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Analyzing Portfolio Optimization in Cryptocurrency Markets: A Comparative Study of Short-Term Investment Strategies Using Hourly Data Approach

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Abstract: This paper investigates portfolio optimization methodologies and short-term investment strategies in the context of the cryptocurrency market, focusing on ten major cryptocurrencies from June 2020 to March 2024. Using hourly data, we apply the Kurtosis Minimization methodology, along with other optimization strategies, to construct and assess portfolios across various rebalancing frequencies. Our empirical analysis reveals significant volatility, skewness, and kurtosis in cryptocurrencies, highlighting the need for sophisticated portfolio management techniques. We discover that the Kurtosis Minimization methodology consistently outperforms other optimization strategies, especially in shorter-term investment horizons, delivering optimal returns to investors. Additionally, our findings emphasize the importance of dynamic portfolio management, stressing the necessity of regular rebalancing in the volatile cryptocurrency market. Overall, this study offers valuable insights into optimizing cryptocurrency portfolios, providing practical guidance for investors and portfolio managers navigating this rapidly evolving market landscape.

Keywords: portfolio optimization; Sharpe's; kurtosis minimization; rebalancing frequency; diversification; short-term investment strategy

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1. Introduction

Cryptocurrencies are reshaping the financial landscape, poised to revolutionize the global financial system (Rajharia 2023). These digital assets garner attention from policymakers, investors, and academics as a burgeoning alternative asset class (Jana et al. 2024), exhibiting unprecedented growth and establishing a significant international foothold (Subramoney et al. 2023). According to CoinMarketCap (2024), the current market capitalization of cryptocurrency is US $2.72 trillion, showing a 3.67% increase from the previous day and highlighting the burgeoning interest in this domain (Krishna et al. 2023).

Cryptocurrency, characterized as a digital or virtual currency devoid of traditional backing like precious metals or commodities (Khan 2022), presents a unique challenge in understanding inter- and intra-asset dependencies among key financial variables (Zhang 2024). A comprehensive understanding of cryptocurrencies is imperative to expedite their broader adoption within the financial ecosystem (Shahzad 2024), particularly given their dynamic role within the evolving financial landscape (Wang 2024). Butterfill (2024) reported record weekly capital inflows totaling USD 2.7 billion in the first week of March 2024, bringing the total inflow year-to-date to USD 10.3 billion, nearing the record USD 10.6 billion inflow for the whole of 2021. This highlights the growing adoption and interest in cryptocurrencies.

The rapid expansion of cryptocurrencies is unfolding amidst an evolving regulatory framework, necessitating a nuanced approach to investment strategies. Regulatory considerations, encompassing consumer protection, financial stability, and taxation, loom large in the cryptocurrency space. Consequently, understanding interdependencies in cryptocurrency markets is indispensable for informed decision-making (Alipour and Charandabi 2023).

The genesis of cryptocurrencies traces back to Bitcoin's emergence in 2009, catalyzing a tumultuous evolution of the cryptocurrency market (ElBahrawy et al. 2017). Originally conceived to cater to the unbanked, reduce costs and energy consumption, and eliminate financial intermediaries (McMorrow and Esfahani 2021), cryptocurrencies have morphed into a distinct species within the financial instrument ecosystem. Characterized by decentralization, volatility, and high risk–reward potential, cryptocurrencies have ascended in global financial significance, attracting investors seeking diversification and short-term gains (Mungo et al. 2023).

Effective portfolio management emerges as pivotal in mitigating risks and maximizing returns in cryptocurrency investments. The dynamic nature of cryptocurrencies necessitates a thorough analysis to inform policymakers and regulatory bodies of their evolving role as investment assets. Cryptocurrencies offer potential avenues for risk diversification and portfolio optimization (Araujo et al. 2023), improving the risk–return trade-off and enhancing portfolio efficiency (Trimborn et al. 2019).

This study's novelty lies in its utilization of the top ten cryptocurrencies based on market capitalization. Our objective was to investigate the effectiveness of utilizing kurtosis in the portfolio construction framework, specifically by minimizing the kurtosis of the portfolio. This approach will be compared with the traditional Sharpe's maximization technique to determine which method performs better in the realm of cryptocurrency. Furthermore, we implemented five short-term strategies (half-week, one-week, two-week, four-week, and eight-week) for portfolio construction. Each strategy was tested using three different methodologies: naive portfolio construction, Sharpe maximization, and kurtosis minimization. This comprehensive approach allowed us to assess which short-term strategy aligns best with the volatile nature of cryptocurrencies.

To evaluate the performance of each portfolio, we considered both holding period returns and annualized returns. Statistical analysis techniques were then applied to the data to identify significant trends or patterns. This systematic analysis provided insights into the efficacy of different portfolio construction methods and short-term strategies within the cryptocurrency market.

The subsequent sections of this paper are structured as follows: in Section 2 is a literature review; Section 3 expounds on our empirical analysis; Section 4 presents the results and discussion; and, finally, Section 5 concludes our study.

2. Literature Review

The literature on cryptocurrency portfolio management strategies provided insights into various methodologies and their implications in cryptocurrency markets. Gupta et al. (2022) explored reducing portfolio risk using cryptocurrencies, highlighting the associated challenges. Silva et al. (2022) critically evaluated cryptocurrency trading algorithms, identifying areas for further exploration. Lorenzo and Arroyo (2023) compared risk-based portfolio allocation on crypto asset subsets, enriching the portfolio management literature. Symitsi and Chalvatzis (2019) quantified the economic gains achievable through cryptocurrency portfolio strategies. Previous research has explored interlinkages between major cryptocurrencies (Yousaf and Ali 2020), portfolio diversification in emerging markets (Letho et al. 2022), and the impact of volatility on cryptocurrency investment (Zaretta and Pangestuti 2023), offering insights into market dynamics.

The evolving regulatory landscape significantly influences investment strategies, impacting safety perceptions, risk characteristics, and market dynamics. Conlon et al. (2020) illustrated how regulatory developments during the COVID-19 pandemic affected the role of cryptocurrencies as safe havens for equity markets. Sukumaran et al. (2022) focused on regulatory developments in specific jurisdictions, while Waspada et al. (2022) stressed the importance of regulation in managing risks associated with emerging crypto assets. Ethical considerations in cryptocurrency investments are crucial for responsible practices. Bagus and Horra (2021) undertook an ethical assessment of cryptocurrencies, highlighting considerations associated with investment decisions. Insights from the behavioral finance literature aid in understanding investors' psychological factors and decision-making in cryptocurrency investments (Ballis and Verousis 2022; Zhao and Zhang 2021; Choi and Feinberg 2022).

Transitioning to portfolio optimization methodologies, incorporating three distinct methodologies—naive portfolio construction, Sharpe ratio maximization, and kurtosis minimization—offers a comprehensive approach that considers various aspects of risk and return (Hanif et al. 2023). Naive portfolio construction involves equally weighting the assets in a portfolio and serves as a straightforward baseline strategy (Chen et al. 2022). Conversely, Sharpe ratio maximization aims to enhance the risk-adjusted return of a portfolio, effectively balancing risk and return (Dabbous et al. 2022). Lastly, kurtosis minimization seeks to mitigate the impact of extreme returns, bolstering portfolio resilience against market volatility (Susilo et al. 2020).

By integrating these methodologies, investors can obtain a holistic perspective on portfolio optimization. Naive portfolio construction provides simplicity and serves as an initial step towards diversification, while Sharpe ratio maximization underscores the optimization of risk-adjusted returns, and kurtosis minimization concentrates on managing extreme risks. Together, these methodologies address various facets of portfolio performance, offering a well-rounded approach to constructing efficient and robust investment portfolios.

Short-term strategies and optimization methodologies play a crucial role in navigating the dynamics of the cryptocurrency market. Mean-variance optimization techniques provide valuable insights into managing short-term portfolios (Inci and Lagasse 2019), while robust risk management strategies help to mitigate short-term volatility (Kozlovskyi et al. 2022). The analysis of hourly data assists in understanding trading patterns, market efficiency, and the co-movements of volatility in cryptocurrency markets (Petukhina et al. 2020; Zhang et al. 2020).

Employing five short-term strategies across various durations—half-week, one-week, two-week, four-week, and eight-week—allows for a comprehensive approach to portfolio construction in cryptocurrencies. Each strategy serves a distinct purpose: the half-week strategy enables investors to rapidly adjust to capitalize on immediate market movements (Kong and Xu 2023), while the one-week strategy provides a slightly longer timeframe for evaluating trends (Gu 2022). Transitioning to a two-week strategy strikes a balance between agility and stability, capturing unfolding trends (Liu 2022). Extending to a four-week strategy enables investors to conduct a deeper analysis of performance and risk management (Zhang 2023). Finally, the eight-week strategy offers a longer-term perspective, facilitating strategic decision-making based on sustained trends (Ruban et al. 2022). By integrating these strategies, investors can tailor their approaches to different market conditions, optimizing risk-adjusted returns (Kong and Xu 2023).

The analysis of relationships and dependencies between cryptocurrencies through methodologies such as logarithmic returns and correlation matrices aids in portfolio diversification and risk management strategies (Scagliarini et al. 2022; Plerou et al. 2002). Testing strategies across different time horizons captures distinct aspects of their performance, emphasizing the importance of considering different time horizons in strategy testing (Nasir and Wahab 2022). Additionally, the buy-and-hold strategy exhibits variability in performance in cryptocurrency markets compared to other trading rules (Adrianus and Soekarno 2018).

The existing literature on cryptocurrency portfolio management strategies offers a comprehensive understanding of digital assets within the global financial system. Effective portfolio management strategies are crucial as cryptocurrencies disrupt traditional financial markets. The studies reviewed underscore the importance of considering interdependencies among major cryptocurrencies, volatility's impact on investment decisions, and the significance of short-term strategies in navigating market dynamics.

Our study addresses a gap in the existing literature by examining the effectiveness of various portfolio optimization methodologies in short-term investments using a selection of ten cryptocurrencies. While previous studies have investigated portfolio management strategies and optimization techniques in cryptocurrency markets, we have not specifically focused on comparing different short-term investment strategies and their corresponding portfolio optimization methods. We aim to fill this gap by exploring which short-term investment strategy would be most suitable for investors in the cryptocurrency market and, within each strategy, identifying the optimal portfolio optimization approach. Through this analysis, we seek to provide valuable insights for investors looking to optimize their cryptocurrency portfolios for short-term gains.

3. Empirical Analysis

3.1. Data and Methodology

The hourly closing prices of the top ten cryptocurrencies by market capitalization—Binance (BNB), Bitcoin (BTC), Cardano (ADA), Chainlink (LINK), Dogecoin (DOGE), Ethereum (ETH), Litecoin (LTC), Polygon (MATIC), Ripple (XRP), and Tron (TRX)—were used to conduct this study. The data used for the study ranged from 1 June 2020 to 13 March 2024. All the data used for the analysis were downloaded from CoinMarketCap (https://coinmarketcap.com/coins/), (accessed on 11 March 2024). The reason for choosing this period was to incorporate the effects of the post-COVID-19 period.

Market capitalization serves as a vital metric for assessing the value and size of a cryptocurrency (Liu et al. 2022). Unlike individual cryptocurrency prices, which may not reflect the total value accurately, market capitalization provides a more comprehensive measure, allowing for comparisons with other cryptocurrencies. This concept mirrors the stock market, where market capitalization is calculated by multiplying the current stock price by the total number of shares outstanding. In the cryptocurrency realm, market capitalization is determined by multiplying the circulating supply (the number of coins available to the public) by the current price. Due to its significance, market capitalization is often a primary criterion for selecting cryptocurrencies. However, it should also be considered independently during portfolio optimization to ensure a well-rounded approach for practitioners.

Table 1 presents summary statistics for hourly cryptocurrency returns, revealing well-known financial stylized facts such as negative skewness and positive excess kurtosis. Out of the ten cryptocurrencies analyzed, eight showed negative average hourly returns, indicating a loss in value over the analyzed period. However, these average returns were close to 0%, with Polygon having the highest positive return and Litecoin showing the lowest negative return, as well as the largest range of 67.27%. Tron had the highest hourly median return at 0.019%.

The median and mean values for the sample were nearly identical, differing by less than 0.02%. The skewness, which measures the symmetry of the data distribution, varied among the cryptocurrencies, with all currencies skewed towards the lower tail and Cardano exhibiting the highest skewness in the sample.

The volatility, measured using the standard deviation and coefficient of variation, remained high for all cryptocurrencies, with the absolute values of the coefficient of variation ranging from 56.58 (Litecoin) to 493.69 (Binance). None of the currencies demonstrate normality at a 99% confidence level according to the Jarque–Bera test, as evidenced by consistently low p-values (<0.01). Additionally, all cryptocurrencies exhibited high kurtosis, with values ranging from 11.15 (Bitcoin) to 117.68 (Litecoin).

The combination of high volatility, skewness, and kurtosis in most currencies highlights the importance of a methodology that enables investors to understand currency behavior and construct improved portfolios by actively managing factors such as kurtosis.

Table 1. Shows the descriptive statistics of hourly returns of the ten cryptocurrencies.

Descriptive Statistics	Binance	Bitcoin	Cardano	Chainlink	Dogecoin	Ethereum	Litecoin	Polygon	Ripple	Tron
Minimum	−24.67%	−8.00%	−13.24%	−20.19%	−19.64%	−14.77%	−45.17%	−23.04%	−21.23%	−14.89%
Maximum	24.68%	9.34%	11.28%	11.37%	15.80%	7.37%	22.10%	19.33%	24.30%	9.27%
Range	49.35%	17.34%	24.52%	31.56%	35.44%	22.14%	67.27%	42.37%	45.53%	24.16%
Mean	0.00%	−0.01%	−0.01%	−0.02%	−0.02%	0.00%	−0.02%	0.01%	−0.02%	−0.01%
Median	0.01%	0.00%	−0.01%	0.00%	−0.01%	0.01%	0.01%	0.00%	0.02%	0.02%
Standard Deviation	1.32%	0.88%	1.34%	1.51%	1.56%	1.15%	1.38%	1.94%	1.48%	1.20%
Coefficient of Variation	493.69	−92.98	−126.87	−77.98	−69.19	−268.19	−56.58	230.49	−89.70	−86.95
Skewness	−0.26	−0.26	−0.15	−0.67	−0.53	−0.52	−3.68	0.40	−0.40	−0.60
Kurtosis	38.31	11.15	11.52	13.41	14.79	11.62	117.68	17.07	30.97	15.40
Jarque–Bera Test (*p*-value)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Elaborated by the author.

We started by calculating the returns through the log difference of consecutive hourly closing prices of cryptocurrencies, following the method described by Akyildirim et al. (2021). This calculation followed the following equation:

$$R_{\mathrm{n}} = (In\ CP_{\mathrm{n}} - In\ CP_{(\mathrm{n}-1)}) \times 100 \quad (1)$$

In this equation, R_{n} denotes returns at the nth hour as a percentage; CP_{n} denotes the closing price at the nth hour; $CP_{(\mathrm{n}-1)}$ denotes the closing price on the previous trading hour; and In is a natural log.

After analyzing the returns statistics, the next step is to create a simple portfolio. This involved allocating an equal fraction of 1/N of our total wealth to each of the N assets available for investment, following the '1/N' allocation rule. This approach is commonly recommended as a reference portfolio. In this study, we assigned 10% to each of the 10 assets in the portfolio. We conducted empirical investigations using two distinct portfolios: one using the Sharpe maximization methodology, and the other using the Kurtosis minimization methodology.

We initially estimated the input parameters required for computing optimal portfolio weights according to the two strategies using a T-period-long dataset of returns. We then used subsequent periods, expressed in weeks, to assess the portfolio performance over the following W periods. The value of W was determined by the chosen rebalancing frequency. Throughout these W periods, we implemented a buy-and-hold approach, which is more practical for real-world investors compared to a constant mixed approach.

To evaluate and optimize the portfolios, we followed an iterative process. This process involved shifting the estimation window forward by a certain number of periods (W) and then recalculating the optimal portfolio weights. We repeated this process for the subsequent W periods while discarding an equal number of earliest returns. This iterative approach helped ensuring a comprehensive evaluation and optimization of the portfolios. We continued this process until we reached the end of the dataset.

3.2. Sharpe Maximization Methodology Portfolio

Constructing a portfolio that maximizes the Sharpe ratio offers numerous advantages within portfolio management. Investors utilize the Sharpe ratio, a crucial metric for evaluating investment performance, as it assesses the risk-adjusted return of a portfolio. According to a study by Siegel and Woodgate (2007), under appropriate conditions, portfolios that maximize the Sharpe ratio tend to become more diversified, which indicates that maximizing the Sharpe ratio can enhance portfolio diversification.

Portfolio analysts widely employ the Sharpe maximization methodology in portfolio analysis, as it assesses the opportunity cost of investing in a particular portfolio relative to the Risk-Free Asset. In this study, we utilized the 28-day T-bill as a reference. To implement this methodology, we used rolling averages to smoothen the highly volatile database of prices and returns. We examined this smoothing process based on the period chosen for each strategy.

$$Sharpe = \frac{E(R_p) - R_F}{\sigma_p} \tag{2}$$

where $E(R_p)$ represents the expected return of the portfolio, R_F denotes the risk-free rate, and σ_p indicates standard deviation of the portfolio shown as $\sigma_p = \sqrt{Variance\ of\ the\ Portfolio}$.

We adjusted the annual risk-free rate to match the frequency of the rebalancing period, ensuring consistency and accuracy in our calculations. It is crucial to emphasize that whenever a negative Sharpe ratio emerged, meaning that the return of the Risk-Free Asset surpassed that of the portfolio in that specific period, we chose to use the naive portfolio weights. In other words, we conducted rebalancing in every period without exception.

3.3. Kurtosis Minimization Methodology Portfolio

The Kurtosis minimization methodology utilizes a descriptive statistic known as kurtosis to measure how data disperse between a distribution's center and tails. Kurtosis values suggest that a data distribution may have "heavy" tails, meaning they are thickly concentrated with observations or have long tails with extreme observations (Green et al. 2023). The kurtosis minimization methodology in Pearson's kurtosis model aims to regulate the kurtosis of the portfolio's assets by assigning lower weights to assets with higher kurtosis and vice versa. We performed this calculation during each rebalancing period to ensure we achieved the lowest possible kurtosis whenever we traded currencies.

$$kurtosis_{x_k} = \frac{\sum_i^n (x_{ki} - \bar{x_k})^4}{n\sigma_{x_k}^4} \tag{3}$$

where $kurtois_{x_k}$ is the kurtosis of the variable x_k, a normally distributed sample will have a kurtosis close to 3.

Like the Sharpe maximization methodology, the same considerations and calculations were applied in this methodology. Rolling averages were utilized to smooth the highly volatile database of prices and returns, with the smoothing period determined by the strategy's timeframe. These rolling averages were then used to determine the portfolio weights that would result in the lowest possible kurtosis in each period. Subsequently, these weights were utilized in the subsequent holding period. Formula (5) ensures that the asset with the highest kurtosis receives the least weight of investment, while assets with lower kurtosis are assigned higher weights, thereby optimizing the portfolio for kurtosis minimization.

The formula for calculating the Kurtosis Minimization Portfolio Return is as follows:

$$Kurtosis\ Minimization\ Portfolio\ Return = \sum_{n=1}^{i} W_{Kn(t)} \times R_{n(t+1)} \tag{4}$$

where $W_{Sn(t)}$ represents the weight of asset n calculated with Kurtosis minimization in period t. $R_{i(t+1)}$ denotes the return of asset n in period t + 1.

$$w_{x_k} = \frac{\frac{1}{kurtosis_{x_k}}}{\sum \frac{1}{kurtosis_x}} \times 100\% \tag{5}$$

where $\sum \frac{1}{kurtosis_x}$ represents the sum of inverses of the kurtosis of all the variables in a portfolio.

4. Results and Discussion

We conducted an analysis using the buy-and-hold strategy across five distinct rebalancing frequencies: half a week, one week, two weeks, four weeks, and eight weeks. We complemented this analysis by applying three portfolio optimization strategies: creating a Naive portfolio, maximizing the Sharpe ratio, and minimizing kurtosis. Given the high volatility inherent in cryptocurrencies, we opted for shorter holding periods. These shorter intervals allow for more frequent rebalancing and are suitable for investors with a shorter investment horizon. The rationale behind this approach is to capitalize on potential returns within a condensed timeframe. Table 2 provides a comprehensive overview of the returns obtained under different strategies and methodologies for the holding period spanning from 2020 to 2023.

Table 2. The holding period returns from 2020 to 2023.

Rebalancing Frequency	Naive Portfolio	Sharpe Maximization Methodology	Kurtosis-Minimization Methodology
Half a week	713.14%	762.73%	**1166.73%**
One week	651.20%	638.98%	**823.24%**
Two weeks	643.05%	354.48%	**650.53%**
Four weeks	386.66%	175.22%	**682.84%**
Eight weeks	293.93%	**1225.68%**	628.36%

Source: elaborated by the author. The figures in bold indicate the highest return achieved under either the Naive strategy, Sharpe maximization strategy, or kurtosis minimization strategy.

We further investigated the effectiveness of the optimization strategies by reducing the holding period to one year and evaluating their performance under the same rebalancing frequencies. Table 3 presents the returns achieved with different rebalancing strategies over a one-year time frame. Through this analysis, we aimed to determine which optimization strategy proves superior in optimizing returns within this extended investment horizon while maintaining consistent rebalancing frequencies.

Table 3. The holding period returns for one year.

Rebalancing Frequency	Naive Portfolio	Sharpe Maximization Methodology	Kurtosis Minimization Methodology
Half a week	90.62%	94.13%	**118.50%**
One week	86.09%	85.10%	**98.23%**
Two weeks	76.18%	59.37%	**85.98%**
Four weeks	62.76%	36.57%	**88.41%**
Eight weeks	52.51%	**121.58%**	84.28%

Source: elaborated by the author. The figures in bold indicate the highest return achieved under either the Naive strategy, Sharpe maximization strategy, or kurtosis minimization strategy.

The findings from Tables 2 and 3 indicate that the portfolio optimization method based on kurtosis minimization consistently outperformed others in the short term, particularly over holding periods of half a week, one week, two weeks, and four weeks, delivering optimal returns to investors. This observation aligns with the nature of cryptocurrencies, which are often traded in shorter terms, making kurtosis minimization particularly beneficial for capturing their market dynamics. This finding is corroborated by the literature, which emphasizes the importance of employing short-term strategies across various durations to construct comprehensive portfolios in cryptocurrencies. Each of these strategies serves a distinct purpose, enabling investors to tailor their approaches to different market conditions and optimize risk-adjusted returns.

Figure 1 illustrates the distribution of weights along the estimation window when implementing the Sharpe maximization strategy. Most of the assets receive a portion of the investment throughout the entire period. Although there are sporadic periods where certain cryptocurrencies, mainly Ripple, did not contribute to the portfolio return, the weight allocation remained distributed among the ten assets.

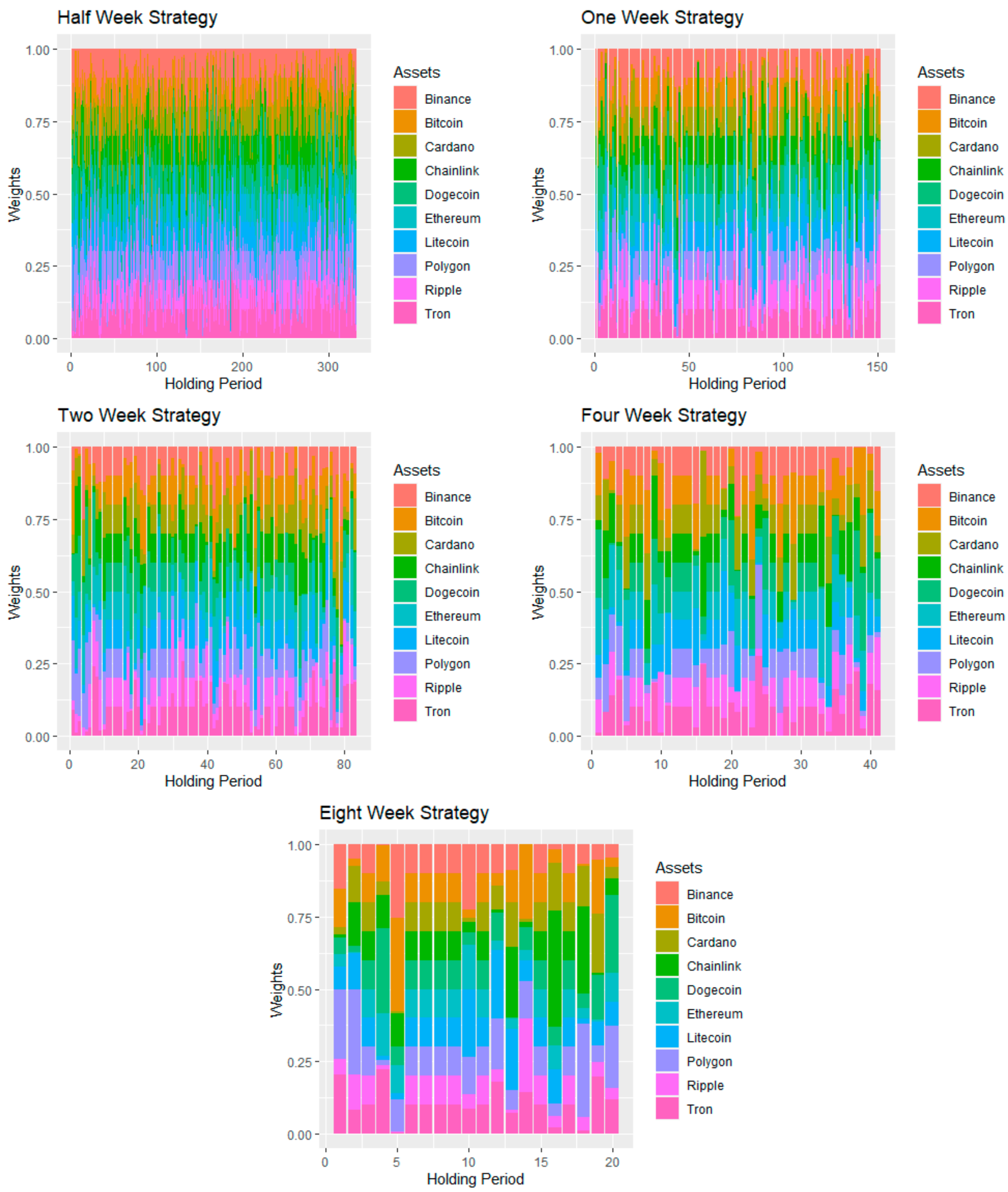

Figure 1. Bar charts representing the distribution of weights during holding periods with various rebalancing frequencies using the Sharpe ratio minimization strategy. Source: elaborated by the author.

Figure 2 depicts the distribution of weights during both holding and rebalancing periods within the kurtosis minimization strategy. There was no significant imbalance observed across any of the depicted strategies. However, a notable observation is the presence of a white line in the figures corresponding to the half-, one-, and two-week periods. This occurrence in April 2022 occurred because kurtosis was not calculated for the portfolio due to the absence of movement in Litecoin's price.

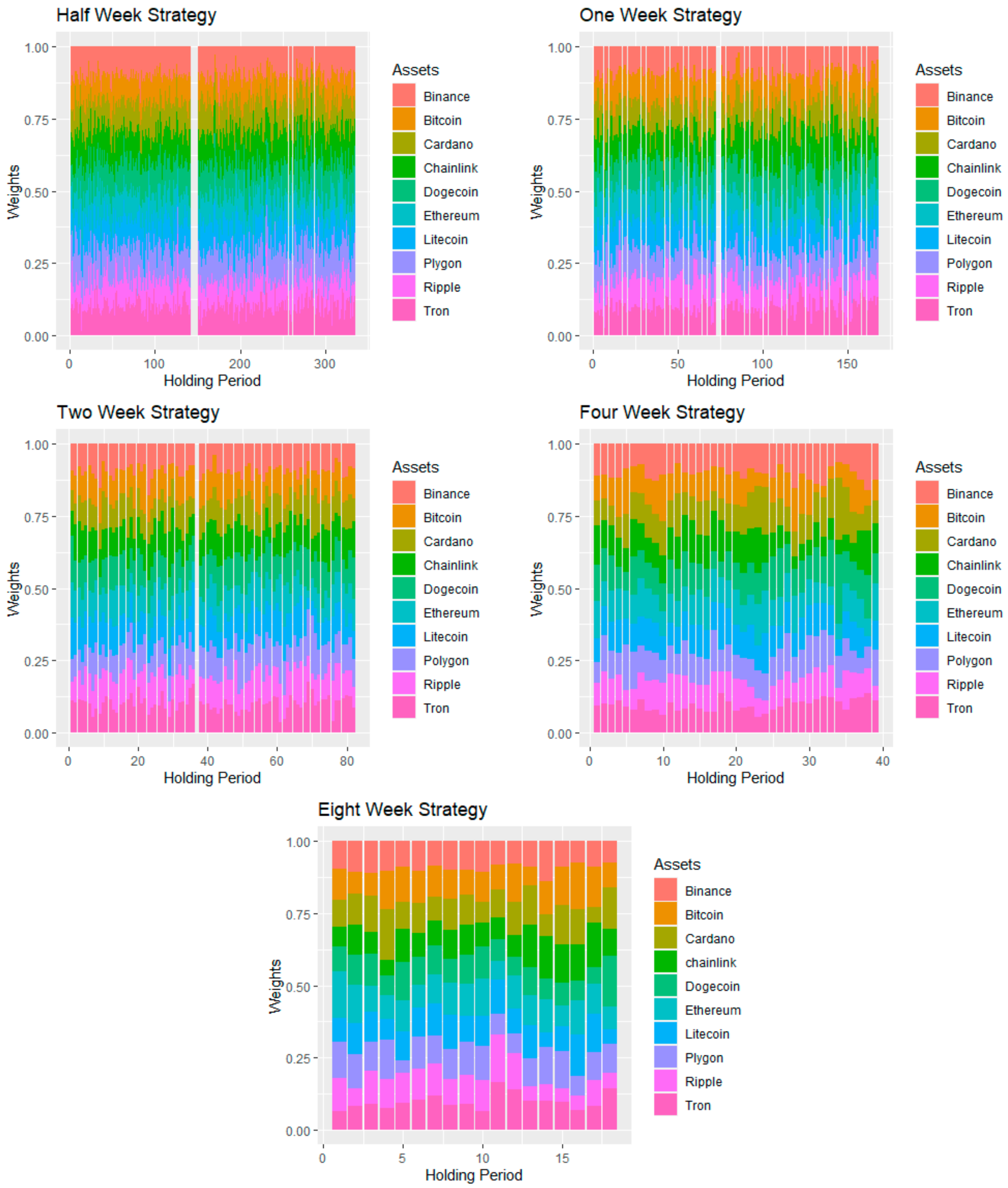

Figure 2. Bar charts representing the distribution of weights during holding and rebalancing periods using the kurtosis minimization strategy. Source: elaborated by the author.

Comparing the two methodologies, while the Sharpe maximization approach generated a more random distribution of portfolio weights along the estimation window, the kurtosis minimization method presented a steadier and more homogeneous distribution. Graphically, a consistent pattern is evident in the kurtosis minimization methodology, with most cryptocurrencies appearing in every rebalancing period. Conversely, the Sharpe maximization methodology exhibits a less patterned distribution, with several periods where some assets did not receive any investment.

Figure 3 presents a comparison of how portfolio returns behave under each methodology, segmented by strategy, revealing distinct patterns. The graphs illustrate that both the kurtosis minimization and Sharpe maximization methodologies effectively reduced the impact of high volatility on portfolio returns, and this was especially noticeable during periods of heightened volatility, such as those observed in the naive portfolio strategy. Furthermore, the graphs show that strategies with higher rebalancing frequencies experience more pronounced reductions in volatility.

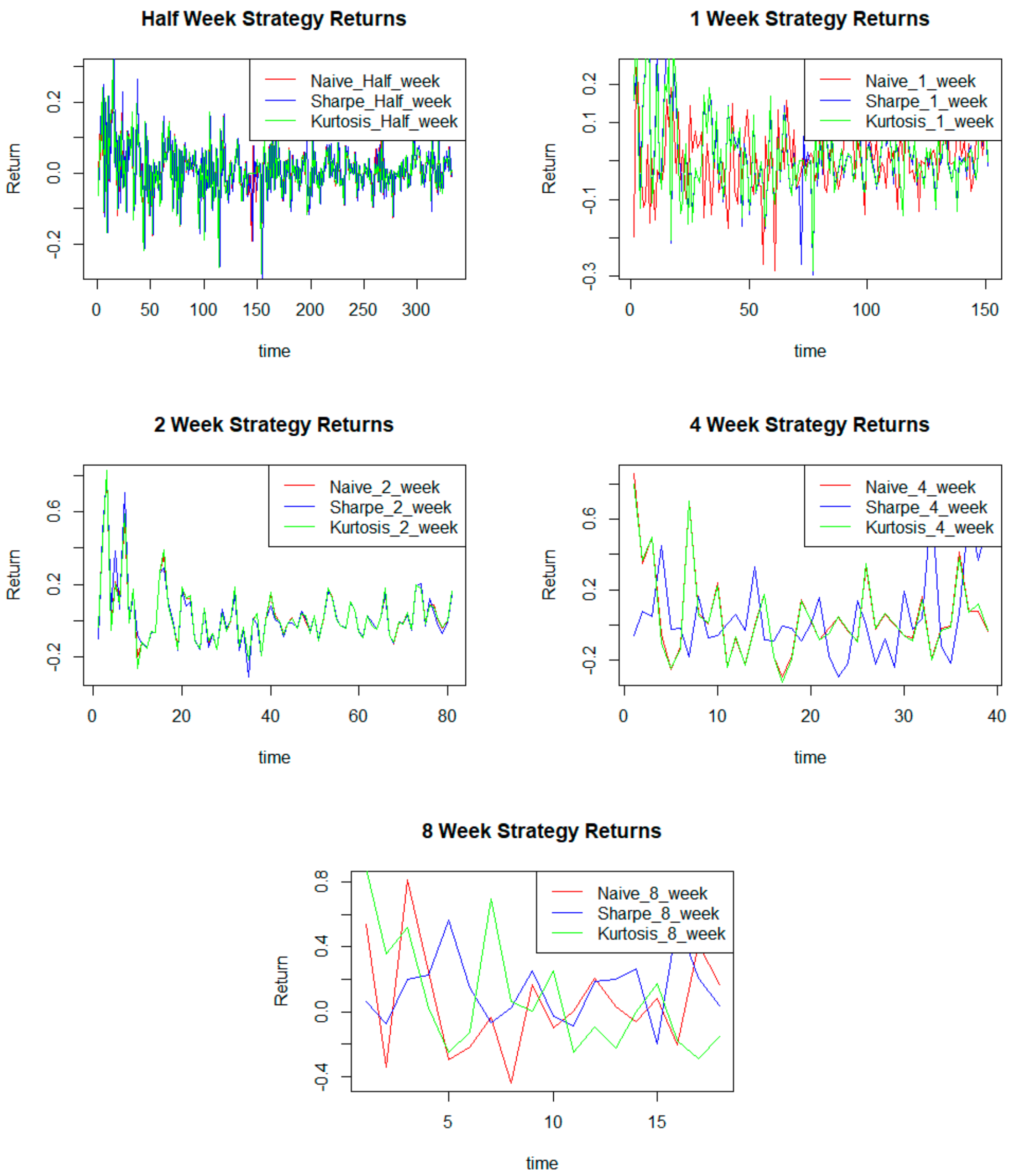

Figure 3. Comparison of portfolio returns behavior under different methodologies and strategies. Source: elaborated by the author.

In contrast to the findings of Ma et al. (2020), who emphasized the superior performance of the naive portfolio using the Sharpe ratio across various cryptocurrency portfolios in terms of return and risk profile, our study revealed the effectiveness of the kurtosis minimization portfolio, particularly within shorter-term rebalancing frequencies. While Ma et al. focused on longer-term diversification strategies, our research indicates that kurtosis minimization optimization yields favorable outcomes even in shorter investment horizons.

Similarly, Letho et al. (2022) underscored the diversification benefits of cryptocurrencies within an emerging market economy investment portfolio, employing metrics such as mean-variance analysis and the Sharpe ratio to support their findings. Our study aligns with this perspective, demonstrating that cryptocurrencies indeed offer diversification benefits. Moreover, leveraging the kurtosis minimization optimization can enhance portfolio design by mitigating the risks associated with outliers and extreme market conditions, as supported by the findings of Cesarone et al. (2021).

Contrary to the empirical study conducted by Schellinger (2020), which prioritized maximizing the Sharpe ratio for optimizing cryptocurrency portfolios, our research challenges this approach by advocating for kurtosis minimization as a superior methodology, especially for short-term rebalancing frequencies. While Schellinger extended the traditional mean-variance approach, our findings suggest that focusing on minimizing kurtosis leads to more favorable results in cryptocurrency portfolio management.

The practical implications of our findings for portfolio managers and investors in the cryptocurrency market are significant and diverse. Our analysis highlights the necessity of employing advanced portfolio optimization techniques tailored to the unique attributes of cryptocurrencies. Specifically, we emphasize the effectiveness of the kurtosis minimization methodology in enhancing portfolio performance, particularly within shorter-term investment horizons. This insight equips portfolio managers with a valuable tool for maximizing returns while simultaneously mitigating risk in their cryptocurrency holdings.

Kurtosis minimization aims to diminish the impact of extreme returns or outliers in a portfolio, thereby enhancing its resilience to unforeseen market events and volatility (Wang et al. 2022). Conversely, Sharpe ratio maximization focuses on optimizing the risk-adjusted return of a portfolio by balancing risk and return to achieve higher returns for a given level of risk (Kumar and Shahid 2023). In scenarios where investors aim to mitigate potential risks associated with extreme market movements, kurtosis minimization is particularly relevant, aiming to create a stable and robust portfolio. By minimizing kurtosis, investors can reduce the likelihood of significant losses during turbulent market conditions, thereby improving overall risk management.

Furthermore, our research emphasizes the importance of regular portfolio rebalancing, especially in the volatile cryptocurrency market. By adopting a dynamic approach to portfolio management, investors can adapt to changing market conditions and optimize their portfolios for maximum returns. The use of shorter rebalancing frequencies, as advocated in our study, enables investors to capitalize on short-term opportunities and adjust their portfolios accordingly.

Regarding risk management strategies, our analysis underscores the significance of controlling factors such as kurtosis in portfolio construction. By minimizing kurtosis, investors can reduce the likelihood of extreme market events and enhance portfolio stability. This risk management approach is particularly relevant in the cryptocurrency market, characterized by inherent volatility and significant consequences of unexpected price movements.

5. Conclusions

The emergence of cryptocurrencies has brought about unique opportunities and challenges for investors and portfolio managers. In this study, we examined various portfolio optimization techniques and short-term investment strategies in the context of the cryptocurrency market, focusing on ten major cryptocurrencies.

Our analysis revealed several important findings. Firstly, we observed that cryptocurrencies are highly volatile and exhibit significant skewness and kurtosis. This highlights the need for sophisticated portfolio management techniques that are tailored to their unique characteristics. Secondly, we found that the kurtosis minimization methodology consistently outperformed other optimization strategies, delivering optimal returns to investors, especially in shorter-term investment horizons. This underscores the importance of controlling factors such as kurtosis for effective risk management and portfolio stability in the cryptocurrency market.

Our research also emphasized the importance of regular portfolio rebalancing, particularly in the volatile cryptocurrency market. A dynamic approach to portfolio management allows investors to take advantage of short-term opportunities and optimize returns.

Shorter rebalancing frequencies enables investors to adapt quickly to changing market conditions, thereby maximizing returns and mitigating risks effectively.

In conclusion, the insights gained from our analysis can guide decision-making processes, risk management strategies, and portfolio construction techniques in the cryptocurrency market. By incorporating the kurtosis minimization methodology, diversifying portfolios with cryptocurrencies, adopting regular rebalancing practices, and prioritizing risk management, portfolio managers and investors can navigate the complexities of the cryptocurrency market more effectively and optimize their returns.

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References

Adrianus, Rio, and Subiakto Soekarno. 2018. Determinants of momentum strategy and return in short time horizon: Case in indonesian stock market. *International Journal of Trade and Global Markets* 11: 1. [CrossRef]

Akyildirim, Erdinc, Ahmet Goncu, and Ahmet Sensoy. 2021. Prediction of cryptocurrency returns using machine learning. *Annals of Operations Research* 297: 3–36. [CrossRef]

Alipour, Peyman, and Sina E. Charandabi. 2023. Analyzing the interaction between tweet sentiments and price volatility of cryptocurrencies. *European Journal of Business Management and Research* 8: 211–15. [CrossRef]

Araujo, Fernando Henrique Antunes, Leonardo H. S. Fernandes, José W. L. Silva, Kleber E. S. Sobrinho, and Benjamin Tabak. 2023. Assessment the predictability in the price dynamics for the top 10 cryptocurrencies: The impacts of russia–ukraine war. *Fractals* 31. [CrossRef]

Bagus, Philipp, and Luis P. de la Horra. 2021. An ethical defense of cryptocurrencies. *Business Ethics the Environment & Responsibility* 30: 423–31. [CrossRef]

Ballis, Antonis, and Thanos Verousis. 2022. Behavioural finance and cryptocurrencies. *Review of Behavioral Finance* 14: 545–62. [CrossRef]

Butterfill, J. 2024. Digital Asset Fund Flows | March 11. Etp.coinshares.com. Available online: https://etp.coinshares.com/knowledge/market-activity/fund-flows-11-03-24 (accessed on 11 March 2024).

Cesarone, Francesco, Manuel L. Martino, and Fabio Tardella. 2021. Mean-variance-var portfolios: Miqp formulation and performance analysis. *OR Spectrum* 45: 1043–69. [CrossRef]

Chen, Yinnan, Xinchao Zhao, and Jianmei Yuan. 2022. Swarm intelligence algorithms for portfolio optimization problems: Overview and recent advances. *Mobile Information Systems* 2022: 1–15. [CrossRef]

Choi, Sooyeon, and Richard A. Feinberg. 2022. Linking consumer innovativeness to the cryptocurrency intention: Moderating effect of the lohas (lifestyle of health and sustainability) lifestyle. *Journal of Engineering Research and Sciences* 1: 1–8. [CrossRef]

CoinMarketCap. 2024. Cryptocurrency Market Capitalizations | CoinMarketCap. CoinMarketCap. Available online: https://coinmarketcap.com/ (accessed on 11 March 2024).

Conlon, Thomas, Shaen Corbet, and Richard J. McGee. 2020. Are cryptocurrencies a safe haven for equity markets? an international perspective from the COVID-19 pandemic. *Research in International Business and Finance* 54: 101248. [CrossRef]

Dabbous, Amal, May Merhej Sayegh, and Karine Aoun Barakat. 2022. Understanding the adoption of cryptocurrencies for financial transactions within a high-risk context. *The Journal of Risk Finance* 23: 349–67. [CrossRef]

ElBahrawy, Abeer, Laura Alessandretti, Anne Kandler, Romualdo Pastor-Satorras, and Andrea Baronchelli. 2017. Evolutionary dynamics of the cryptocurrency market. *Royal Society Open Science* 4: 170623. [CrossRef]

Green, Jennifer L., Sarah E. Manski, Timothy A. Hansen, and Jennifer E. Broatch. 2023. Descriptive statistics. In *International Encyclopedia of Education*, 4th ed. Edited by Robert J. Tierney, Fazal Rizvi and Kadriye Ercikan. Amsterdam: Elsevier, pp. 723–33, ISBN 9780128186299. [CrossRef]

Gu, Qianyu. 2022. Comparison of risk minimizing and return maximizing portfolio models. *BCP Business & Management* 30: 489–95. [CrossRef]

Gupta, Nupur, Pradip Mitra, and Debjani Banerjee. 2022. Cryptocurrencies and traditional assets: Decoding the analogy from emerging economies with crypto usage. *Investment Management and Financial Innovations* 20: 1–13. [CrossRef]

Hanif, Waqas, Hee-Un Ko, Linh Pham, and Sang Hoon Kang. 2023. Dynamic connectedness and network in the high moments of cryptocurrency, stock, and commodity markets. *Financial Innovation* 9: 1–40. [CrossRef]

Inci, A. Can, and Rachel Lagasse. 2019. Cryptocurrencies: Applications and investment opportunities. *Journal of Capital Markets Studies* 3: 98–112. [CrossRef]

Jana, Susovon, Ankita Nandi, and Tarak Nath Sahu. 2024. Can cryptocurrencies provide better diversification benefits? evidence from the indian stock market. *Journal of Interdisciplinary Economics* 15: 551–73. [CrossRef]

Khan, Saleh Nawaz. 2022. The legality of cryptocurrency from an islamic perspective: A research note. *Journal of Islamic Accounting and Business Research* 14: 289–94. [CrossRef]

Kong, Silin, and Mingchen Xu. 2023. Portfolio optimization for junior investors under different industries. *BCP Business & Management* 38: 1506–15. [CrossRef]

Kozlovskyi, Serhii, Iaroslav Petrunenko, Hennadii Mazur, Vira Butenko, and Najatalya Ivanyuta. 2022. Assessing the probability of bankruptcy when investing in cryptocurrency. *Investment Management and Financial Innovations* 19: 312–21. [CrossRef]

Krishna, Jaya Shankar, Akankhya Panda, and Pappu Sindhuja. 2023. Cryptocurrency adoption and its influence on traditional financial markets. *Interantional Journal of Scientific Research in Engineering and Management* 7: 1–11. [CrossRef]

Kumar, Akhilesh, and Mohammad Shahid. 2023. Portfolio selection model using teaching learning-based optimization approach. *IAES International Journal of Artificial Intelligence (IJ-AI)* 12: 1083. [CrossRef]

Letho, Lehlohonolo, Grieve Chelwa, and Abdul Latif Alhassan. 2022. Cryptocurrencies and portfolio diversification in an emerging market. *China Finance Review International* 12: 20–50. [CrossRef]

Liu, Yongyu. 2022. Portfolio optimization with or without safe asset. Paper presented at 2022 International Conference on Economics, Smart Finance and Contemporary Trade (ESFCT 2022), Xi'an, China, July 22–24; pp. 425–32. [CrossRef]

Liu, Yukun, Aleh Tsyvinski, and Xi Wu. 2022. Common risk factors in cryptocurrency. *The Journal of Finance* 77: 1133–77. [CrossRef]

Lorenzo, Luis, and Javier Arroyo. 2023. Online risk-based portfolio allocation on subsets of crypto assets applying a prototype-based clustering algorithm. *Financial Innovation* 9: 1–40. [CrossRef]

Ma, Yechi, Ferhana Ahmad, Miao Liu, and Zilong Wang. 2020. Portfolio optimization in the era of digital financialization using cryptocurrencies. *Technological Forecasting and Social Change* 161: 120265. [CrossRef]

McMorrow, Jake, and Mona Seyed Esfahani. 2021. An exploration into people's perception and intention on using cryptocurrencies. *Holistica—Journal of Business and Public Administration* 12: 109–44. [CrossRef]

Mungo, Luca, Silvia Bartolucci, and Laura Alessandretti. 2023. Crypocurrency co-investment network: Token returns reflect investment patterns. *EPJ Data Science* 13: 11. [CrossRef]

Nasir, Nurul Afaaf Mohd, and Hishamuddin Abdul Wahab. 2022. Analysing time-scales currency exposure using maximal overlap discrete wavelet transform (modwt) for malaysian industrial. Paper presented at International Conference on Mathematical Sciences and Statistics 2022 (ICMSS 2022), Online, March 15–16; pp. 426–39. [CrossRef]

Petukhina, Alla A., Raphael C. G. Reule, and Wolfgang Karl Härdle. 2020. Rise of the machines? Intraday high-frequency trading patterns of cryptocurrencies. *European Journal of Finance* 27: 8–30. [CrossRef]

Plerou, Vasiliki, Parameswaran Gopikrishnan, Bernd Rosenow, Luís A. Nunes Amaral, Thomas Guhr, and H. Eugene Stanley. 2002. Random matrix approach to cross correlations in financial data. *Physical Review E* 65: 066126. [CrossRef]

Rajharia, Poonam. 2023. Cryptocurrency adoption and its implications: A literature review. *E3s Web of Conferences* 456: 03002. [CrossRef]

Ruban, Aleksei Aleksandrovich, Alina Viktorovna Krivopuskova, and Dmitrii Sergeevich Kleimenov. 2022. Анализ эффектов включения биткоина в состав инвестиционных портфелей. *финансы и управление* 61–78. [CrossRef]

Scagliarini, Tomas, Giuseppe Pappalardo, Alessio Emanuele Biondo, Alessandro Pluchino, Andrea Rapisarda, and Sebastiano Stramaglia. 2022. Pairwise and high-order dependencies in the cryptocurrency trading network. *Scientific Reports* 12: 1–20. [CrossRef] [PubMed]

Schellinger, Benjamin. 2020. Optimization of special cryptocurrency portfolios. *The Journal of Risk Finance* 21: 127–57. [CrossRef]

Shahzad, Muhammad. 2024. Cryptocurrency awareness, acceptance, and adoption: The role of trust as a cornerstone. *Humanities and Social Sciences Communications* 11: 1–14. [CrossRef]

Siegel, Andrew F., and Artemiza Woodgate. 2007. Performance of portfolios optimized with estimation error. *Management Science* 53: 1005–15. [CrossRef]

Silva, Isabela Ruiz Roque, Eli Hadad Junior, and Pedro Paulo Balbi. 2022. Cryptocurrencies trading algorithms: A review. *Journal of Forecasting* 41: 1661–68. [CrossRef]

Subramoney, Stephanie Danielle, Knowledge Chinhamu, and Retius Chifurira. 2023. Var estimation using extreme value mixture models for cryptocurrencies. *Preprints* 2023: 2023070187. [CrossRef]

Sukumaran, Shangeetha, Thai Siew Bee, and Shaista Wasiuzzaman. 2022. Cryptocurrency as an investment: The malaysian context. *Risks* 10: 86. [CrossRef]

Susilo, Didik, Sugeng Wahyudi, Irene Rini Demi Pangestuti, Bayu Adi Nugroho, and Robiyanto Robiyanto. 2020. Cryptocurrencies: Hedging opportunities from domestic perspectives in southeast asia emerging markets. *Sage Open* 10: 215824402097160. [CrossRef]

Symitsi, Efthymia, and Konstantinos J. Chalvatzis. 2019. The economic value of bitcoin: A portfolio analysis of currencies, gold, oil and stocks. *Research in International Business and Finance* 48: 97–110. [CrossRef]

Trimborn, Simon, Mingyang Li, and Wolfgang Karl Härdle. 2019. Investing with cryptocurrencies—A liquidity constrained investment approach. *Journal of Financial Econometrics* 18: 280–306. [CrossRef]

Wang, Yanqing. 2024. Do cryptocurrency investors in the uk need more protection? *Journal of Financial Regulation and Compliance*. [CrossRef]

Wang, Zhuocheng, Zhiwei Huang, Rongkuan He, and Yixin Feng. 2022. *Cryptocurrency and the Herd Behavior*. Amsterdam: IOS Press. [CrossRef]

Waspada, Ikaputera, Dwi Fitrizal Salim, and Astrie Krisnawati. 2022. Horizon of cryptocurrency before vs. during COVID-19. *Investment Management and Financial Innovations* 20: 14–25. [CrossRef]

Yousaf, Imran, and Shoaib Ali. 2020. Discovering interlinkages between major cryptocurrencies using high-frequency data: New evidence from COVID-19 pandemic. *Financial Innovation* 6: 1–18. [CrossRef]

Zaretta, Bara, and Irene Rini Demi Pangestuti. 2023. A methodological point of view in a systematic review of the documentation of the effect of volatility on cryptocurrency investment. *International Conference on Research and Development (ICORAD)* 2: 7–23. [CrossRef]

Zhang, Mianmian. 2024. Relationships among return and liquidity of cryptocurrencies. *Financial Innovation* 10: 1–30. [CrossRef]

Zhang, Shicheng. 2023. Portfolio management for multi-industry. *Highlights in Business, Economics and Management* 5: 214–21. [CrossRef]

Zhang, Yuanyuan, Stephen Chan, Jeffrey Chu, and Hana Sulieman. 2020. On the market efficiency and liquidity of high-frequency cryptocurrencies in a bull and bear market. *Journal of Risk and Financial Management* 13: 8. [CrossRef]

Zhao, Haidong, and Lini Zhang. 2021. Financial literacy or investment experience: Which is more influential in cryptocurrency investment? *The International Journal of Bank Marketing* 39: 1208–26. [CrossRef]