

# Discovering the Relationship Between the Returns of Cryptocurrencies and the Returns of Traditional Industries

Author: Yannick Theo Inge Maria Slenter  
University of Twente  
P.O. Box 217, 7500AE Enschede  
The Netherlands

## ABSTRACT

*This research paper aims to provide a comprehensive analysis of the relationship between the returns of cryptocurrencies and the returns of various traditional industries. This is done by analysing the differences in correlation, returns, and risk-adjusted returns between the cryptocurrency index CRIX and indices of the information technology, health care, real estate, energy and financials industries. It also creates various portfolios to assess the viability of including cryptocurrencies in a diversified portfolio. The study concludes that there is still no correlation between the returns of cryptocurrencies and the returns of the 5 traditional industries. Furthermore, while cryptocurrencies have yielded significantly higher returns than the 5 traditional industries, these returns also came with high volatility. When looking at the risk-adjusted returns of the analysed indices over the analysed period, cryptocurrencies had a lower Sharpe ratio than the indices of both the Information Technology and the Health Care industries despite the average monthly returns of cryptocurrencies being a multiple of the average monthly returns of these two indices. The use of a cryptocurrency index for comparison to traditional assets yielded similar results to using a single cryptocurrency for comparison, indicating strong correlation among cryptocurrencies. Lastly, it concludes that including cryptocurrencies in a diversified portfolio offers slight diversification benefits.*

Graduation Committee members:

Laura Spierdijk, Vijay Bhaskar Marisetty

## Keywords

Cryptocurrencies, diversification, hedge, investment, risk-return analysis, finance

# 1. INTRODUCTION

While 10 years ago almost nobody had heard of the term or any terms related to it, it is impossible to deny the presence of cryptocurrencies in the modern world. Appendix 1 also visually shows this by displaying the search interest in cryptocurrencies and highly related keywords such as “bitcoin”, “crypto” (short for cryptocurrency), and “ethereum” (second-most popular cryptocurrency). As can be seen, interest in the most popular cryptocurrency, Bitcoin, has always had some form of relevance but spiked in search interest around the end of 2018. While less popular cryptocurrency related terms started gaining more traction around the start of 2021 and have been following the search interest of “bitcoin” more closely.

This interest in cryptocurrencies can be accredited to the high returns of cryptocurrencies, with more and more people realising the interesting characteristics of cryptocurrencies as an investment vehicle. This can also be seen when comparing Appendix 2 with Appendix 1. With every major increase in the price of cryptocurrencies, search interest also increases.

This has led many people to start looking into cryptocurrencies as an investment vehicle, and whether they can be effective in this regard. Current research about the relationship between cryptocurrencies and traditional assets can be divided into three main categories, namely research on cryptocurrencies for portfolio diversification, cryptocurrencies as a hedge against uncertainty, and cryptocurrencies as a general investment vehicle.

## 1.1 Existing research on the relationship between the returns of cryptocurrencies and traditional assets

Studies like Brière et al. (2015) have found that including cryptocurrencies in a portfolio can offer diversification benefits, as it can lead to a lower volatility and a higher Sharpe ratio compared to a portfolio containing only traditional assets. Similarly, Čiumakovas (2022) found that institutional investors can benefit from diversifying their portfolios with cryptocurrencies, as the returns of cryptocurrencies have a low correlation with traditional asset returns.

Other studies like Bouri et al. (2017) and Koutmos et al. (2021) have found that the returns of cryptocurrencies are negatively correlated with global uncertainty, suggesting that cryptocurrencies may be used as a hedge against uncertainty. They also found that the relationship between financial uncertainty and cryptocurrency returns is stronger during periods of high uncertainty, and suggest that investors can benefit from including cryptocurrencies in their portfolios during these periods as a hedge against financial uncertainty.

Furthermore, and Liu & Tsyvinski (2018) found that the risk-return trade-off of investing in cryptocurrencies is relatively attractive, especially compared to that of investing in traditional assets. Brauneis and Mestel (2019) also found that using a mean-variance framework can be a useful tool for constructing cryptocurrency portfolios and that actively managing and rebalancing the portfolio can help to improve the risk-return trade-off.

## 1.2 Research question and hypotheses

Despite the findings of these studies, there are still gaps in the current research that can be addressed. These gaps include, a lack of focus in choosing traditional assets for comparison and the use

of short-interval early-stage data of cryptocurrency returns, as well as the gap of not picking a representative index of sorts to represent cryptocurrency returns.

This research aims to address these gaps by looking at the relationship between the returns of cryptocurrencies and various traditional industries by comparing the monthly returns of cryptocurrency index CRIX against the monthly returns of 5 indices of 5 traditional industries over a 60-month period.

The research question is then as follows: *What is the relationship between the returns of the cryptocurrency industry and the returns of 5 major traditional industries?*

This question will be answered by looking at the correlation between the returns, difference in returns, and difference in risk-adjusted returns between the CRIX and 5 industry indices. For each of these components, a hypothesis has been made, keeping in mind findings of other research. Namely the following hypotheses:

Hypothesis 1: *Cryptocurrency industry returns have low correlation with the returns of the indices of the chosen 5 major traditional industries.*

Hypothesis 2: *Cryptocurrencies yield higher returns than the indices of the chosen 5 major traditional industries.*

Hypothesis 3: *Cryptocurrencies have higher Sharpe ratios than the indices of the chosen 5 major traditional industries.*

## 1.3 Structure of this paper

Chapter 2 of this paper provides an overview of existing research on the relationship between the returns of cryptocurrencies and traditional assets. In addition to this it highlights the gaps in current research and the need for further investigation. Chapter 3 elaborates the research methodology used in this study, including information on the data sources used, and the methods used to analyse the data. Chapter 4 presents the findings of the study, including statistical analyses. Chapter 5 interprets the findings, relates them to the literature review, and highlights the implications of the results. It also provides recommendations for future research. Chapter 6 concludes the paper by summarising the main findings and key takeaways.

## 2. LITERATURE REVIEW

Cryptocurrencies have seen a significant increase in popularity in recent years. With this rise in value and usage of digital currencies, investors, financial experts, and researchers have begun to explore the relationship between cryptocurrency returns and the returns of other types of financial assets. The purpose of this literature review is to examine the existing research on this topic. This review will focus on studies that investigate the dynamic relationship between cryptocurrency returns and the returns of other financial assets.

Current research into this topic has been done almost exclusively in the past 10 years due to the recentness of cryptocurrencies, and can be divided in various categories. These categories include research about the relationship between the returns of cryptocurrencies and the returns of other financial assets. And more specifically, research about cryptocurrencies for portfolio diversification and cryptocurrencies as a hedge against uncertainty. And lastly, research about cryptocurrencies as an investment in general.

## 2.1 Relationship between the returns of cryptocurrencies and traditional assets

Two recurring trends in the reviewed literature is research into the effectiveness of using cryptocurrencies for portfolio diversification and using various cryptocurrencies as a hedge against certain types of financial uncertainty. Research on these matters will be described below.

### 2.1.1 Portfolio diversification

Brière et al. (2015) analysed data over a 3-year period between 2010 and 2013 and found that including Bitcoin in a portfolio can improve the risk-return trade-off of well-diversified portfolios due to the low correlation between Bitcoin returns and traditional asset returns. However, they also noted that these abnormally high returns may reflect early-stage behaviour and may not be reflective of long-term performance.

Kajtazi and Moro (2019) also investigated the role of Bitcoin in a well-diversified portfolio over a 5-year period. They found that Bitcoin can be an effective diversifier, particularly during periods of market stress, and that including Bitcoin in a portfolio can lead to improved Sharpe, Sortino, and Omega ratios, despite also increasing volatility of the portfolios.

Čiumakovas (2022) studies the diversification benefits of cryptocurrency for institutional investors. He found that institutional investors can benefit from diversifying their portfolios with cryptocurrency, as the returns of cryptocurrencies have a low correlation with traditional asset returns. He also noted that the overall volatility of institutional portfolios when including cryptocurrencies in the portfolio is increased, but that adding a mix of cryptocurrencies can reduce and control volatility.

Corbet et al. (2018) study on the dynamic relationships between cryptocurrencies and other financial assets. They found that the relationship between cryptocurrencies and traditional assets is dynamic, with the correlation between returns changing over time. They also found that including cryptocurrency in a portfolio can lead to improved diversification benefits during periods of low correlation between cryptocurrency and traditional asset returns. They also found high correlation of the returns among various cryptocurrencies.

In summary, research indicates that integrating cryptocurrencies, particularly Bitcoin, in a diverse portfolio can have positive effects on diversification. In particular during times of market stress, these advantages include a decrease in portfolio volatility and an improvement in risk-adjusted returns.

### 2.1.2 Financial uncertainty hedge

The literature has also investigated the potential use of cryptocurrencies as an uncertainty hedge. Specifically, several studies have investigated the relationship between cryptocurrencies, particularly Bitcoin, and global uncertainty.

Bouri et al. (2017) studied the relationship between Bitcoin and global uncertainty. They found that Bitcoin returns were negatively correlated with global uncertainty, suggesting that Bitcoin may be used as a hedge against uncertainty. They also found that Bitcoin's ability to act as a hedge against uncertainty is stronger during periods of high uncertainty, but also noted that this is mostly during shorter investment horizons.

Koutmos et al. (2021) investigates the relationship between financial uncertainty and cryptocurrencies. They found that the relationship between financial uncertainty and cryptocurrency returns is stronger during periods of high uncertainty and suggest

that investors can benefit from including cryptocurrencies in their portfolios during these periods as a hedge against financial uncertainty. They did however also note that while cryptocurrencies proved to be an effective hedge, that this was largely in periods where they exhibit zero or negative beta behaviour.

In summary, the research points to the potential use of cryptocurrencies, particularly Bitcoin, as a hedge against risk. Various studies have discovered a negative correlation between cryptocurrency returns and world unpredictability, indicating that Bitcoin may offer a sanctuary during uncertain economic times. Additionally, they discovered that there is a higher correlation between financial uncertainty and cryptocurrency returns during times of high uncertainty, which suggests that investors may profit from holding cryptocurrencies as a hedge against financial uncertainty during these times.

## 2.2 Cryptocurrencies as an investment

Previous research also investigated the potential use of cryptocurrencies as an investment. Specifically, several studies have examined the risks and returns associated with investing in cryptocurrencies and the use of a mean-variance framework for constructing cryptocurrency portfolios.

Liu and Tsyvinski (2018) studied the risks and returns of investing in cryptocurrencies. They found that the returns of cryptocurrencies are highly volatile and subject to large fluctuations, as well as having low exposures to traditional asset classes. They also found that the risk-return trade-off of investing in cryptocurrencies is relatively attractive compared to that of investing in traditional assets. Lastly, they concluded that cryptocurrency returns can be predicted by factors specific to that market.

Brauneis and Mestel (2019) studied the construction of cryptocurrency portfolios in a mean-variance framework. They found that using a mean-variance framework can be a useful tool for constructing cryptocurrency portfolios and that including a mix of different cryptocurrencies, in this case the same CRIX index used to represent cryptocurrencies, in a portfolio can reduce the overall risk. They also found that the risk-return trade-off of a cryptocurrency portfolio can be improved by actively managing the portfolio and regularly rebalancing it.

In conclusion, the literature suggests that cryptocurrencies can be a worthwhile investment, despite their high volatility. Similar to other research, the risk-return trade-off of investing in cryptocurrencies is relatively attractive, especially compared to that of investing in more traditional assets. Additionally, using a mean-variance framework can be a useful tool for constructing cryptocurrency portfolios, and actively managing and rebalancing the portfolio can help to improve the risk-return trade-off.

## 2.3 Gaps in current research

In summary, the literature has examined the potential of cryptocurrencies as an investment, the usage of cryptocurrencies as a hedge against uncertainty, and the relationship between the returns of cryptocurrencies and other financial assets. According to various studies, adding cryptocurrency to a diverse portfolio can have positive effects on diversification, such as lowering portfolio volatility and raising risk-adjusted returns. The literature also implies that, despite their high volatility, investing in cryptocurrencies can be profitable and that they can be used as a hedge against risk, although their effectiveness as a hedge tends to be conditional.

Despite the findings of these studies, there are several gaps in the current research. One gap is that many studies have only compared the returns of single cryptocurrencies, such as Bitcoin, to the general market. A more comprehensive approach would be to use a representative index for cryptocurrencies, such as the CRIX index, to better represent the overall market. Additionally, many studies have only compared the returns of cryptocurrencies to the entire market, rather than more specific industries. This limits the understanding of the relationship between cryptocurrencies and other financial assets within specific industries.

Another gap in the current research is the lack of long-term studies on the performance of cryptocurrency investments. Most studies have focused on short-term returns, which may not accurately reflect the long-term potential of cryptocurrencies as an investment. Furthermore, due to the recentness of cryptocurrencies, a lot of research is based on very early-stage data on cryptocurrencies which may not be indicative of long-term results.

Additionally, there is a need for more research on the diversification benefits of other cryptocurrencies besides Bitcoin and the effect of different types of financial uncertainty on the returns of cryptocurrencies.

Overall, while the literature has provided insight into the relationship between cryptocurrencies and other financial assets, there are still gaps in the current research that can be addressed in further research. This research aims to address some of these gaps, such as the lack of focus in choosing traditional assets for comparison and the use of short-interval early-stage data of cryptocurrency returns, as well as the gap of not picking a representative index of sorts to represent cryptocurrency returns.

## 3. METHODOLOGY

### 3.1 Data selection

For the purpose of this study, the returns of 5 different industries will be compared to the returns of cryptocurrencies. Monthly return data for each of these indices will be used over a five-year period from 01-01-2017 to 01-01-2022.

#### 3.1.1 Industries

The chosen industries for this study are the information technology industry (represented by the S&P500 Information Technology index), the health care industry (represented by the S&P500 Health Care index), the energy industry (represented by the S&P500 Energy index), the real estate industry (represented by the S&P500 Real Estate index), and the financials industry (represented by the S&P500 Financials index).

#### 3.1.2 Cryptocurrencies

For the cryptocurrency industry, data from the CRIX index will be used, as it gives an accurate representation of the performance of the cryptocurrency market. The Royalton CRIX Index closely tracks the total market index (TMI) of cryptocurrencies using a minimum of 5 liquid cryptocurrencies.

The index measures those coins that can be verified as investable out of the 1000+ cryptocurrencies, leaving 500+ cryptocurrencies in the total market and eliminating coins tied to non-crypto assets (e.g. stablecoins). The ideal number of cryptocurrency constituents is chosen on a quarterly basis using the in-house CRIX Technology Decision Curve (CTDC) algorithm in order to precisely mimic the features of the total market return. The weights of the component cryptocurrencies

are updated monthly based on the current market capitalisation in between quarterly reconstitutions. The Royalton CRIX Index value is determined daily by S&P Global using a list of weights and constituents provided by Royalton Partners. (*Custom Indices - Royalton CRIX Crypto Index | S&P Dow Jones Indices*, n.d.)

### 3.2 Research methodology

The aim of this research is to research the relationship between the returns of cryptocurrencies and various traditional industries. This will be done by researching three hypotheses, namely the first hypothesis, which states that cryptocurrency industry returns have low correlation with the returns of the indices of the chosen 5 major traditional industries. The second hypothesis, which states that cryptocurrencies yield higher returns than the indices of the chosen 5 major traditional industries. And the third hypothesis, which states that cryptocurrencies have higher Sharpe ratios than the indices of the chosen 5 major traditional industries.

To obtain a general understanding of the returns, several descriptive statistics will be summarised. In order to answer hypothesis 1, Pearson's R coefficient will be used to investigate the correlation between the returns of the CRIX and the indices of each of the industries. A t-test will also be conducted to test whether the correlation is statistically significant.

In order to answer hypothesis 2, the relationship between the returns will be explored by comparing the monthly returns of the CRIX with the monthly returns of the indices of each of the industries. Following the calculation of the returns, a one-tailed independent samples t-test with a Satterthwaite approximation for the degrees of freedom will be conducted to test if there is statistical evidence to either reject or approve the hypothesis. We assume that the variances of the CRIX data set and the respective industry data sets are unequal, and will also test this using Levene's test.

Lastly, to answer hypothesis 3, the risk-return relationship will be investigated by comparing the Sharpe ratio of the CRIX with the Sharpe ratios of the indices of each of the industries. The Sharpe ratio will be calculated using yearly return data which is calculated by taking the average of the yearly returns of each year in the period. Furthermore, the risk-free rate of return that will be used is 1.09%, as this is the average 3-month US treasury bill rate over the measured period (*3 Month Treasury Bill Rate*, n.d.)

Based on the differences in correlation, returns, and the risk-return relationship, a conclusion will be drawn about the relationship between the returns of cryptocurrencies and the returns of the indices of the 5 different industries in order to answer the research question. For all statistical tests,  $\alpha = 0.05$  will be used.

In addition to this 4 portfolios will be constructed and compared to each other to assess the viability of adding cryptocurrencies to a diversified portfolio. The 4 portfolios that will be constructed are a portfolio of the CRIX and the 5 indices of the traditional industries with all assets having equal weights, a portfolio of the 5 indices of the traditional industries with all assets having equal weights, a minimum variance portfolio of the CRIX and the 5 indices of the traditional industries which takes the average return of the past 30 months and then rebalances monthly to achieve at least 1.5% monthly returns, and lastly a portfolio of the 5 indices of the traditional industries which takes the average return of the past 30 months and then rebalances monthly to achieve at least 1.5% monthly returns.

These portfolios will then be compared to each other based on their returns, standard deviation and their Sharpe ratios. The 1.5% minimum monthly returns have been chosen as investors

seek relatively high returns with cryptocurrencies due to their risky nature.

## 4. FINDINGS

### 4.1 Correlation

As can be seen in Table 1, there is low correlation between the monthly returns of cryptocurrencies and the monthly returns of the analysed industries. The correlation between the monthly returns of cryptocurrencies and the 5 analysed industries seems to be pretty similar, though. This also becomes evident in Appendix 3, where the monthly returns of cryptocurrencies and the 5 analysed industries is visualised. As can be seen, the monthly returns of the 5 traditional industries follow a relatively similar pattern while the monthly returns of cryptocurrencies follow a vastly different pattern, especially in the first half of the selected data.

Correlations						
		Monthly returns S&P500 Information Technology	Monthly returns S&P500 Health Care	Monthly returns S&P500 Financials	Monthly returns S&P500 Real Estate	Monthly returns S&P500 Energy
Monthly returns CRIX	Pearson Correlation	.218	.187	.236	.190	.202
	Sig. (2-tailed)	.097	.155	.072	.149	.124
	N	59	59	59	59	59

Table 1: Correlation between monthly returns

The statistical significance of the correlation is also shown in Table 1. As can be seen, the p value of each statistical test of the correlation between the monthly returns of cryptocurrencies and the monthly returns of the 5 analysed industries is higher than our  $\alpha$ . Therefore the correlations are not statistically significant, but insightful nonetheless.

### 4.2 Monthly returns

As can be seen in Appendix 4, cryptocurrencies have massively outperformed the 5 analysed industries in the period between 01-01-2017 and 01-01-2022. The mean monthly return of cryptocurrencies in the measured period is 11.3%, followed by the Information Technology industry, with a mean monthly return of 2.4%. The least performing chosen industry is the Energy industry, with a mean monthly return of 0.0%.

The high monthly returns of cryptocurrencies did not come without risk though, with the standard deviation of the monthly returns of cryptocurrencies being 30.9%. With the range between the values of the monthly returns of cryptocurrencies being 170.9%. Appendix 3 also visually displays the differences in monthly returns between cryptocurrencies and the various industries

In order to test the statistical significance between the monthly returns, a one-tailed independent samples t-test with a Satterthwaite approximation for the degrees of freedom is conducted, with the results shown below in Appendix 5. As can be seen in the column with the results of Levene's test, the monthly returns of cryptocurrencies and the monthly returns of each of the 5 industries have unequal variances.

Therefore, only the rows in Appendix 5 where equal variances are not assumed should be considered. And as shown in each of these rows, there is statistical evidence to support that the monthly returns of cryptocurrencies in the measured period were higher than the monthly returns of the 5 chosen industries.

### 4.3 Risk-adjusted returns

When taking a look at the average monthly returns, it is clear that cryptocurrencies yielded higher returns than the 5 chosen industries. But these returns do not take into account the risk that was taken in order to achieve them. Therefore we also need to look at the risk-adjusted returns. As can be seen in Table 2, all industries except for the Energy industry had a positive Sharpe ratio. But perhaps more interestingly, the industry with the highest Sharpe ratio is the Health Care industry, with a Sharpe ratio of 1.64. This is closely followed by the Information Technology industry, with a Sharpe ratio of 1.45.

The cryptocurrency industry has a lower Sharpe ratio than these two industries, just marginally above the Sharpe ratios of the Financials and Real Estate industry. This is due to the high volatility of the monthly returns of cryptocurrencies, as can also be seen in Appendix 3

Sharpe ratios	
	$\rho$
CRIX	.56
S&P500 Energy	-.12
S&P500 Financials	.50
S&P500 Health Care	1.64
S&P500 Information Technology	1.45
S&P500 Real Estate	.49

Table 2: Sharpe ratios of cryptocurrencies and the 5 chosen industries

### 4.4 Portfolio diversification

As can be seen in Table 3, the equal weight portfolio without the inclusion of the CRIX has massively outperformed the one with the inclusion of the CRIX on returns. While the standard deviation of the portfolio with the CRIX included is slightly higher the Sharpe ratio makes the better risk-return relationship clear.

### Portfolio comparison

	Average monthly returns	Standard deviation	Sharpe ratio
MinVar Portfolio CRIX and 5 indices with at least 1.5% monthly return	.015	.032	.940
MinVar Portfolio 5 indices with at least 1.5% monthly return	.015	.032	.926
Equal weight portfolio CRIX and 5 indices	.018	.060	.776
Equal weight portfolio 5 indices	.008	.047	.360

Table 3: Comparison of various portfolios

When comparing the minimum variance portfolios against each other the differences become much smaller. The standard deviation of the minimum variance portfolio which includes the CRIX is slightly smaller than the minimum variance portfolio which only has the 5 indices. This leads to a slightly higher Sharpe ratio of the minimum variance portfolio that includes the CRIX.

Appendix 6 and 7 also show the evolution of the weights in the portfolios. As can be seen the portfolio which includes the CRIX sees more of the assets included in the portfolio having a weight greater than 0 a greater amount of the time than the portfolio which does not include the CRIX, reducing the market risk of the portfolio.

## 5. DISCUSSION

This study has aimed to provide a comprehensive examination of the relationship between the returns of cryptocurrencies and the returns of various traditional industries. However, there are several limitations that should be considered when interpreting the results of this study.

One limitation is the scope of the study, as cryptocurrency returns are only compared against the returns of 5 traditional industries. Furthermore, it takes only 1 cryptocurrency index into account. This may not be representative of the broader market and future research should consider expanding the sample size to include a more diverse range of traditional assets, as well as analysing data over a longer period. Furthermore, the study has not investigated the emerging investment opportunities within the broader web3 space, such as Non-Fungible Tokens (NFTs), tokenised assets, and more, which are becoming increasingly popular and may have a different relationship with traditional assets.

Another limitation of this study is the time frame of the data analysed, which is relatively short due to the recentness of the creation of the CRIX index. Future research should consider using data over a longer period in order to provide a more accurate picture of the long-term performance of cryptocurrency investments and the relationship between cryptocurrencies and traditional assets. Additionally, future research could consider more specific industry comparisons to better understand the relationship between cryptocurrencies and other financial assets within specific industries.

Additionally, the study has not investigated the constantly-changing regulatory aspect of cryptocurrency, which is an important aspect to consider when assessing the viability of investment opportunities of cryptocurrencies. Future research should consider the regulatory environment in order to provide a more comprehensive understanding of how regulations may affect the investment opportunities of cryptocurrencies as the cryptocurrency market matures.

Lastly, the data for the construction of the portfolios is relatively limited. Furthermore, the portfolios do not take transaction costs and price slippages into account.

In conclusion, the findings of this study provide valuable insights into the relationship between the returns of cryptocurrencies and traditional assets. However, the limitations of this study should be taken into account when interpreting the results. Future research should address these limitations in order to provide a more comprehensive understanding of the topic.

## 6. CONCLUSION

The analysis done in this study concludes that there is still no correlation between the returns of cryptocurrencies and the returns of the 5 traditional industries. Furthermore, while cryptocurrencies have yielded significantly higher returns than the 5 traditional industries, it can be concluded that this did not come without significant risk. When looking at the risk-adjusted returns of the analysed indices over the analysed period, cryptocurrencies had a lower Sharpe ratio than the indices of both the Information Technology and the Health Care industries despite the average monthly returns of cryptocurrencies being a multiple of the average monthly returns of these two indices.

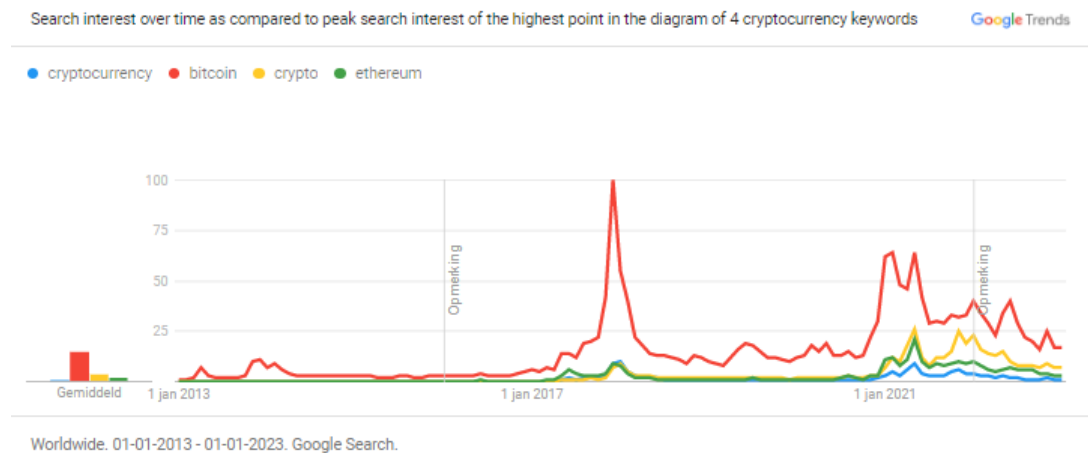
It can be concluded that while cryptocurrency returns tend to outperform the returns of various industries, investing in cryptocurrencies also comes with higher magnitudes of risk as compared to investing in these industries. The use of a cryptocurrency index rather than single cryptocurrencies does not seem to yield different results than using a single cryptocurrency for comparison. This also seems to align with Brauneis and Mestel (2019) which found that correlation among cryptocurrency returns is high.

Lastly, this research shows that the inclusion of cryptocurrencies in a diversified portfolio yields slight diversification benefits, usually in the form of increased returns.

## 7. REFERENCES

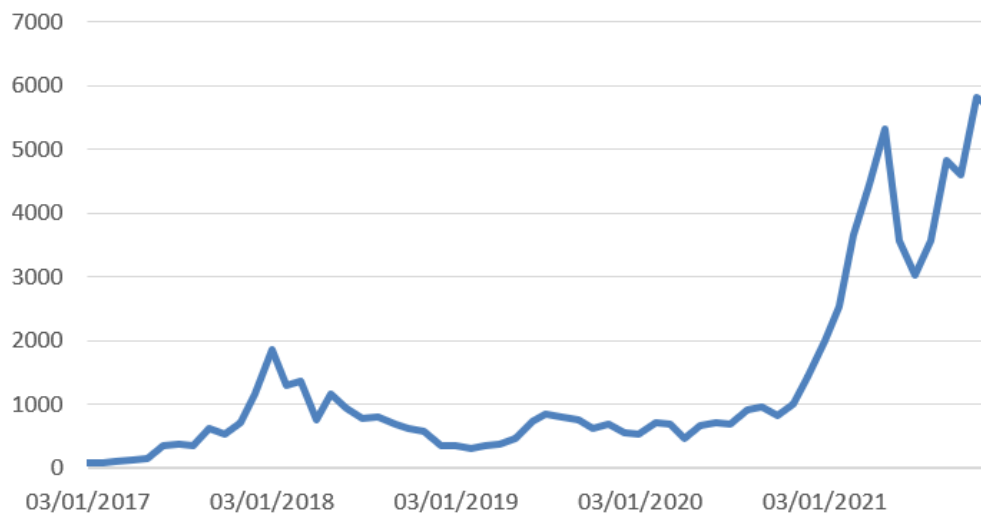
- 3 Month Treasury Bill Rate. (n.d.). Retrieved January 5, 2023, from [https://ycharts.com/indicators/3\\_month\\_t\\_bill](https://ycharts.com/indicators/3_month_t_bill)
- Bouri, E., Gupta, R., Tiwari, A. K., & Roubaud, D. (2017). Does Bitcoin hedge global uncertainty? Evidence from wavelet-based quantile-in-quantile regressions. *Finance Research Letters*, 23, 87–95. <https://doi.org/10.1016/J.FRL.2017.02.009>
- Brauneis, A., & Mestel, R. (2019). Cryptocurrency-portfolios in a mean-variance framework. *Finance Research Letters*, 28, 259–264. <https://doi.org/10.1016/J.FRL.2018.05.008>
- Brière, M., Oosterlinck, K., & Szafarz, A. (2015). Virtual currency, tangible return: Portfolio diversification with bitcoin. *Journal of Asset Management*, 16(6), 365–373. <https://doi.org/10.1057/JAM.2015.5>
- Čiumakovas, I. (2022). *Diversifying Your Portfolio with Cryptocurrency-Does It Improve Sharpe Ratios for Institutional Investors?*
- Corbet, S., Meegan, A., Larkin, C., Lucey, B., & Yarovaya, L. (2018). Exploring the dynamic relationships between cryptocurrencies and other financial assets. *Economics Letters*, 165, 28–34. <https://doi.org/10.1016/J.ECONLET.2018.01.004>
- Custom Indices - Royalton CRIX Crypto Index / S&P Dow Jones Indices. (n.d.). Retrieved January 5, 2023, from <https://www.spglobal.com/spdji/en/custom-indices/royalton-partners-ag-rpag/royalton-crix-crypto-index/#overview>
- Google Trends. (n.d.). Retrieved January 21, 2023, from <https://trends.google.com/trends/?geo=NL>
- Kajtazi, A., & Moro, A. (2019). The role of bitcoin in well diversified portfolios: A comparative global study. *International Review of Financial Analysis*, 61, 143–157. <https://doi.org/10.1016/j.irfa.2018.10.003>
- Koutmos, D., King, T., & Zopounidis, | Constantin. (2021). *Hedging uncertainty with cryptocurrencies: Is bitcoin your best bet?* <https://doi.org/10.1111/jfir.12264>
- Liu, Y., & Tsyvinski, A. (2018). *Risks And Returns Of Cryptocurrency*. <http://www.nber.org/papers/w24877>

## 8. APPENDIX



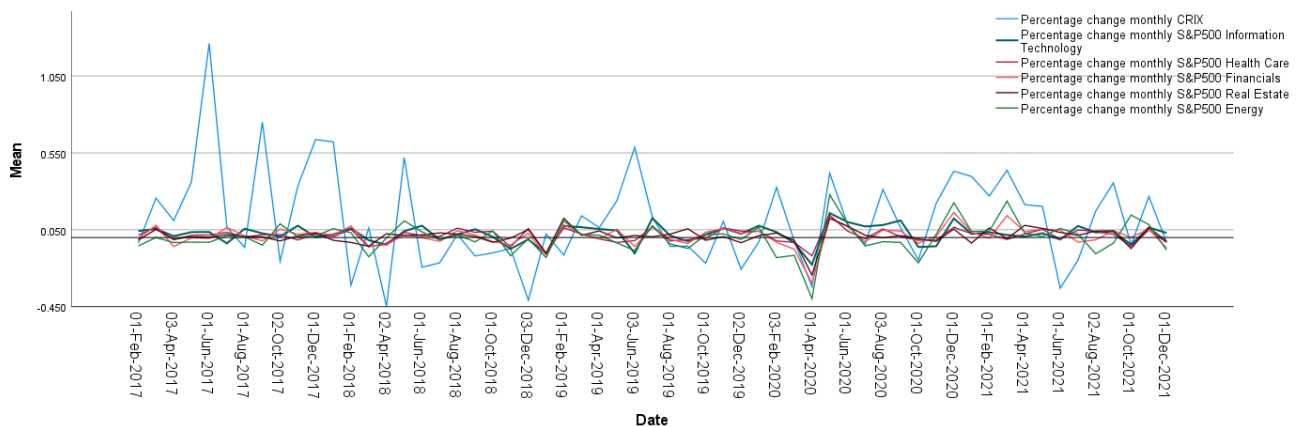
Appendix 1: Search interest over time as compared to peak search interest at the highest point in the diagram of 4 cryptocurrency related keywords (Google Trends, n.d.)

### CRIX Price Graph



Appendix 2: CRIX price graph of the analysed period

### Monthly returns of the 6 analysed industries



Appendix 3: Monthly returns 6 analysed industries visualised



### Descriptive Statistics

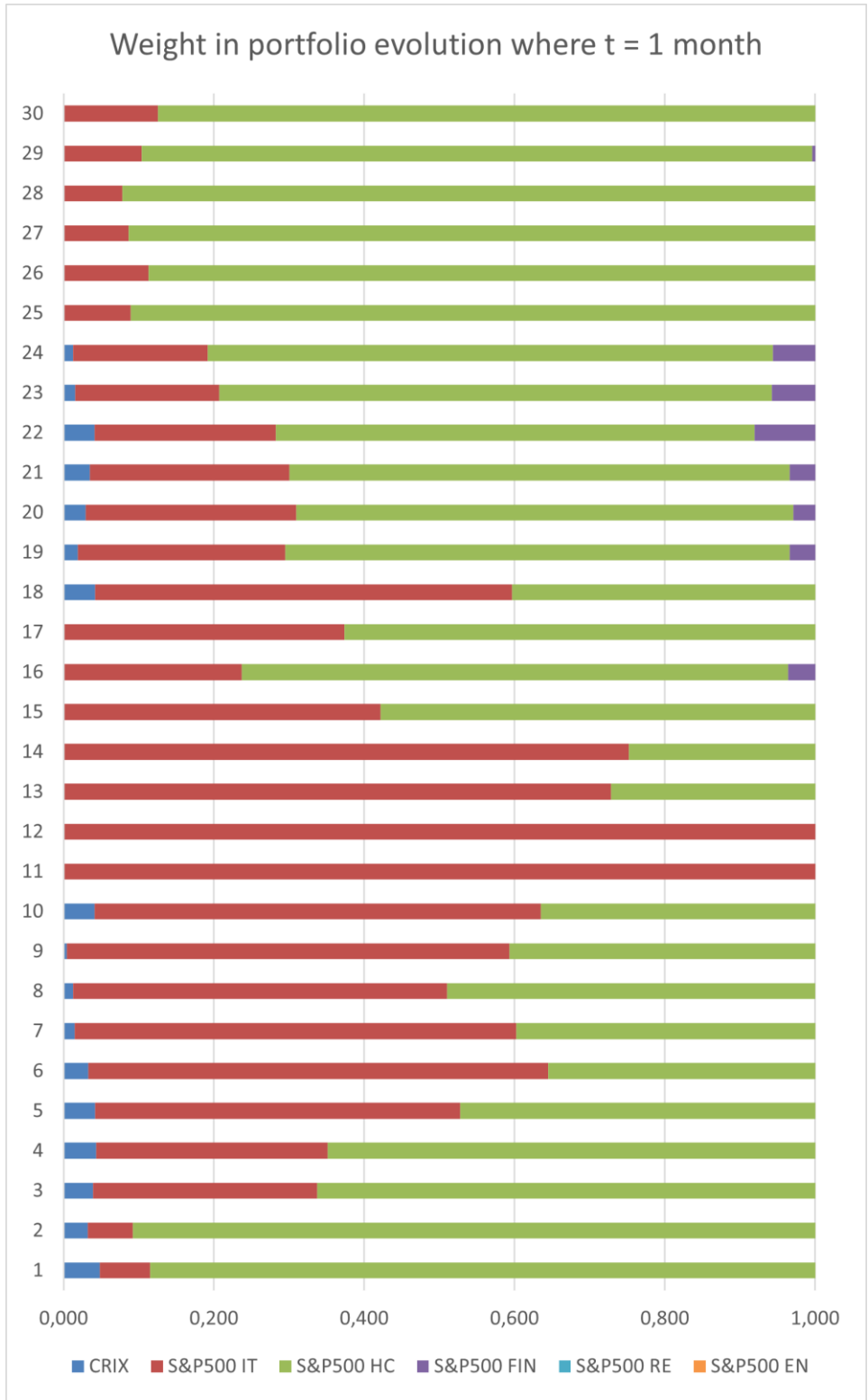
	N	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Monthly returns CRIX	59	1.709	-.447	1.262	.113	.309	.096
Monthly returns S&P500 Information Technology	59	.336	-.177	.159	.024	.060	.004
Monthly returns S&P500 Health Care	59	.265	-.119	.146	.012	.045	.002
Monthly returns S&P500 Financials	59	.459	-.296	.163	.010	.067	.004
Monthly returns S&P500 Real Estate	59	.371	-.244	.127	.009	.053	.003
Monthly returns S&P500 Energy	59	.676	-.398	.278	.000	.101	.010

Appendix 4: Descriptive statistics monthly returns

### Independent Samples T Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Significance One-Sided p	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Monthly Returns CRIX and Monthly Returns S&P500 Information Technology	Equal variances assumed	56.805	<.001	2.182	116	.016	.089	.041	.008	.171
	Equal variances not assumed			2.182	62.323	.016	.089	.041	.008	.171
Monthly Returns CRIX and Monthly Returns S&P500 Energy	Equal variances assumed	39.537	<.001	2.673	116	.004	.113	.042	.029	.197
	Equal variances not assumed			2.673	70.260	.005	.113	.042	.029	.198
Monthly Returns CRIX and Monthly Returns S&P500 Financials	Equal variances assumed	64.029	<.001	2.496	116	.007	.102	.041	.021	.182
	Equal variances not assumed			2.496	60.405	.008	.102	.041	.020	.183
Monthly Returns CRIX and Monthly Returns S&P500 Health Care	Equal variances assumed	64.029	<.001	2.496	116	.007	.102	.041	.021	.182
	Equal variances not assumed			2.496	60.405	.008	.102	.041	.020	.183
Monthly Returns CRIX and Monthly Returns S&P500 Real Estate	Equal variances assumed	62.851	<.001	2.557	116	.006	.104	.041	.024	.185
	Equal variances not assumed			2.557	61.382	.007	.104	.041	.023	.186

Appendix 5: Independent samples t-test of monthly returns of cryptocurrencies and the 5 analysed industries



Appendix 6: Evolution of weights MinVar Portfolio CRIX and 5 indices with at least 1.5% monthly returns



Appendix 7: Evolution of weights MinVar Portfolio 5 indices with at least 1.5% monthly returns