whales participate in market manipulation [62]. Some well-known crypto whales are Strategy, Brian Armstrong, Tesla, and the Winklevoss Twins.

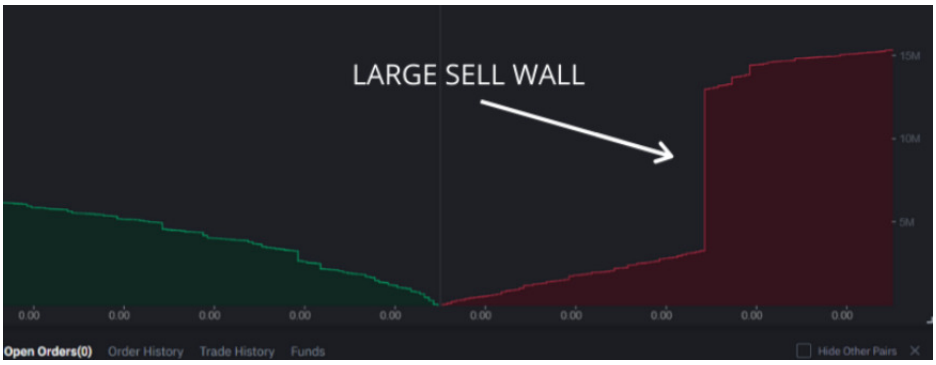

Figure 3.8: Significant sell orders create a large sell wall at a specific price level, suppressing upward price movement and influencing trader behavior [16].

Chapter 4

Simulation Tools for Testing Trading Strategies

This chapter will explore existing simulation tools available for testing trading strategies. These tools allow traders to assess their strategy's performance without risking actual market capital. Typically, these tools offer backtesting, forward testing, and risk assessment, which help traders understand how their strategy may perform under different scenarios.

4.1 Backtesting

Backtesting simulates the strategy's potential outcomes using historical market data to evaluate returns and analyze risk and profitability with virtual money. Backtesting includes adjustable input parameters, enabling traders to experiment with different configurations to optimize returns. This may involve using various technical indicators or responses to events that could influence the market.

Over-optimizing a trading strategy to maximize historical profitability can lead to poor live trading performance. This phenomenon, called curve fitting, results in systems that seem highly successful during backtesting but struggle in live markets. Curve fitting uses optimizing techniques to generate the greatest profits during the same tested historical period. To ensure reliability, traders must test the system on multiple sets of historical data not included in the initial backtesting phase. This leads to more realistic potential performance in live trading [3].

4.2 Forward Testing

Forward testing is another important step in evaluating a trading strategy that has already been backtested. It simulates the strategy's performance in live market conditions by executing trades without using real capital. All trade entries, exits, profits, and losses are documented during this process to evaluate the strategy's outcome. A trading strategy that shows positive results and consistency between backtesting and forward testing is considered ready to be implemented in a live market using real capital [3].

4.3 Metrics to Evaluate Trading Performance

Evaluating trading performance involves analyzing various metrics that reflect a trading strategy's profitability, risk, and overall efficiency. While performance reports can include a wealth of data, focusing on a few key metrics that provide the most meaningful insights is more effective [33].

Total Net Profit

Total net profit indicates the overall profitability of a trading system over a specific period. It is calculated as the difference between gross profits and gross losses, including costs like commissions. Although it provides a precise measure of a strategy's success, relying on it alone can be misleading because it does not consider the level of risk taken. Evaluating total net profit alongside other performance metrics is important for comprehensively understanding overall performance [33].

$$TotalNetProfit = GrossProfit - GrossLoss$$

$$\begin{aligned} GrossProfit &= \text{Gross profit of all winning trades} \\ GrossLoss &= \text{Gross loss of all losing trades} \end{aligned}$$

Sharpe Ratio

The Sharpe Ratio measures the return of an investment relative to its risk by comparing excess returns to volatility. Introduced by William F. Sharpe in 1966, it evaluates an investment's performance against a benchmark, such as the risk-free rate. This ratio helps determine if higher returns are due to increased risk exposure.

$$SharpeRatio = \frac{R_p - R_f}{\sigma_p}$$

$$\begin{aligned} R_p &= \text{return of portfolio} \\ R_f &= \text{risk-free rate} \\ \sigma_p &= \text{standard deviation of the portfolio's excess return} \end{aligned}$$

The formula compares the returns of a strategy to a benchmark and calculates the difference divided by the standard deviation of returns, which measures risk. A higher Sharpe Ratio indicates a more efficient balance between risk and reward, while a lower value suggests that the returns do not justify the level of risk taken. This makes the Sharpe Ratio especially useful for comparing trading strategies with different levels of volatility.

However, it assumes that returns follow a normal distribution. Financial markets can experience extreme movements much more often than a normal distribution would predict. As a result, the standard deviation used to calculate the Sharpe ratio may understate the possibility that an asset performs significantly above or below its average past performance [49].

Maximum Drawdown

The maximum drawdown metric measures the worst-case scenario during a trading period, indicating the largest loss from a previous equity peak. It is a key indicator of the risk incurred by a trading strategy and helps determine whether the system is practical based on the trader's risk tolerance and account size.

This metric emphasizes the need to balance profitability with risk. Maximum drawdown should align with the trader's risk tolerance and available capital to ensure the strategy's net profit can be achievable and sustainable over time [33].

4.4 Existing Simulation Tools

This section explores open-source tools developed in Python that are widely used for creating, testing, and optimizing algorithmic trading strategies. These Python-based frameworks offer backtesting, live trading, and portfolio analysis features. They are designed to support various types of assets and trading strategies. The following subsections provide an overview of existing specific tools that illustrate these capabilities.

Blueshift

Blueshift is a cloud-based platform developed by QuantInsti[1] for backtesting and algorithmic trading. It supports various assets, including equities, forex, and futures. The platform allows the employment of event-based approaches, technical analysis, and machine learning-driven models.

Blueshift is designed for both backtesting and real-time trading and enables an easy transition of trading strategy from backtesting to live trading [8]. The web-based platform allows users to efficiently develop, backtest, save, and manage multiple trading strategies through a simple API.

The platform provides tools for managing various assets, including portfolio rebalancing. Strategies that have been backtested can easily be transitioned to live trading, whether in paper trading or using real capital.

To evaluate strategy, Blueshift offers a dashboard featuring detailed statistics on executed trades, providing valuable insights into performance metrics and a record of trades taken. It also supports Telegram notifications, receiving real-time alerts about executed trades and performance insights.

Freqtrade

Freqtrade is a cryptocurrency trading bot that was developed and can be controlled via Telegram or webUI. The platform provides extensive tools for backtesting trading strategies, with the possibility of downloading historical market data and optimizing strategies using machine learning techniques.

Custom strategies are created in Python using libraries like pandas[2] and can be tested through backtesting and live trading [25]. Freqtrade also provides sample strategies that include pre-configured functions for commonly used technical indicators.

[1] https://www.quantinsti.com/
[2] https://pandas.pydata.org/

The platform can be run using Docker[3] and enables real-time notifications through Telegram, where the bot sends alerts when it enters or exits a trade. Results from backtesting can be viewed in the command-line interface or through the WebUI, which provides a more detailed visual overview of the strategy's historical performance.

Backtrader

Backtrader is a framework designed for backtesting and trading. It allows users to focus on developing reusable trading strategies, indicators, and analyzers without building infrastructure. The platform supports the creation of complex strategies and operates on an event-by-event basis with multiple data feeds [4].

Backtrader provides plotting capabilities for visualizing data and results. The framework is well-documented and offers strategy samples, commonly used indicators, and analyzers. Backtrader can be effectively used within a Jupyter Notebook[4] environment, providing an interactive interface for coding, visualizing, and running backtests.

[3] https://www.docker.com/
[4] https://jupyter.org/

Chapter 5

Simulation Tool

A simulation tool was developed specifically for long-term investing, enabling an objective comparison of various automated trading strategies. While analyzing platforms such as Backtrader[1], Freqtrade[2], and Blueshift[3], it became clear that none provided the desired simplicity and flexibility. This led to creating a custom simulator focused on long-term investing simulations.

5.1 Simulator Design and Functionality

The simulation tool is designed to test various strategies within a unified framework. It creates a virtual portfolio, applies investment strategies to historical price data, and records key metrics. The tool supports buying multiple assets and allows users to define specific start and end dates for the simulation, investing capital according to user-defined weights. During the simulation, it keeps track of portfolio changes, calculates performance metrics, and saves the output in a JSON file. A separate plotting module then visualizes these results. This setup enables faster future analysis without rerunning the entire simulation.

Data and Preparation

Cryptocurrencies are intriguing due to their decentralized nature and strong performance over recent years. With a focus on long-term investing, the attention has shifted to the two most well-known cryptocurrencies: **Bitcoin** (BTC) and **Ethereum** (ETH). Each of these cryptocurrencies serves fundamentally different purposes within the blockchain ecosystem.

Historical hourly closing price data for Bitcoin and Ethereum was downloaded from the Binance Exchange[4] using the Python-binance[5] library. The dataset covers the period from 2020 to January 2025 and includes timestamps and the corresponding closing prices for each asset. Only closing prices were selected, as they are sufficient for the strategies planned for testing. An hourly resolution was chosen to evaluate strategies that involve **Hourly Rebalancing**, inspired by a study [27] that determined one hour to be the optimal fixed period for rebalancing. Primary strategies such as **HODL** (Hold On for Dear Life) and **Monthly Dollar-Cost Averaging** (DCA) will also be tested.

[1] https://www.backtrader.com/docu/
[2] https://www.freqtrade.io/en/stable/
[3] https://blueshift.quantinsti.com/docs/
[4] https://www.binance.com/en
[5] https://python-binance.readthedocs.io/en/latest/overview.html

Before running any simulation, the user must configure several parameters. These include the file path to the price data in CSV format, a list of assets to include in the portfolio, and a set of start and end dates for the investment period. The simulator also requires inputs such as the total amount of capital to be invested and the desired allocation weights for each asset, which must sum to 1.0 to represent a complete portfolio. The simulator then iterates through all valid combinations of start and end dates.

5.2 Implementing Simulator and Strategies

The simulation framework is implemented in Python and is organized into multiple files. The `main.py` file serves as the entry point for executing the simulations, defining all necessary parameters, and initiating the simulation process.

Simulator

In `main.py`, the user specifies key inputs such as the paths to historical price data, the list of assets to be tested, the total investment capital, asset allocation weights, and a set of start and end dates that define the investment period. Once these parameters are determined, the script calls the core simulation function in the `backtest.py`.

The `run_backtest` function in `backtest.py` systematically goes through every possible combination of specified start and end dates, allowing for flexible backtesting across different market cycles. For each combination, it extracts the relevant portion of historical data and provides this data to each defined investment strategy.

The strategy begins by processing the input and simulating its logic on the selected time window and price data. It then generates an output with a structured time series containing the original historical price data for the selected assets, calculated portfolio values, and key performance metrics for each time step. Afterward, the final results and the specific start and end dates used for that particular run are appended to a cumulative results list. This list represents all strategy outcomes across the various date combinations.

Once all iterations are complete, the final results list is returned, allowing for the evaluation of the metrics and the creation of visual plots. The entire process is visualized in the workflow shown in Figure 5.1.

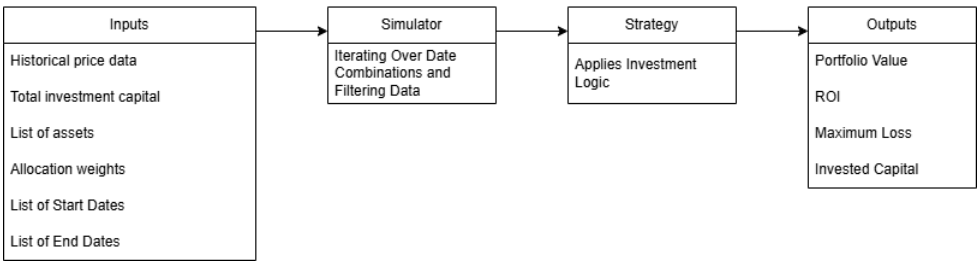

Figure 5.1: Workflow of the Investment Simulation Process.

Strategies

Each investment strategy, **HODL**, **Dollar-Cost Averaging**, and **Hourly Rebalancing**, is implemented as a separate function within the simulation framework. This structure allows for each strategy's independent development, testing, and modification without affecting the overall simulation logic.

When a strategy is executed, it receives a segment of historical data corresponding to the selected start and end date. In addition to this time series, the strategy is provided with a list of assets included in the portfolio, the total investment amount to be distributed over the specified period, and a dictionary of asset weights. These weights define the proportion of capital allocated to each asset, ensuring the full investment amount is deployed according to the desired allocation.

HODL

The HODL (Hold On for Dear Life) strategy is the simplest of the three implemented approaches. It assumes that the entire investment capital is allocated at the beginning of the investment period and held unchanged until the end.

The strategy starts by calculating how many units of each asset can be purchased at the initial closing price within the selected date range.

$$units_{asset} = (investment * weight_{asset})/price_{asset}$$

This calculation provides the number of units for each asset that will be held constant for the remainder of the simulation.

For every timestamp in the historical data, the portfolio value of each asset is computed by multiplying the fixed number of units by the current closing price. The resulting value is recorded in a new column corresponding to the value of each asset over time.

$$portfolio = (units_{asset_1} * price_{asset_1}) + ... + (units_{asset_n} * price_{asset_n})$$

This produces a time series representing the evolution of the total portfolio value throughout the investment period.

Hourly Rebalancing Strategy

The Hourly Rebalancing strategy builds on the same initial logic as the HODL approach. At the start of the investment period, the strategy uses the initial closing prices and the defined asset weights to calculate how many units of each asset can be purchased with the total investment capital. However, unlike the HODL strategy, which keeps the asset distribution fixed, the Hourly Rebalancing strategy actively adjusts the portfolio to maintain the desired allocation by rebalancing it every hour.

At each hourly interval, the portfolio's total value is calculated by summing the value of all currently held assets based on their closing prices. The investment strategy then reallocates the portfolio by determining the number of units for each asset to ensure that their values align with their target proportions, as defined by the specified weights.

$$units_{asset} = (portfolio * weight_{asset})/price_{asset}$$

As a result, the portfolio is continually adjusted to maintain the original allocation, regardless of fluctuations in asset prices over time.

Dollar-Cost Averaging

The Dollar-Cost Averaging (DCA) strategy differs from the HODL and Hourly Rebalancing strategies in that it does not invest the entire capital at the beginning of the investment period. Instead, it distributes the investment evenly across regular intervals.

At the beginning of the simulation, the strategy identifies all the timestamps when investments will be made. In this implementation, capital is injected once a month. Based on the total investment amount and the number of investment dates, the strategy calculates how much to invest at each interval to ensure the entire capital is fully allocated by the end of the period.

The strategy calculates how many units of each asset can be purchased on each investment date based on predefined weights and current asset prices. The purchased asset units are then added to the total holdings.

To track the actual performance and risk of the strategy, the implementation keeps a running total of the cumulative invested capital. This is needed for metrics such as maximum loss and return on investment (ROI), which, in the case of DCA, must be calculated relative to the amount invested up to that point in time rather than the total investment amount. The final output includes the evolving portfolio value, cumulative investment, and derived metrics.

5.3 Testing Strategies

A series of backtests were conducted using various investment periods to simulate the real-world performance of the implemented strategies.

Each simulation began with a fixed initial capital of **$30,000**, equally divided between **Bitcoin** and **Ethereum** for a **50/50 portfolio allocation**. The backtests were executed over various start and end dates to replicate different market conditions and investment horizons.

All three strategies were applied to the same underlying data for each combination of start and end dates. The simulator produced the final portfolio value for each strategy, and the results were saved for further analysis.

The primary metric used for comparison was the average final portfolio value at the end of the investment period across various investment periods. Figure 5.2 summarizes these results.

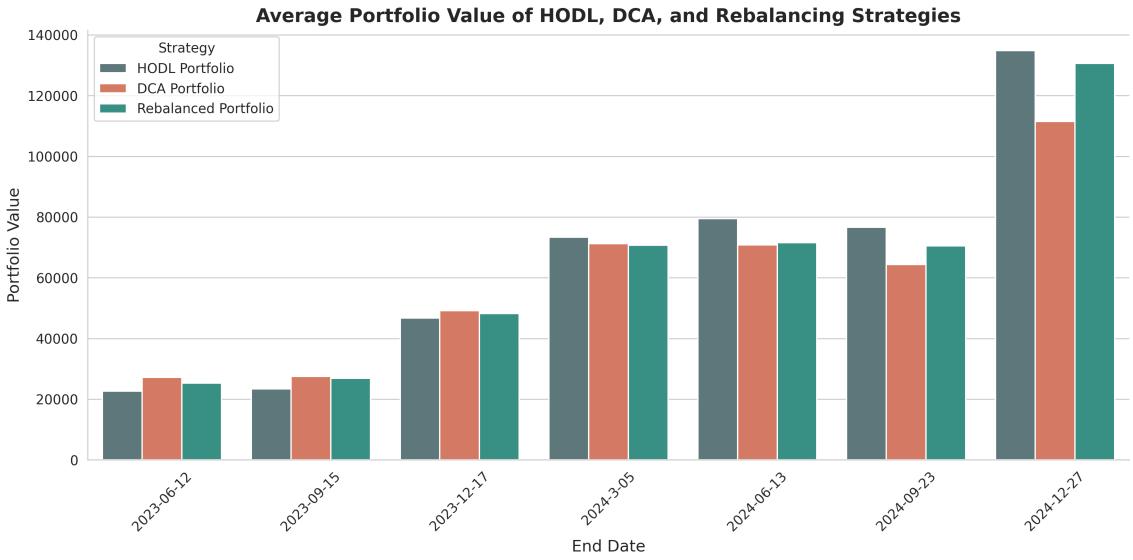

Figure 5.2: Average final portfolio value for each ending date.

It's important to understand that average performance alone does not provide a complete picture, especially in volatile markets such as cryptocurrencies, where extreme events can greatly impact the average. To gain a clearer perspective on the consistency of each strategy's performance, the median final portfolio value was analyzed for each end date across all start dates. Figure 5.3 provides a clearer comparison of each strategy's typical results, regardless of unique extreme outcomes.

The worst-case scenarios were analyzed to highlight the downside risks associated with each investment strategy. The **Rebalanced** and **HODL** strategies experienced final portfolio values that dropped to around **$10,000** during the most unfavorable market conditions. In contrast, the **Dollar-Cost Averaging** strategy demonstrated significantly greater resilience, with its lowest final value reaching **$23,593**.

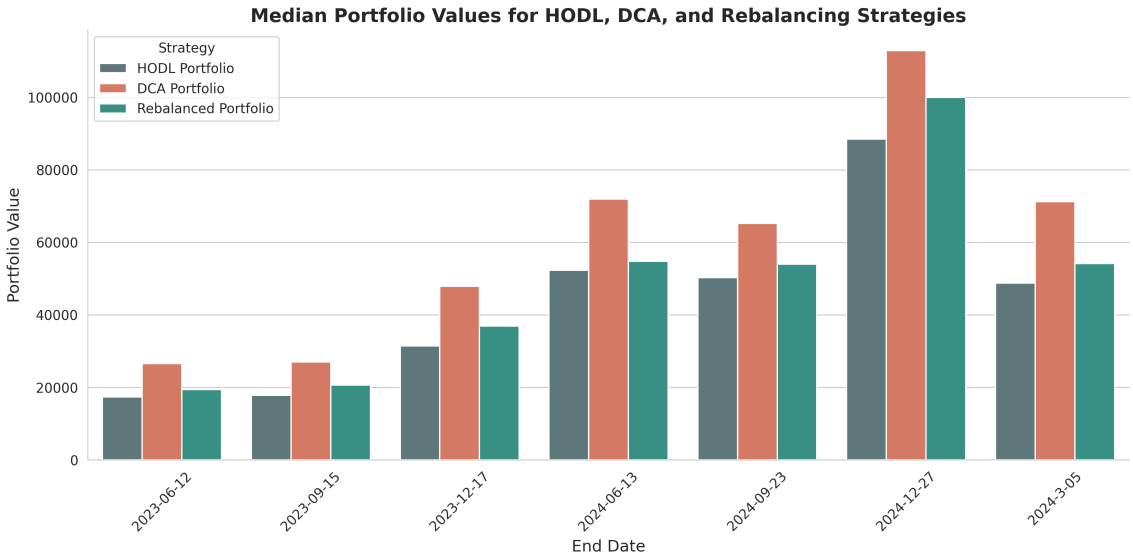

Figure 5.3: Median final portfolio value for each ending date.

Figures 5.2 and 5.3 present the average and median portfolio values for the HODL, DCA, and Rebalancing strategies, measured at the end of each investment period. These results were computed across multiple starting dates to simulate market conditions and investment timings. The overall average and median portfolio values were calculated and interpreted in Table 5.1 to summarize the strategies' behavior across all runs comprehensively.

Strategy	**Average Portfolio Value ($)**	**Median Portfolio Value ($)**
HODL	**65,308**	40,931
DCA	60,244	**64,353**
Rebalancing	63,386	48,590

Table 5.1: Summary of portfolio value across all runs.

Chapter 6

Proposal of a New Trading Strategy

In the previous chapter, it was discovered that the Dollar-Cost Averaging (DCA) strategy consistently produces reliable results. Its main advantage is safety, it spreads risk by investing fixed amounts at regular intervals, reducing the likelihood of making a large investment at an inappropriate time.

However, one significant drawback of DCA is that it invests the same amount regardless of market conditions. This means it allocates identical funds during both favorable and unfavorable periods. An effort is being made to enhance this approach by designing a variant of DCA that invests more when market conditions are favorable and less when they are not. To achieve this, various external sources have been explored to determine whether market conditions are favorable.

6.1 Collecting External Data Sources

Several external data sources that have historically influenced Cryptocurrencies' behavior were collected to support the development of a sentiment-based trading strategy.

Tweets

The process began with collecting tweets using the Twikit[1] Python library, focusing on influential accounts in the cryptocurrency market from 2021 onwards.

Elon Musk[2] and **Michael Saylor**[3] are two prominent figures in this space. Elon Musk, the CEO of Tesla, has significantly impacted Bitcoin prices through his tweets. For instance, his announcements regarding Tesla's acceptance or rejection of Bitcoin payments have considerably affected the market. In contrast, Michael Saylor, the CEO of Strategy, which holds a substantial amount of Bitcoin, frequently tweets in support of the cryptocurrency. He often promotes holding Bitcoin and never selling it, reinforcing the concept of Bitcoin as a reliable store of value.

In addition to these individual influencers, tweets from **Binance**[4], the world's largest cryptocurrency exchange, were included, as they regularly share updates about Bitcoin and

[1] https://pypi.org/project/twikit/
[2] https://x.com/elonmusk
[3] https://x.com/saylor
[4] https://x.com/binance

maintain large reserves of it. Tweets from the **Federal Reserve**[5] were also tracked since their announcements about interest rates and inflation can broadly influence cryptocurrencies, Bitcoin is often perceived as a hedge against inflation.

Lastly, tweets from **Lookonchain**[6], an account that monitors whale activity and large on-chain movements, such as exchange inflows and outflows, were gathered. These tweets can provide valuable insights into the behavior of major investors, serving as early indicators of shifts in market sentiment.

Macroeconomic Data

In addition to social media data, several macroeconomic and sentiment indicators were collected to reflect broader market dynamics and investor psychology. These metrics were selected for their potential to influence long-term trends in Bitcoin.

From a macroeconomic perspective, **Interest Rate** data and the **Consumer Price Index** (CPI) were gathered. Although cryptocurrencies operate outside the traditional banking system, they are still influenced by shifts in monetary policy. Interest rate decisions are crucial in economic policy and often impact investor behavior. Lower interest rates drive capital toward riskier assets, such as cryptocurrencies. Conversely, the CPI is a widely used measure of inflation, which is relevant since Bitcoin is often viewed as a hedge against inflation.

Sentiment Data

Historical values of the **Fear and Greed Index** were collected for sentiment indicators. This index reflects market psychology by combining data from seven components, including volatility, trading volume, and social media sentiment. It provides a daily value indicating investors emotional states, ranging from 0 (extreme fear) to 100 (extreme greed).

The data sources included in this index are:

- **Volatility (25 %)** — Measures current market volatility and drawdowns compared to 30-day and 90-day averages.
- **Market Momentum and Volume (25 %)** — Compares trading volume and market momentum with 30-day and 90-day averages.
- **Social Media (15 %)** — Tracks Twitter activity, focusing on the number of posts and engagement level related to Bitcoin.
- **Surveys (15 %)** — Conduct weekly crypto polls to provide a direct snapshot of public opinion.
- **Bitcoin Dominance (10 %)** — Measures Bitcoin's dominance relative to altcoins.
- **Google Trends (10 %)** — Analyzes the frequency of Cryptocurrency-related search queries.

The index provides a broad picture of crypto's market sentiment by analyzing all these external data points [23].

[5] https://x.com/federalreserve
[6] https://x.com/lookonchain

Additionally, the **ColinTalksCrypto Bitcoin Bull Run Index** (CBBI) was included, following a recommendation from the thesis supervisor. The CBBI combines nine metrics to estimate Bitcoin's position, indicating whether the market is approaching the peak of a bull run or the bottom of a bear run by a confidence score between 0 and 100. The CBBI includes the following metrics [11]:

- **Pi Cycle Top Indicator** – Has historically effectively picked market cycle highs within 3 days. It uses the 111-day moving average and a newly created multiple of the 350-day moving average [40].
- **RUPL/NUPL** – Evaluating realized and unrealized profits/losses by subtracting Realized Value from Market Value [46].
- **RHODL Ratio** – Compares the relative value of recently moved coins to those held for 1–2 years [45].
- **Puell Multiple** – Analyzes Bitcoin's supply by comparing daily miner revenue with its 365-day moving average, providing insights into market cycles from a mining perspective [42].
- **2-Year Moving Average Multiplier** – Uses a 2-year moving average and a secondary line derived by multiplying it by five [1].
- **Bitcoin Trolololo Trend line** – Logarithmic regression model designed to estimate Bitcoin's fair value by comparing current value to this indicator [61].
- **MVRV Z-Score** – Identifies when Bitcoin is over or undervalued, using Market Value, Realised Value, and Z-score. The Z-score identifies extremes between market value and realized value [37].
- **Reserve Risk** – Measures the confidence of long-term Bitcoin holders regarding the current price and determines if the risk-to-reward ratio is favorable [44].
- **Top Cap vs. CVDD** – Combines two on-chain valuation metrics to assess Bitcoin's market extremes. The top cap is the average market capitalization multiplied by 35 to estimate the potential market tops. At the same time, CVDD identifies market bottoms by tracking the transfer of significantly old coins to new investors [59].

6.2 Integration of External Data

After gathering all external data sources, the next step was to prepare them for integration with our simulation tool. The goal was to align and merge this data with daily Bitcoin prices to enable meaningful analysis.

Each tweet included a timestamp, author, and text content. The Valence-Aware Dictionary and sentiment Reasoning (VADER)[7] sentiment analysis tool evaluated each tweet's sentiment. This tool assigns a sentiment score to each tweet: +1 for positive, -1 for negative, and 0 for neutral. The data was then used to calculate the daily proportion of bullish and bearish ratios, representing the share of tweets with positive or negative sentiment relative to the total number of tweets.

[7] https://pypi.org/project/vaderSentiment/

The macroeconomic and sentiment-based indicators were already available in a time-series format. While some indicators reported values daily and others monthly, aligning them with Bitcoin's historical prices required only minor preprocessing.

All processed data was stored in CSV format and merged into a unified dataset that included the relevant market indicators alongside daily Bitcoin prices. This dataset was the basis for analyzing the correlations between the various values.

6.3 Correlation Analysis

After collecting all the external data sources to test, the next step was to evaluate whether these indicators could help determine the optimal time for investment. The approach focuses on long-term investing, particularly in the values at the end of each month, when investments would be made. A daily bullish versus bearish ratio was calculated based on sentiment extracted from tweets. If the bullish ratio exceeded the bearish ratio on a given day, that day was marked as +1, conversely, if it was higher, it was marked as -1. These daily signals were summed each month, resulting in a monthly score reflecting the dominant sentiment.

No transformation was necessary for the Consumer Price Index (CPI) and interest rate data, as both values are reported monthly and remain unchanged throughout the period. For the Fear and Greed Index and the Bitcoin Bull Run Index, the value on the day of investment was used without considering how they evolved throughout the month to assess whether it was the right time to invest.

Once all the monthly values were prepared, the **Pearson correlation coefficient** was calculated between each indicator and the Bitcoin closing price at the end of each month. This analysis helped identify which external factors had the strongest historical relationship with Bitcoin's performance.

The findings from the correlation analysis are presented in Figure 6.1.

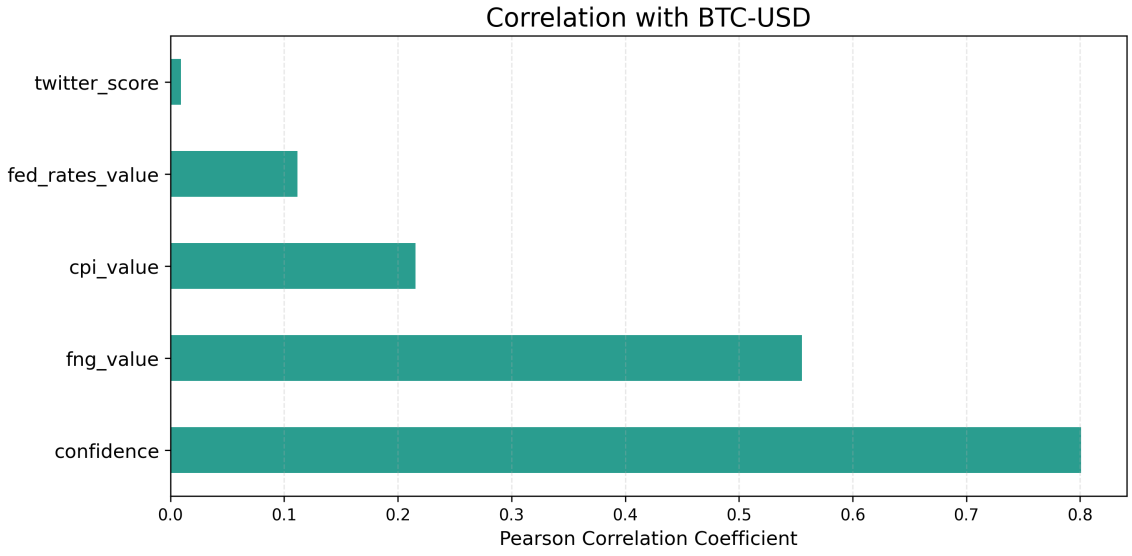

Figure 6.1: Pearson correlation coefficients between indicators and the price of Bitcoin.

6.4 Improved DCA Strategy

Figure 6.1 illustrates the strongest correlation with Bitcoin's price, which was notably observed in the **CBBI confidence score**, closely followed by the **Fear and Greed Index**. Other indicators, such as interest rates, CPI, and Twitter sentiment, demonstrated weaker or inconsistent correlations.

For long-term investing, tweet-based sentiment did not appear to be the most suitable data source, as tweets often trigger short-term market fluctuations rather than long-lasting trends. Similarly, although low interest rates can sometimes drive capital toward alternative assets like Bitcoin, the correlation between interest rates, CPI, and Bitcoin price was relatively minor. This indicates that relying on macroeconomic indicators could lead to missed investment opportunities when favorable conditions are not reflected in those metrics.

The correlation analysis in this study supports the notion that Bitcoin's price movements are more influenced by market sentiment and investor psychology rather than by macroeconomic factors. Investors often exhibit common behaviors, such as buying more during price increases due to fear of missing out (FOMO) and selling or hesitating to invest when prices drop out of fear. However, lower prices may present the best opportunities to invest.

We are ready to improve the classic **Dollar-Cost Averaging** strategy. We want to maintain its strengths while addressing its weaknesses. The primary advantage of this strategy is that it allows for investments to be spread over time, which helps reduce the risk associated with poor timing. However, one of its main weaknesses is that it involves investing the same amount regardless of market conditions, whether favorable or unfavorable.

Based on the correlation results, attention was given to the **Fear and Greed Index** and **CBBI** as the primary indicators for an Improved Dollar-Cost Averaging strategy. To identify when these indicators signal a strong buying opportunity, the **30th percentile** threshold was calculated for each. This threshold is conservative and low enough to indicate favorable market conditions yet not so low that it would delay investments and risk missing out on a bull market.

Since both sentiment indicators are specific to Bitcoin, this strategy was applied exclusively to Bitcoin. To implement this approach, a new column was added to the dataset to indicate whether a buying opportunity existed. The value is set to 1 when both thresholds are met and 0 otherwise. This signal helps determine the investment amount and assists with further analysis of the strategy's performance. The remainder of the implementation was similar to standard Dollar-Cost Averaging, with the main difference being the multiplier applied to the invested amount based on favorable market conditions.

6.5 Multiplier

Investing was executed at the end of each month, and the investment multiplier depended on the market sentiment. If the CBBI and Fear and Greed indexes were below their respective thresholds (30th percentile), which is **35** for **FNG** and **30** for **CBBI**, a full multiplier was applied to the monthly investment. Otherwise, slightly above half, a reduced multiplier of **0.6**× was used to maintain some exposure during potential bull market conditions.

Multiplier	Portfolio ($)	ROI (%)	Invested ($)	Max Loss (%)
2.4x	71,803	171.71	26,548	-52.62
2.6x	75,209	174.90	27,498	-52.38
2.8x	78,615	177.88	28,448	-52.20
3.0x	81,949	180.69	29,398	-52.04
3.2x	85,178	183.33	30,347	-51.88

Table 6.1: Improved DCA performance using various multipliers during all investment durations.

In Table 6.1, we tested several multipliers ranging from 2.4x to 3.2x to assess their impact on the improved DCA strategy. The ROI consistently increased with higher multipliers. However, the most significant improvement was observed between the **2.4x** and **2.6x** multipliers. The maximum loss remained nearly the same across all tested multipliers, indicating that increasing the investment did not lead to a substantial rise in downside risk. For these reasons, we chose the **2.6x multiplier**, which offers a solid increase in performance while still being conservative with capital.

6.6 Investment timing

Now that the multiplier has been chosen, the next step is to investigate whether the timing of monthly investments can influence the strategy's performance. Specifically, the strategy was evaluated based on investments made at each month's beginning, middle, or end, while keeping all other conditions the same.

Investment Timing	Portfolio ($)	ROI (%)	Invested ($)	Max Loss (%)
Start of Month	77,212	179.58	27,828	-39.18
Middle of Month	70,380	164.16	26,626	-32.40
End of Month	75,208	174.90	27,498	-39.42

Table 6.2: Improved DCA with 2.6x multiplier applied across various investment periods.

Table 6.2 shows that investing at the beginning of the month slightly outperformed investing at the end of the month in terms of final portfolio value and return on investment. The mid-month strategy lagged behind the other two approaches while demonstrating slightly lower capital exposure and a minor max loss.

Given the marginal differences in results between the **start** and **end-of-month** strategies, both will be retained for further testing in upcoming experiments. However, the mid-month strategy will be excluded due to its lower performance.

6.7 Different Approaches to FNG and CBBI

In the initial version of the strategy, the **FNG** and **CBBI** values on the day of investment were used to decide whether market conditions were favorable. However, this approach may rely too heavily on a single moment and overlook broader sentiment trends within the month.

As a result, several alternative methods were tested:

- **Minimum** – The lowest value of FNG and CBBI during the month.
- **Maximum** – The highest value of FNG and CBBI during the month.
- **Median** – The median value calculated over the month.
- **Average** – The arithmetic average calculated for the month.
- **Classic** – Using the value on the day of investment.

Each method was tested for investments made at the **beginning** and at the **end of the month**, using a **2.6x multiplier** and maintaining the threshold condition of both indexes being **below the 30th percentile**. The results of investing at the start of the month are shown as 6.3, while those of investing at the end of the month are shown as 6.4.

Approach	**Portfolio ($)**	**ROI (%)**	**Invested ($)**
Minimum	92,845	183.83	32,986
Maximum	45,967	138.85	19,257
Median	80,604	179.12	29,068
Average	77,665	180.81	27,811
Classic	77,213	179.59	27,828

Table 6.3: Improved DCA for investing at the **start of the month** using various methods to calculate FNG and CBBI.

Approach	**Portfolio ($)**	**ROI (%)**	**Invested ($)**
Minimum	92,227	182.01	32,971
Maximum	45,564	136.70	19,255
Median	79,830	176.47	29,052
Average	77,083	178.71	27,797
Classic	75,209	174.90	27,498

Table 6.4: Improved DCA for investing at the **end of the month** using various methods to calculate FNG and CBBI.

The highest **ROI** was achieved using the **Minimum** variant when investing at the start of the month, closely followed by the same variant at the end of the month. However, it's important to note that this approach required a higher capital investment than other methods. This suggests there is potential for further optimization by testing smaller multipliers to reduce the investment size while maintaining performance.

Across all methods, investments made at the **start of the month** consistently outperformed those made at the end, although only slightly. Therefore, we will continue to use the start-of-month investment timing for further testing.

Regarding performance rankings, the **Minimum** variant was the best overall, followed by the **Average**, **Classic**, and **Median** variants, which had similar results. The **Maximum** variant proved too conservative and underperformed compared to the other approaches.

Testing Different Approaches

Several approaches were tested to trigger full investments and determine the most effective variant of the improved DCA strategy.

These approaches included comparing **Minimum**, **Average**, **Median**, and **Classic FNG** and **CBBI** daily values. Investment signals were generated for each variant when FNG was **below 30** and CBBI was **below 35**. Investments were made at the beginning of each month.

Each approach was tested using a range of multipliers applied during favorable market conditions. The goal was to maximize **ROI** while ensuring that the average capital invested did not exceed **$30,000** for the traditional DCA and HODL strategies. A summary of the results is provided in Table 6.5.

Approach	**Multiplier**	**Portfolio ($)**	**ROI (%)**	**Invested ($)**
Minimum	1.6x	67,134	164.62	26,829
	1.8x	72,276	169.27	27,810
	2.0x	77,418	173.46	28,791
	2.2x	82,560	177.24	29,772
	2.4x	87,702	180.68	30,754
Median	2.2x	72,767	172.47	26,854
	2.4x	76,685	175.92	27,960
	2.6x	80,603	179.12	29,067
	2.8x	84,522	182.1	30,174
	3.0x	88,440	184.88	31,281
Average	2.4x	74,041	177.38	26,829
	2.6x	77,665	180.81	27,810
	2.8x	81,289	184.02	28,791
	3.0x	84,913	187.03	29,772
	3.2x	88,538	189.85	30,754
Classic	2.4x	73,634	176.21	26,845
	2.6x	77,213	179.59	27,828
	2.8x	80,792	182.75	28,811
	3.0x	84,370	185.71	29,793
	3.2x	87,949	188.5	30,776

Table 6.5: Comparison of different approaches with various multipliers.

After testing various approaches, the best-performing methods relied on evaluating the values of the indicators either on the actual **day of investment** (Classic) or as a **monthly average** (Average). Since the outcomes were nearly identical, the daily value approach was chosen because there was a concern about whether it remained a good investment opportunity at the time of investing.

Furthermore, a **2.6x multiplier** was selected, as the ROI differences among the tested multipliers were minimal. This choice allows for strong performance while preserving capital and maintaining the average investment amount close to traditional DCA and HODL strategies.

Chapter 7

Strategy Performance and Comparison

To evaluate the effectiveness of the Improved Dollar-Cost Averaging strategy, a comparison was made between its results and those of the traditional DCA and HODL strategies.

This comparison was based on four key performance metrics:

- **Final Portfolio Value**
- **Return On Investment (ROI)**
- **Maximum Loss**
- **Total Invested Capital**

Each strategy was simulated over the same period, and their performances were evaluated based on the values at the end of the investment period.

Since the portfolio in this study consisted solely of **Bitcoin**, the Portfolio Rebalancing strategy was excluded from the evaluation, as rebalancing is typically relevant only when multiple assets are involved.

7.1 Portfolio Value

All strategies were simulated using an initial portfolio of **$30,000**, which was invested over time according to the specific logic of each approach. The Improved DCA strategy consistently delivered the highest average final portfolio value across all tested investment periods, outperforming the HODL and classic DCA strategies.

Across all simulation runs, the improved DCA strategy achieved an average final portfolio value of **$75,209**, compared to **$67,368** for the HODL strategy and **$68,582** for the classic DCA strategy. This indicates an average outperformance of approximately **11.64 %** over HODL and **9.66 %** over the classic DCA.

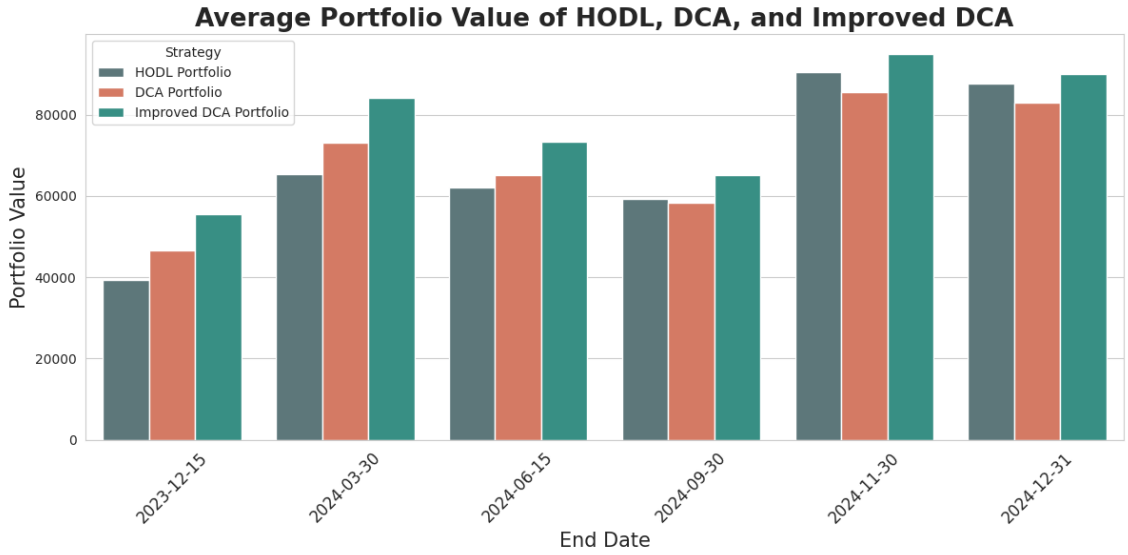

Figure 7.1: Average portfolio value by investment end date.

This result is even more notable because the improved DCA strategy achieved these returns while investing less average capital than both strategies. The only exception occurred at the end of 2023 when the improved strategy invested slightly more. However, during most of 2024, the strategy invested significantly less, as sentiment indicators suggested that Bitcoin was no longer undervalued and conditions were no longer favorable for increased exposure. As a result, the average invested capital dropped during this period, yet the improved DCA still outperformed both HODL and classic DCA.

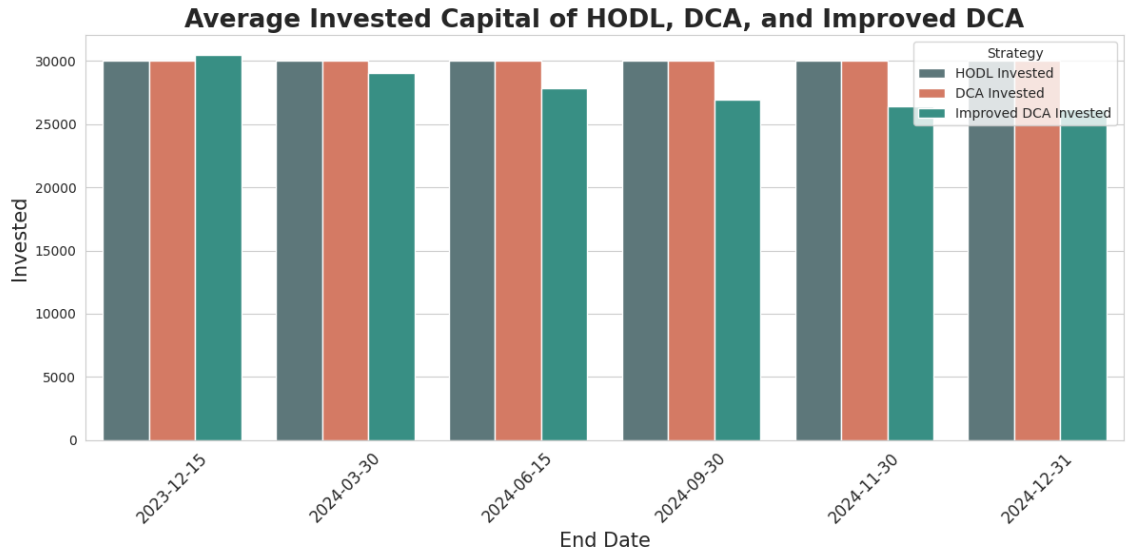

Figure 7.2: Average invested capital by investment end date.

7.2 Return on Investment

Return on investment (ROI) is a key measure of profitability, reflecting how effectively each strategy converts invested capital into returns. The improved DCA strategy delivered the highest average ROI across all simulated investment periods, outperforming classic DCA and HODL at every end-of-investment date.

Across all runs, the improved DCA achieved an average ROI of **174.90 %**, significantly higher than **128.61 %** for classic DCA and **124.56 %** for HODL. This corresponds to an improvement of **40.41 %** over HODL and **35.99 %** over classic DCA. This suggests stronger overall performance and greater capital efficiency, as the strategy generated higher profits with more selective investments.

In addition to its higher profitability, the improved DCA strategy demonstrated a more favorable risk profile. It recorded the lowest average maximum loss, experiencing a drawdown of **-39.42 %**, compared to **-42.25 %** for classic DCA and **-50.27 %** for HODL. This shows that the improved DCA limited exposure during an overheated market reduces the impact of price corrections and improves downside protection. Together, these metrics suggest that the improved DCA strategy achieves the balance between return and risk.

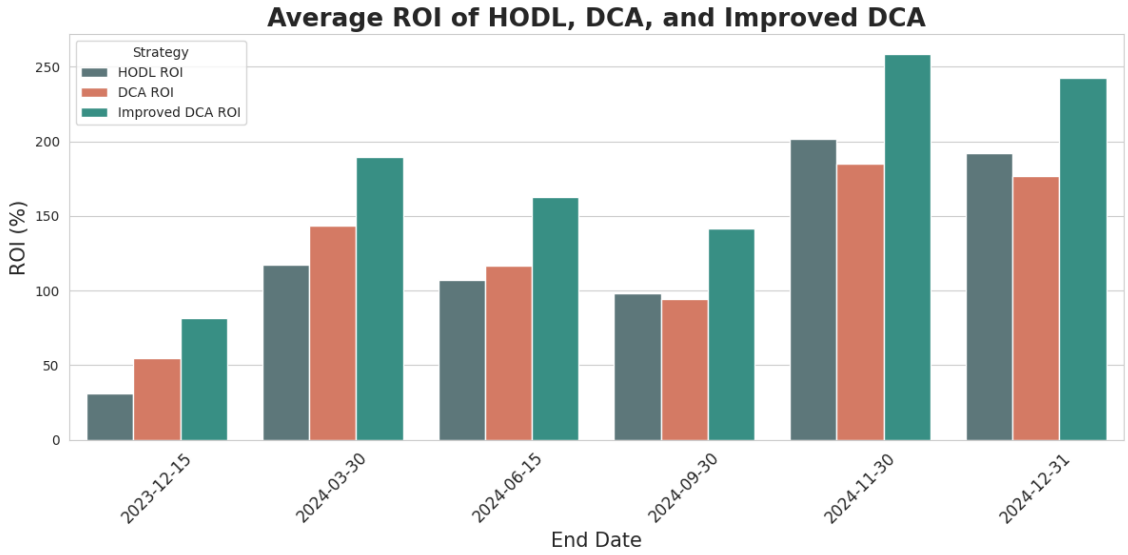

Figure 7.3: Average ROI by investment end date.

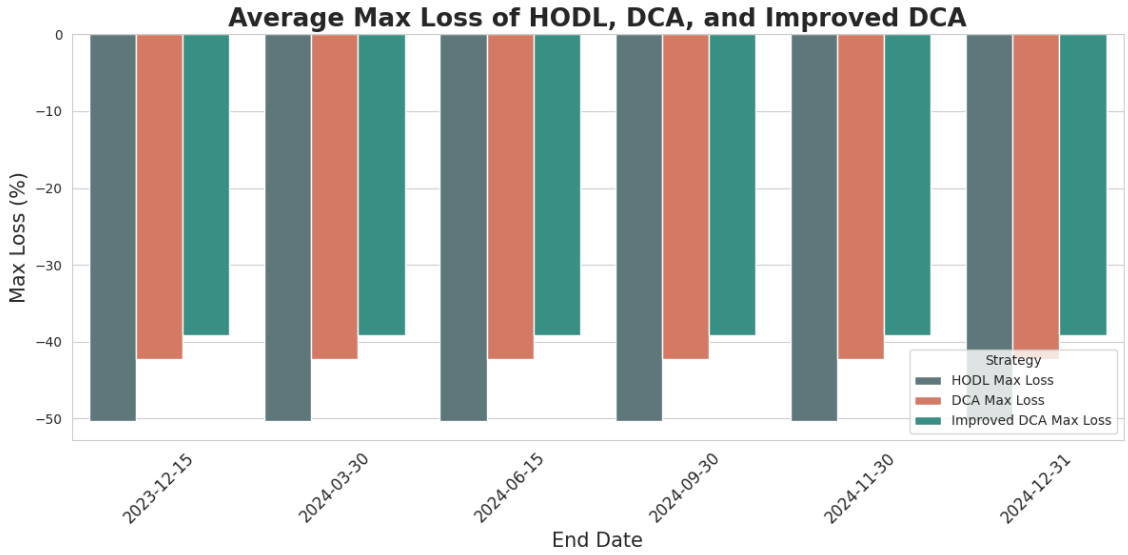

Figure 7.4: Average maximum loss by investment end date.

7.3 Performance Summary

The figures 7.1, 7.2, 7.3, and 7.4 show the average portfolio value, average ROI, average maximum loss, and average invested capital for the HODL, traditional DCA, and improved DCA strategies. Each figure consolidates from various starting dates to simulate different market conditions and entry timings.

To provide a comprehensive summary of the results, the average values from all runs are shown in Table 7.1, while the corresponding median values are displayed in Table 7.2.

Strategy	**Portfolio ($)**	**ROI (%)**	**Max Loss (%)**	**Invested ($)**
HODL	67,368	124.56	-50.27	30,000
Classic DCA	68,582	128.61	-42.25	30,000
Improved DCA	**77,212**	**179.59**	**-39.42**	**27,827**

Table 7.1: Summary of average results across all runs.

Strategy	**Portfolio ($)**	**ROI (%)**	**Max Loss (%)**	**Invested ($)**
HODL	55,602	85.34	-57.05	30,000
Classic DCA	68,648	128.82	-52.60	30,000
Improved DCA	**75,696**	**173.79**	**-46.708**	**27,729**

Table 7.2: Summary of median across all runs.

Chapter 8

Conclusion

This thesis aimed to enhance our understanding of financial markets and explore existing investment strategies. After examining multiple asset classes and comparing short-term and long-term approaches, the focus was narrowed to long-term investing in cryptocurrencies. The goal was to improve one of the already established long-term strategies to navigate the cryptocurrency market's volatility better.

The thesis explored several well-known long-term investment approaches and provided a detailed comparison. To support this comparison, a custom backtesting framework was developed, specifically designed for long-term strategies, which allowed for comprehensive evaluation based on key performance metrics. Additionally, Bitcoin and Ethereum were analyzed to determine which external factors most significantly impacted their price movements.

The selected strategies were tested on these assets, and their strengths, weaknesses, and overall results were analyzed and discussed throughout the thesis. It was found that Bitcoin showed the strongest correlation with sentiment-based indicators, such as the Fear & Greed Index and the ColinTalksCrypto Bitcoin Bull Run Index (CBBI). Among the tested strategies, Dollar-Cost Averaging (DCA) was chosen for further development due to its more consistent and conservative performance.

Subsequently, an improved version of DCA was implemented, where the investment amount was dynamically adjusted, investing more during periods of market fear and reducing investments during periods of greed. The improved DCA strategy consistently outperformed HODL and traditional DCA strategies, requiring less total invested capital.

Looking ahead, one idea for future work is to refine the improved DCA strategy even further. Based on market sentiment, the current approach remains somewhat aggressive, sharply increasing or decreasing investment amounts. Even tho it's an automated trading strategy, a more smoothed adjustment mechanism could be introduced, making the strategy more practical and psychologically easier for investors to follow, rather than relying solely on extreme market conditions. Given the strong correlations observed with sentiment-based indicators like the Fear & Greed Index and CBBI, further integration of these indicators into investment decision-making appears to be a promising direction for future research and development.

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