

**h e g**

Haute école de gestion  
Genève

# **How the crypto assets impact the diversification of a portfolio?**

**Bachelor Project submitted for the degree of  
Bachelor of Science HES in International Business Management**

by

**Maxime PERDRISAT**

Bachelor Project Mentor:  
**Professor Anjeza KADILLI, PhD**

**Geneva, 19<sup>th</sup> August 2023**  
**Haute école de gestion de Genève (HEG-GE)**  
**International Business Management**



## **Disclaimer**

This report is submitted as part of the final examination requirements of the Haute école de gestion de Genève, for the Bachelor of Science HES-SO in International Business Management. The use of any conclusions or recommendations made in or based upon this report, with no prejudice to their value, engages the responsibility neither of the author, nor the author's mentor, nor the jury members nor the HEG or any of its employees.

# Acknowledgements

I would like to express my sincere appreciation to everyone who has contributed to the completion of this bachelor's thesis.

Before anything else, I would like to acknowledge my supervisor, Prof. Anjeza Kadilli, for her guidance, invaluable advice, and unwavering support throughout the duration of this research project. Her extensive knowledge and sage advice have significantly enhanced my work.

This work would not be complete without the contributions of Alexandre Viedma, whose intensive editing and writing sessions were essential to its completion. His perseverance and dedication were priceless.

Prof. François Duc deserves a tremendous amount of gratitude for his support and knowledge in the field of finance. His insightful comments played an essential role in enhancing the quality of this paper.

I would like to thank my colleagues and classmates for creating an atmosphere conducive to the exchange of ideas and the spread of knowledge. My brother, Lucas Perdrisat, and my dear friend, Damien Frei, deserve special recognition for their eye for detail and invaluable feedback in reviewing my work. Their helpful suggestions considerably assisted in refining my ideas.

I would like to thank the study participants, whose contributions were crucial to achieving meaningful results. Their contribution of time and valuable information expanded the scope of this study.

I would also like to thank my girlfriend and my family for their unwavering support, forbearance, and constant encouragement. Throughout this academic voyage, their confidence in me has served as a crucial source of inspiration.

In conclusion, I am indebted to everyone who contributed in any way to the completion of this bachelor's thesis. Your contribution has been priceless in making this endeavor a reality, so thank you.

# Executive Summary

The primary objective of this study is to investigate the effect of crypto assets on portfolio diversification, specifically by employing Markowitz's optimization theory and analyzing their correlation dynamics, risk-return profiles, and capacity to enhance overall portfolio performance. The study is based on two major hypotheses. The first hypothesis suggests that including crypto assets in a portfolio result in higher returns and lower volatility than a traditional portfolio composed of 60% equities and 40% bonds. The second hypothesis proposes that crypto assets have a low correlation with traditional financial assets but a significant correlation among themselves.

The literature around Bitcoin is growing fast, and many researchers are trying to find the optimal way to include it in a portfolio. As Bitcoin captures the majority of the spotlight, much less research is extended to other crypto assets. In the meantime, we witnessed an increasing volume of crypto asset trades and the total market capitalization of solely Bitcoin becoming bigger than Visa, Mastercard, JP Morgan, or Exxon Mobil (CoinMarketCap, 2023). A question is starting to emerge into investors' heads more and more frequently: is it worth it to pay attention to this rather new phenomenon, and above all, how to participate, and could this generate returns?

The methodology of this paper includes the analysis of daily data, and the empirical results indicate that the Markowitz model is applicable and wished for that class of assets. However, some assumptions of the Modern Portfolio Theory (MPT), such as the omission of the transaction costs, limit the reliability of the findings. Our results demonstrate crypto assets as an interesting way to diversify a portfolio and uncorrelated relationships between traditional asset classes and crypto assets. All sorts of investors, from the most conservative to the most audacious, may be satisfied.

In conclusion, strategic allocation will be the key to achieving desirable returns. Risk-averse investors will be cautious when selecting crypto assets and stay away from high-kurtosis ones, while investors with a high-risk appetite will seek an optimal allocation around 6–10%. A long-term perspective is highly recommended considering the long duration of maximum drawdown periods, and active management is required to obtain the best results out of this new asset class.

# Contents

How the crypto assets impact the diversification of a portfolio? .....	1
Disclaimer .....	i
Acknowledgements.....	ii
Executive Summary .....	iii
Contents.....	iv
List of Tables .....	v
List of Figures .....	v
1. Introduction .....	1
2. Literature review.....	3
2.1 Definition of crypto assets .....	3
2.2 Asset class.....	5
2.2.1 Definition of an asset class .....	5
2.3 Evidence on the diversification benefits of crypto assets.....	7
2.4 Traditional way to invest in crypto market.....	9
3. Methodology .....	11
3.1 Data description.....	14
4. Results .....	15
4.1 Key metrics and correlations matrix .....	15
4.2 Portfolio optimization and volatility and expected returns targets .....	17
5. Discussion .....	21
5.1 Diversification effect of crypto assets.....	21
5.2 Decorrelation with traditional assets.....	21
5.3 Risks analysis.....	22
5.4 Recommendations.....	23
Conclusion.....	25
Bibliography .....	27

## List of Tables

Table 1 Correlation Coefficient Effect of Diversification on Risk .....	7
Table 2 Statistics by assets .....	16
Table 3 Correlation Matrix .....	16
Table 4 List of portfolios based on expected volatility and on expected returns for the period 10.2014-02.2023 .....	17
Table 5 List of portfolios based on expected volatility and on expected returns without allocation in the crypto index for the period 10.2014-02.2023.....	18
Table 6 Best optimized portfolio based on the Sharpe ratio for the period 10.2014-02.2023.....	18
Table 7 Key metrics by Crypto index allocation for the period 10.2014-02.2023...	19

## List of Figures

Figure 1 Rolling 90-day correlation of daily returns between Bitcoin and other major risky asset classes, 1 <sup>st</sup> January 2017 – 30 <sup>th</sup> September 2020.....	8
Figure 2 60-40 Portfolio with gradual crypto index allocation and Optimized Sharpe ratio without constraint .....	20



# 1. Introduction

Since diversification minimizes an investor's exposure to risk and should provide protection, the potential benefits of diversification have long been desirable to investors. Diversification gives investors the possibility to better manage risks and therefore, reduce their overall exposure to risk. An effective diversification strategy serves as a safety net; it lessens the amount of risk that investors are exposed to and prevents their investment portfolio from declining in value. To obtain a diversified portfolio, an investor will be looking for a rather low-correlated variety of asset classes. Ideally, a portfolio would be composed of assets with a negative correlation close to  $-1$ . In this way, when one asset loses value, it is offset by another asset that should appreciate at the same time.

For decades, the ultimate objective in the world of finance has been figuring out how to construct the ideal portfolio with the myriad of disposable assets. The portfolio investment technique has been studied from many angles and generated plenty of mathematical models. Modern portfolio theory seeks to identify the optimal allocation of asset that produces the most profitable outcomes in terms of risk-return.

Drastic changes have occurred in the history of the financial market; the most recent one is the appearance of crypto assets and blockchain technology. Much research is conducted on how to include Bitcoin in a portfolio, considering crypto assets a new asset class and rightly so, Bitcoin as the main element representing this class. As a direct consequence of considering Bitcoin as the main element, far less attention has been paid to the many other members of the broad crypto asset family until now. Consequently, the following paper will try to expand the literature about the properties of other crypto assets than Bitcoin by exploring the effect of adding cryptocurrencies, which will be called crypto assets as they will be considered an asset class in a portfolio, by applying the modern portfolio theory of Markowitz (1952). The first hypothesis is that integrating crypto assets in a portfolio will allow to create a portfolio that delivers higher returns while reducing volatility, compared to a classic portfolio of 60% stocks and 40% bonds containing neither crypto assets nor any other financial assets. The second hypothesis is that crypto assets are uncorrelated with traditional financial assets such as stocks, bonds, commodities, etc. but correlated with each other.

The fundamental model of modern portfolio theory developed by Harry Markowitz in 1952 in the paper Portfolio Selection (Markowitz, 1952) was used as the basis to test the hypothesis proposed in our paper. As described by Grujić, Mekinjić and Vujičić

Stefanović (2021), the greatest contribution of modern portfolio theory is the formula for calculating portfolio variance, i.e., for calculating efficient portfolio diversification. In Markowitz's model, the most significant assumption regarding investors' behavior is that they estimate portfolio risk based on the variance of expected returns (standard deviation). Another assumption is that investors are rational and will always favor the optimal portfolio. Their utility curves are therefore a function of the expected return and the expected variance of the return (Grujić, Mekinjić and Vujičić Stefanović 2021). Also, an essential hypothesis holds that investors always prefer the highest returns for a given level of risk, similarly, they will always prefer the lowest risk for the same level of return.

In finance, a portfolio corresponds to an amalgamation of numerous financial assets. Chen (2021) stated that financial assets are liquid assets that derive their value from a contractual right or a claim of ownership. Their value reflects supply and demand factors in the market in which they trade, as well as the degree of risk they bear. Typically, financial assets include cash, stocks, bonds, precious metals, and crypto assets. Asset combination is driven by two main elements: risk dilution and maximization of returns. The perfect portfolio will strongly depend on the risk aversion of the investors, its expected return, and the correlation within the assets chosen. The most representative maxim of the idea behind diversification would be "Do not put all your eggs in one basket".

To test the hypotheses of the author, a fictional crypto assets index has been built and combined with two Exchange Traded Funds (ETFs) representing the 60-40 portfolio of Markowitz. Several portfolios corresponding to the risk tolerance and expected returns of investors have been built for this purpose. Furthermore, an investigation will be conducted about the correlation between the crypto assets studied and the two ETFs.

## 2. Literature review

### 2.1 Definition of crypto assets

Over the last few years, the craze surrounding crypto assets, or cryptocurrencies, has continued to grow, with an increasing number of investors looking to acquire them. Referring to Ehlers and Gauer (2019), the number of cryptocurrencies listed on CoinMarketCap in October 2017 was 1256, for a market capitalization of 195 billion USD. As of 29<sup>th</sup> July 2023, the increase appears gigantic: no less than 9642 cryptocurrencies are currently listed with a global market cap of 1,19 trillion USD (CoinMarketCap, 2023). The term "cryptocurrencies" is named after the mathematical field of cryptography<sup>1</sup> which is used to guarantee the safety of transactions (Narayanan et al., 2016 cited by Ram, 2019). Initially seen as a method of payment for the black market, Foley Karlsen & Putniņš (2018) emphasize that crypto assets are one of the biggest unregulated markets. Their findings suggest that  $\frac{1}{4}$  of Bitcoin (BTC) users were involved in illegal activity. However, with the extension of mainstream interest in Bitcoin, and the appearance of more opaque crypto assets, the illicit proportion of Bitcoin transactions tends to diminish.

Regulations<sup>2</sup> will play a crucial role in enabling everyday investors to comprehend what crypto assets are and what risks are associated with this sort of investment. Furthermore, the weightiest investors, known as institutional investors, are keen to see new regulations emerge. Coinbase (2023), one of the largest cryptocurrency exchange platforms, conducted a survey showing that institutional investors agree that the US does not have clear enough rules about crypto assets. Almost 90% of the respondents said that they would be more confident in investing in crypto assets if regulations were to be implemented. 78% of respondents' concerns pertain to the need for a more precise classification of digital assets, while 71% want greater clarity regarding their fiscal treatment. Despite those concerns, the survey indicates that amongst the 90% of the 151 investors will stay invested 62% stay invested or consider increasing their allocation (28%). The interest shown by financial institutions and the media is now prompting us to ask to what extent cryptocurrencies are financial asset and what measures need to be

---

<sup>1</sup> Cryptography's aim is to construct schemes or protocols that can still accomplish certain tasks even in the presence of an adversary. A basic task in cryptography is to enable users to communicate securely over an insecure channel in a way that guarantees their transmissions' privacy and authenticity.

<sup>2</sup> See, for example, Regulation (EU) 2023/1114 of the European Parliament and of the Council of 31 May 2023 on markets in crypto-assets

taken to regulate them if financial institutions were to offer crypto assets as investment solutions to their customers (Söderberg, 2018).

The crypto assets phenomenon being quite recent, there is no universally accepted definition. However, the one from European Central Bank (ECB) seems particularly well explained.

*“A new type of asset recorded in digital form and enabled by the use of cryptography that does not represent a financial claim on, or a liability of, any identifiable entity” (Bullmann, Klemm and Pinna, 2019: 7).*

Ram (2019) concludes by adding that crypto assets are decentralized, meaning that they are not governed by a centralized entity but rather by computer nodes in a peer-to-peer network. Every transaction is documented on the blockchain, an unalterable public database (Nakamoto, 2008). There are a plethora of discussions and papers written about crypto assets, but one thing is certain: the overwhelming majority of them are centred around Bitcoin, which has the largest market capitalization. It is commonly regarded as a key driver for the rest of the crypto asset market, so when research is conducted on them, it is likely to serve as a benchmark (Ram, 2019; Burniske & White, 2017). The first successful crypto asset is named “Bitcoin” and was created by a computer programmer working under the pseudonym of Satoshi Nakamoto in 2008 (Hougan and Lawant, 2021). In his White paper called “Bitcoin: A Peer-to-Peer Electronic Cash System” he explained his vision on how to get rid of traditional financial intermediaries and be able to perform electronic transactions and hold items of value (Nakamoto, 2008). He fixed the transmission of electronic cash without requiring a central authority to verify the ownership record. This represented a revolutionary aspect of this innovative technology.

As one of the research objectives of this paper is to expand knowledge on the behavior of crypto assets in the vast universe of financial products, it is necessary to understand what an asset class is. It is essential, from a purely practical standpoint, to determine whether or not they constitute a new asset class. The answer to this question has the potential to influence investment choices made not just by people but also by investment firms. According to Ram (2019), investing in a variety of asset classes can result in considerable profits over the long run. Furthermore, as previously stated, the modern portfolio theory has provided us with methods to reduce the risks of constructing a portfolio of investments (Markowitz, 1952), and if crypto assets are to be considered a new asset class, they may be incorporated into the construction of a portfolio. Burniske and Tatar (2017) explained that traditional investment portfolios put very little weight on alternative assets. Alternative assets are defined as assets other than stocks and bonds

that have their own distinct economic and behavioral characteristics. However, recent, alternative assets have been the subject of research to discover the mechanisms by which they might generate value and beneficially impact their adoption (Ram, 2019; Burniske & Tatar, 2017). A classification was attempted six years ago:

*"The Commodity Futures Trading Commission (CFTC) asserts that it's a commodity, the Internal Revenue Service (IRS) deems it a property, and the U.S. Securities and Exchange Commission (SEC) has decided to approach it on a case-by-case basis"* (Burniske & White, 2017: 1).

Still, as of today, as mentioned earlier, there is a clear lack of classification for digital asset. It is very surprising coming from one of the world's strongest economic powers where we will find the highest concentration of crypto asset holders in 2021 (Worldcoin, 2023).

## **2.2 Asset class**

To shed some light on this thorny issue, it is necessary to first establish what an asset class is and how the literature defines it. Investing is fundamentally based on the idea of risks and returns, as well as the relationship between the two of them. Every investable asset, such as equities, bonds, marketable securities, commodities, or real estate (Ganti, 2023), has its own unique risk-return ratio. Therefore, using asset classes allows us to group them by family (Markowitz, 1952; Shipway, 2009; Bodie, Kane, and Markus, 2014). Section 2.2.1 will examine the characteristics of an asset class.

### **2.2.1 Definition of an asset class**

On the premises of this concept, one of the first to provide a clear definition was Robert J. Greer (1997) in his paper entitled "What is an Asset Class, Anyway?". He described it as "a set of assets that bear some fundamental economic similarities to each other and that have characteristics that make them distinct from other assets that are not part of that class" (p. 86).

As will most likely appear for crypto assets, this definition will evolve, and the literature provides other angles for this. Oberhofer (2001), cited by Ram (2019) and Bianchi, Drew, and Whittaker (2017), described an asset as follows:

- Assets in the class must be similar;
- The correlation of the returns between the assets must be high;

- The asset class should be able to comprise a significant fraction of the investment opportunity set;
- Price and composition data must be easy to obtain;
- The asset must provide passive investment;
- All defined asset classes should approximate the total opportunity set for investment.

Additionally, Mongars and Marchal-Dombrat (2006) wrote that assets ought to possess the following three features:

- The returns of the asset must provide higher than the risk-free rate;
- The correlation of the asset within this class must provide little or no correlation with the asset of another class;
- Returns cannot be replicated by combining other assets in a linear combination.

Finally, Burniske and White (2017) provide an interesting way to define the boundaries within the traditional asset classes using the four characteristics described by Greer (1997): “Investability, the Politico-Economic features, the Correlation of Return, and the Risk Reward profile” (Burniske and White, 2017 : 4). They applied it to verify that Bitcoin may indeed be considered a new asset class.

Referring to Burniske and White (2017), in order to be considered investable, a class of assets needs to have high liquidity and a wide range of investment opportunities. Secondly, it must have a distinct politico-economic character based on its value, governance, and use case basis. The basis of value refers to the way in which the value of an asset class is derived from tangible assets and/or underlying properties. For example, the value of gold results from the rarity of the metal as well as its intrinsic attributes (Ram, 2019; Burniske and White, 2017). There are three distinct groups that can be found in the governance: the procurers of the asset, the people who own it, and the organizations that regulate it (Ram, 2019; Burniske and Tatar, 2017).

Thirdly, the market value of an asset should fluctuate independently of other assets on the market, exhibiting a low correlation of returns (Mongars and Marchal-Dombrat, 2006). As described by Markowitz (1952), the coefficient of correlation helps to construct an optimal portfolio thanks to its diversification effect. Table 1 illustrates how correlation values affect risk. The final result of the three previous factors should be a distinct risk-reward profile that can be divided into absolute returns and volatility. The Sharpe ratio,

which measures returns per unit of accepted risk, can be used to effectively quantify this reward (Sharpe, 1966). The ratio is used to compare various assets; the higher the ratio, the greater the investor's compensation for the risk he is willing to assume (Sharpe, 1966; Burniske and White, 2017; Burniske and Tatar, 2017).

The combination of the four previously cited characteristics defines which assets pertain to which category (Burniske & White, 2017).

**Table 1 Correlation Coefficient Effect of Diversification on Risk**

Correlation coefficient	Effects of diversification on risk
+1.0	No risk reduction is possible
+0.5	Moderate risk reduction is possible
0	Considerable risk reduction is possible
-0.5	Most risk can be eliminated
-1.0	All risk can be eliminated

Source: Malkiel (2015, p. 154)

### **2.3 Evidence on the diversification benefits of crypto assets**

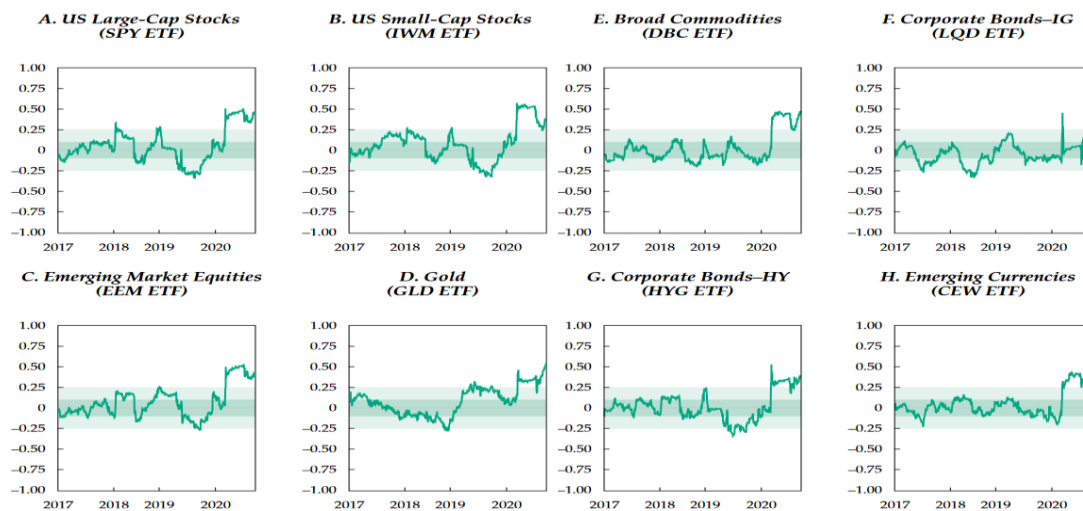
Ultimately, investors come up with the issue of introducing a part of their funds into crypto assets for their portfolio. Hougan and Lawant (2021) provide partial elements of an answer to this matter. In their paper "Cryptoassets, The Guide to Bitcoin, Blockchain, and Cryptocurrency for Investment Professionals," an analysis of the historical returns, volatility, and correlation of Bitcoin with traditional financial assets is performed and provides attractive results. Out of the 11 years of data analysed, nine years provided positive returns, and six of them had triple-digit performance. As one might expect, these high returns came with extreme volatility. Out of the 41 studied quarters, 15 of them experienced negative returns (Hougan and Lawant, 2021). They compared it to other traditional assets and found that its volatility remained significantly higher as of September 30, 2020. In terms of correlation, Bitcoin provided compelling data. Except for the Covid period, Figure 1 shows that its correlation stays low with gold, US large cap, US small cap, emerging market equities, bonds, emerging currencies, or broad commodities.

Nevertheless, Hougan and Lawant (2021) explained that these results must be analysed with caution. Indeed, as crypto assets are in the early stages of their adoption as investment opportunities, the main drivers of Bitcoin are different from those of traditional

assets such as equities. Equities will react to the profit of the companies, the interest rate, the tax policy or the growth, while Bitcoin will be driven mainly by the adoption of the investors, the inflation, the network security, the technological development or by its liquidity.

The results of their study are encouraging for crypto asset advocates. These results showed that adding Bitcoin to a portfolio has historically had a considerable beneficial impact on both absolute and risk-adjusted long-term portfolio performance. From 2014 to September 2020, a quarterly rebalanced 2,5% allocation to Bitcoin would have performed better by 23,9% while keeping the overall volatility at the same level. The Sharpe ratio would have risen from 0,54 to 0,75 (Hougan and Lawant, 2021).

**Figure 1 Rolling 90-day correlation of daily returns between Bitcoin and other major risky asset classes, 1st January 2017 – 30th September 2020**



Source: Hougan and Lawant (2021, p. 26-27)

Grujić, Mekinjić and Vujičić Stefanović (2021) also showed that investing in Bitcoin during 2020 would have been a wise strategy. They compared the expected returns, achieved returns, and volatility of emerging economies (China, Brazil, India, Indonesia, Serbia, and Croatia, to name a few) with those of developed economies. Based on those data, they combined it with the inclusion of Bitcoin to create an optimized portfolio that showed encouraging results. The main ones show that mixing emerging market and Bitcoin portfolios would result in quite similar achieved returns and expected returns. For an expected return of 10%, the portfolio would have returned 8,89% with Bitcoin and only 0,37% without Bitcoin, for 0,126% of volatility vs. 0,127% with Bitcoin. For a 20% expected return, the portfolio would have achieved a return of 17,81% with Bitcoin and 1,09% without Bitcoin. The corresponding volatility of these portfolios is 0,251% vs.

0.253% with Bitcoin. A critical part of their study was when they created a portfolio composed of developed economies and Bitcoin. For an expected return of 10%, the achieved return would be 33,40% with Bitcoin vs. -3,12% with a risk of 0,540% without Bitcoin vs. 0,491% with, and for a 20% expected return, they find 60,60% of the achieved return vs. 5,34%, corresponding to 0,406% of the standard deviation vs. 0,406% also with Bitcoin. Having said that, these results should be taken with a grain of salt: they are by no means representative of the results that can be generated on a stable basis over time. 2020 has been a fruitful year for Bitcoin.

Boiko et al. (2021) and Wang and Ngene (2020) investigated the optimization of crypto assets and found that while the inclusion of various cryptocurrencies in a diversified portfolio under different portfolio optimization strategies could lead to significant improvements in portfolio performance. However, Bitcoin was still the dominant force in the cryptocurrency portfolio. On the other hand, Ma et al. (2020) agreed that the inclusion of various crypto assets may lead to improved portfolio performance. Nevertheless, Ethereum (ETH) presented greater potential for diversification than Bitcoin did.

According to the findings of Watorek et al. (2021), the most liquid crypto assets, such as Bitcoin and Ethereum, were shown to be usually uncorrelated with traditional assets, indicating therefore that investing in these crypto assets might render portfolio diversification easier. A study conducted by Ozturk (2020) went further and indicated that Bitcoin would not provide enough contribution to the diversification of portfolios on a short-term and mid-term basis, pointing out its high volatility nature. However, considering it on a long-term basis, the limited connectedness with other asset classes such as commodities or gold might offer a perspective of diversification.

Finally, Ehlers and Gauer (2019) claimed that the correlation between fiat currencies and crypto assets is close to zero. Compared to fiat currencies, the range in which crypto assets tend to correlate with one another is far more constrained. The result of this study showed that a portfolio composed of both fiat currencies and crypto assets is more diversified. Additionally, Ripple (XRP) and Bitcoin have the most impact in terms of diversification effects within a portfolio of crypto assets.

## **2.4 Traditional way to invest in crypto market**

The literature about crypto assets provides many variations to explore how they work and how to use them as a means of diversification in a portfolio, as seen earlier. What is needed is a way to procure crypto assets and include them as an investor or as a portfolio manager. A few years ago, the Chicago Mercantile Exchange Group (CME) (2016), in

association with Crypto Facilities, launched two products to track the price of Bitcoin: the BRTI (CME CF Bitcoin Real Time Index) and the BRR (CME CF Bitcoin Reference Rate). Both were implemented to accelerate the professionalization of Bitcoin trading. Following this, the CME Group first offers Futures contracts, allowing investors to get an exposition to Bitcoin (5 BTC per contract). Later, they expand their offer to trade Ethereum (50 ETH per contract) and even create Micro Bitcoin Future contracts and Micro Ether Future contracts, allowing for smaller exposure (CME Group, 2023).

Until 2021, Futures contracts were one of the only ways for traditional investors to get exposure to crypto assets. The first Bitcoin exchange-traded fund started in October 2021. (Todorov, 2021). With demand for Bitcoin being extremely strong, this ETF was traded with more than \$1 billion in assets in the first few days, making it one of the most heavily traded funds in history. Currently, the Securities and Exchange Commission has either postponed or turned down proposals to create an ETF that would invest directly in Bitcoin. This is mostly caused by concerns over the fact that Bitcoin is principally traded on unregulated exchanges (Todorov, 2021).

Because of the growing interest in crypto assets, especially Bitcoin, several heavyweight actors from Wall Street (ARK Invest, Bitwise, BlackRock, VanEck, WisdomTree, Valkyrie First Trust Galaxy and Fidelity) have attempted to file an application with the SEC to be authorized to market a Bitcoin spot ETF (Calderon, 2023). This ETF would give investors exposure without the need to buy or sell Bitcoin directly on an exchange platform (Braun, 2023). Europe is ahead of the US, as the first Bitcoin spot ETF has been approved for listing on Euronext Amsterdam since July 2022. Jacobi Asset Management, the manager of the fund, explains that the timing was not right for the launch, mainly because of FTX's bankruptcy in November and the crash of crypto asset Terra Luna (Moisson, 2023). Finally, the first ETF Bitcoin backed by physically settled Bitcoin was launched in Canada in February 2021. Liu (2022) wrote that this ETF generated \$1 billion in assets under management in the first month of its launch, showing the strong interest from investors for this new asset and the importance of the decision taken by the SEC in the following weeks for US investors.

### 3. Methodology

The target of the paper is to discover if crypto assets in the form of an index are a possible and viable means of diversification in portfolio construction. The evaluation of this objective is based on statistics derived from the modern portfolio theory of Markowitz (1952). The key components and statistics studied are variance, standard deviation, covariance, correlation, the expected return, the risk-free rate, and the Sharpe ratio.

The variance measures the dispersion of individual returns relative to their average. In the context of the paper, it is used to quantify the risk of an asset and is represented by the following formula:

$$\sigma^2 = \frac{1}{N} \sum_{i=1}^N (R_i - \bar{R})^2$$

Where:  $N$  represents the total number of observations in the dataset.

- $R_i$  represents the individual observed value (return) at the  $i$ th data point.
- $\bar{R}$  represents the mean (average) return of all the observations.

Standard deviation was used and indicate the volatility of the assets. It was found by applying the square root of the variance's result to this formula:

$$\sigma = \sqrt{\sigma^2}$$

The expected returns of each asset were found by applying this formula:

$$R = \frac{1}{N} \sum_{i=1}^N R_i$$

Where:  $N$  represents the total number of observations in the dataset.

- $R_i$  represents the individual observed value (return) at the  $i$ th data point.
- $R$  represents expected returns.

The covariance estimates the linear association between the returns of two assets. Positive covariance indicates returns moving in the same direction, while negative covariance indicates returns moving in contrary directions.

The Covariance equation is described as:

$$Cov(r_1, r_2) = \frac{1}{N} \sum_{i=1}^N (r_{1i} - \bar{r}_1)(r_{2i} - \bar{r}_2)$$

Where:  $N$  represents the total number of observations.

- $r_{1i}$  represents the individual observed value of variable  $r_1$  at the  $i$ th data point.
- $r_{2i}$  represents the individual observed value of variable  $r_2$  at the  $i$ th data point.
- $\bar{r}_1$  represents the mean value of variable  $r_1$  across all observations.
- $\bar{r}_2$  represents the mean value of variable  $r_2$  across all observations.

The covariance matrix has been used to calculate the annual volatility of the portfolios tested.

The correlation normalizes the covariance by dividing by the two assets' standard deviations. It determines the intensity and direction of the linear relationship between two assets' returns. The following formula describes it:

$$\rho_{r_1, r_2} = \frac{\sigma_{r_1} \sigma_{r_2}}{Cov(r_1, r_2)}$$

- Where:  $\rho_{r_1, r_2}$  represents the correlation coefficient between variables  $r_1$  and  $r_2$ .
- $Cov(r_1, r_2)$  represents the covariance between variables  $r_1$  and  $r_2$ .
- $\sigma_{r_1}$  represents the standard deviation of variable  $r_1$ .
- $\sigma_{r_2}$  represents the standard deviation of variable  $r_2$ .

This metric has been used to test the hypothesis that crypto assets may act as an efficient diversifier factor with regards to the MPT. As mentioned earlier, a correlation coefficient close to 1 or -1 indicates a strong linear relationship; a score of 0 means no or a very weak linear relationship.

The Sharpe ratio (Sharpe, 1966), which measures the excess return per unit of risk, helps to evaluate the optimization of a portfolio and the effectiveness of a portfolio considering the assumed risk. Its equation is the following:

$$\textit{Sharpe Ratio} = \frac{R - R_f}{\sigma}$$

Where:  $R$  represents the return of the asset or portfolio evaluate.

- $R_f$  represents the risk-free return.
- $\sigma$  represents the volatility of the asset or portfolio evaluate.

This equation has been used to compare the various combinations of assets and test the main hypothesis of the paper, which was that adding crypto assets to a portfolio composed of only stocks and bonds will allow it to better perform a traditional 60-40 portfolio as described by Markowitz (1952).

The risk-free rate utilized for the calculation of the paper is based on the US Treasury bonds 3 months. Its total returns had been annualized for the period October 2014 to February 2023 and used as such.

When the study started in February 2023, a set of crypto assets representing more than 60% of the market capitalization of the crypto assets was chosen to build the crypto asset index. The first step was to calculate the annualized returns and volatility of each component. The second step was to optimize the allocation of each of them based on their Sharpe ratio to find the best portfolio, which will be the crypto index. As the available data for each asset varies, this optimization has been performed several times when a new crypto asset emerges. For the optimization, the Solver<sup>3</sup> has been used. The following constraints were set:

- The total sum of the weight of the assets forming the portfolio must be equal to 100%.
- The weight of the assets must not be under 0.
- The Sharpe ratio must be maximized

The third step was to create the crypto index based on the optimal weight find in the previous step.

---

<sup>3</sup> Solver is an add-in program in Excel that allows you to calculate faster and more accurately.

Finally, the variance, covariance, correlations, standard deviation, returns, and other relevant statistics were calculated based on the index and introduced into the portfolio composed of the stocks index (SPY) and the bonds index (AGG).

To construct the 60-40 gradual portfolio, for the weight of the SPY, the calculation was 60% subtracted by 1% multiplied by 60%, and the same for AGG: 40% subtracted by 1% multiplied by 40%, then replacing 1% by 2% until the portfolio was composed solely by the crypto asset index.

To find the optimal portfolio without the constraints (i.e., an asset could have 0% allocation) as for the portfolios described above. The Solver was used with the goal of maximizing the Sharpe ratio. The experience has been reconducted with the goal of maximizing the returns, minimizing the volatility, and with imposed allocations, volatility, and expected returns.

### **3.1 Data description**

The creation of the crypto assets index is limited by the available dates of the data, depending on the sources used. Daily prices were obtained from Yahoo Finance and Investing.com. The data sets vary from 3061 observations for Bitcoin to 1874 for Cardano, which has the least available data. This represented daily data from 1<sup>st</sup> October 2014 to 16<sup>th</sup> February 2023. The crypto asset index is constructed based only on the trading date of the traditional asset (closing prices from Monday to Friday have been used to calculate the returns). Even though crypto assets are traded 7 days a week, as no significant change has been detected after testing both approaches, for convenience of construction and comparison of the assets constituting the portfolios, it has been decided to maintain the first approach. The two other indices are, respectively, an Exchanged Traded Fund called SPY, representing the S&P500 and an ETF called AGG, representing the performance of the total U.S. investment-grade bond market. These two ETFs were used to represent the US market.

## 4. Results

In this section, the comprehensive results of the analysis are presented, derived from the data collected, computed, and analyzed throughout the course of this study. The primary purpose of this study was to evaluate the impact of crypto assets on the diversification of a portfolio. To achieve this objective and test the hypotheses, a fictive crypto index has been created and incorporated into a set of portfolios. The crypto assets to be incorporated into the index were Bitcoin (BTC), Litecoin (LTC), Ripple (XRP), Monero (XMR), Ethereum (ETH), Stellar (XLM), Bitcoin Cash (BTH), Binance Coin (BNB), Chainlink (LINK), Tezos (XTZ), and Cardano (ADA). The studied statistics provide insights into the risk and return profiles of these portfolios, in addition to the assessment of their correlations with well-established benchmark assets (i.e., AGG representing US investment-grade bonds and SPY representing the US stock market).

The empirical results presented in this section are derived from various tests of optimization portfolios conducted with the Solver; three types of optimizations may be distinguished. The first one focuses on targeting a certain level of volatility, the second one will target an amount of expected return, and the last one will present the most optimized portfolio based on the Sharpe ratio. The next chapter will tackle the inclusion of the crypto index in a diversified portfolio with the constraints that stocks and bonds must be allocated according to the standard portfolio 60-40 from Markovitz (1952). The last part of this section will focus the key metrics regarding the assets composing the crypto assets index as well as the two indices used to construct the 60-40 portfolio.

### **4.1 Key metrics and correlations matrix**

The statistics of the variables considered to create the crypto index as well as the two indices used to test the impact on the diversification of portfolios are presented in Table 2. The annualized return from the index is far higher than most of the studied assets, with 58,67%; only BNB and XRP display better results. However, the volatility, the skewness and the kurtosis are way above it. The high kurtosis of 51,1 and 20,91 indicates that it has considerably more extreme events. The assets presenting the highest skewness might be explained by their strong volatility. The way the optimization of the index was done allowed it to beat the Sharpe ratio of every asset during the studied period.

**Table 2 Statistics by assets**

10.2014-02.2023	BTC	LTC	XRP	XMR	ETH	XLM	BCH	BNB	LINK	XTZ	ADA	AGG	SPY	Index Crypto
Annualized returns	42,11%	2,72%	59,23%	11,60%	44,07%	18,32%	-39,57%	84,07%	-2,36%	-29,31%	-41,36%	-1,19%	8,00%	58,67%
Annualized volatility	61,34%	89,85%	149,35%	209,00%	86,19%	118,15%	103,78%	97,73%	107,40%	107,63%	95,34%	4,69%	16,49%	67,42%
Sharpe ratio	0,67	0,02	0,39	0,05	0,50	0,15	-0,39	0,85	-0,03	-0,28	-0,44	-0,46	0,43	0,86
Kurtosis	7,18	16,34	51,10	104,79	4,67	21,96	12,64	20,91	7,60	4,51	5,04	29,59	7,83	6,16
Skewness	-0,18	1,33	4,13	7,56	0,08	2,42	1,25	1,76	0,62	-0,01	-0,51	-1,58	-0,79	-0,09

Source: Author production, 2023

The correlations are presented in Table 3 below. As the main hypothesis proposed of this paper suggests, the crypto index returns low correlations with the bonds index and the stocks index; therefore, it might act as a diversification asset in the portfolio's construction. In addition, the matrix clearly demonstrates that not only the crypto index presents low correlations, but every crypto asset, including Bitcoin, corroborates the results emphasized by Hougan and Lawant (2021). It also validates one characteristic of the definition from Burniske and White (2017) regarding the asset class, which states that within an asset class the correlations between the different assets must be strong. The green numbers represent correlations above 0,25, and the red ones those under -0,25. Surprisingly, the Cardano asset exhibits strong negative correlations with all the assets studied and may have the most impact in terms of diversification effect. On the other hand, Chainlink shows almost no linear relationships with any assets studied.

**Table 3 Correlation matrix**

Correlation Matrix	BTC	LTC	XRP	XMR	ETH	XLM	BCH	BNB	LINK	XTZ	ADA	AGG	SPY	Index Crypto
BTC	1,000													
LTC	0,666	1,000												
XRP	0,283	0,351	1,000											
XMR	0,244	0,219	0,094	1,000										
ETH	0,652	0,641	0,481	0,575	1,000									
XLM	0,513	0,528	0,620	0,551	0,549	1,000								
BCH	0,654	0,707	0,555	0,668	0,714	0,560	1,000							
BNB	0,644	0,605	0,475	0,599	0,645	0,505	0,500	1,000						
LINK	-0,007	-0,034	-0,063	-0,091	-0,049	-0,039	-0,011	-0,034	1,000					
XTZ	0,590	0,580	0,497	0,538	0,622	0,552	0,485	0,498	-0,066	1,000				
ADA	-0,702	-0,729	-0,691	-0,702	-0,775	-0,782	-0,690	-0,597	0,065	-0,616	1,000			
AGG	0,113	0,083	0,061	0,021	0,117	0,066	0,093	0,112	-0,022	0,126	-0,124	1,000		
SPY	0,089	0,079	0,032	0,043	0,104	0,082	0,095	0,114	0,115	0,117	-0,113	0,045	1,000	
Index Crypto	0,900	0,589	0,244	0,217	0,595	0,458	0,592	0,587	0,060	0,532	-0,644	0,099	0,112	1,000

Source: Author production, 2023

## **4.2 Portfolio optimization and volatility and expected returns targets**

Table 4 shows that investors with a volatility approach will be strongly invested in bonds and, therefore, miss the opportunity to maximize their returns. On the other hand, an investor looking for an expected annual return of 15% will be strongly invested in stock and crypto assets and will be able to reach a Sharpe ratio of 0,6651. This is almost 28% higher than an investor trying to optimize his portfolio by targeting a volatility of 20%, corresponding to a portfolio with an expected return of 15%. With the incorporation of the crypto index, the maximum expected return an investor might reach is 26,91%. To do so, the bonds index will be eliminated from the portfolio, and the volatility will logically see a sharp rise to almost 60%.

**Table 4 List of portfolios based on expected volatility and on expected returns for the period 10.2014-02.2023**

<b>PF x volatility</b>	<b>Annualized volatility</b>	<b>Annualized returns</b>	<b>Sharpe ratio</b>	<b>AGG</b>	<b>S&amp;P500</b>	<b>Crypto index</b>
5,00%	5,00%	0,36%	-0,1234	92,79%	4,50%	2,71%
10,00%	10,00%	4,92%	0,3939	82,97%	4,09%	12,94%
15,00%	15,00%	8,31%	0,4889	74,92%	4,10%	20,97%
20,00%	20,00%	11,37%	0,5197	67,19%	4,11%	28,70%
25,00%	25,00%	14,17%	0,5277	59,58%	4,11%	36,31%
30,00%	30,00%	16,72%	0,5247	52,02%	4,11%	43,86%
50,00%	50,00%	24,21%	0,4647	22,01%	4,12%	73,87%
<b>PF x Expected returns</b>	<b>Annualized volatility</b>	<b>Annualized returns</b>	<b>Sharpe ratio</b>	<b>AGG</b>	<b>S&amp;P500</b>	<b>Crypto index</b>
5,00%	8,52%	5,00%	0,4719	65,24%	26,08%	8,69%
10,00%	14,36%	10,00%	0,6283	42,15%	40,68%	17,17%
15,00%	21,08%	15,00%	0,6651	21,40%	51,58%	27,02%
20,00%	31,29%	20,00%	0,6079	18,49%	37,17%	44,35%
25,00%	48,16%	25,00%	0,4987	11,43%	17,84%	70,73%
26,91%	59,28%	26,91%	0,4373	0,00%	12,46%	87,54%

Source: Author production, 2023

Table 5 corroborates our hypothesis that adding crypto assets allows the portfolio to increase returns while decreasing volatility. For a targeted volatility of 10%, the Sharpe ratio is 0,3939 with the crypto index versus 0,2634 without it, representing an increase of 49% with only 13% allocated to the crypto index. The same is true when an expected return is sought. With a target of an expected return of 5%, the portfolio with the crypto index reduces volatility by more than 33%.

Tables 4 and 5 display limited maximum expected returns due to the characteristics of the assets composing it, respectively, 26,91% with a crypto index and 6,54% with a standard 60-40 portfolio.

**Table 5 List of portfolios based on expected volatility and on expected returns without allocation in the crypto index for the period 10.2014-02.2023**

PF x volatility	Annualized volatility	Annualized returns	Sharpe ratio	AGG	S&P500	Crypto index
5,00%	5,00%	0,45%	-0,1064	80,10%	19,90%	0,00%
10,00%	10,00%	3,61%	0,2634	41,01%	58,99%	0,00%
15,00%	15,00%	5,92%	0,3296	9,18%	90,82%	0,00%
16,49%	16,49%	6,54%	0,3373	0,00%	100,00%	0,00%
PF x expected returns	Annualized volatility	Annualized returns	Sharpe ratio	AGG	S&P500	Crypto index
5,00%	12,89%	5,00%	0,3117	22,34%	77,66%	0,00%
6,54%	16,49%	6,54%	0,3373	0,00%	100,00%	0,00%

Source: Author production, 2023

The best optimized portfolio reachable based on the study displays a Sharpe ratio of 0,6869 (Table 6). To obtain such a portfolio, the investor will have to give up on the bonds index (AGG) and allocate  $\frac{3}{4}$  of his portfolio to the stock index. This finding contradicts the common hypothesis that holding bonds is necessary to reduce portfolio volatility, at least for the sample period. It also demonstrates that allocating a quarter of the portfolio to crypto assets allows to double the Sharpe ratio.

**Table 6 Best optimized portfolio based on the Sharpe ratio for the period 10.2014-02.2023**

PF with max Sharpe ratio	Annualized volatility	Annualized returns	Sharpe ratio	AGG	S&P500	Crypto index
0,6869	22,80%	16,64%	0,6869	0,00%	73,26%	26,74%
0,3373	16,49%	6,54%	0,3373	0,00%	100,00%	0,00%

Source: Author production, 2023

Based on the hypothesis that incorporating crypto assets into a portfolio will improve diversification, Table 7 shows the implications of allocating 0-10% of the crypto index. The positive impact on the Sharpe ratio is undeniable: the volatility increase is rather low (10,15% for 0% allocation against 12,03% for 10% allocation), but the Sharpe ratio is multiplied by 2,16 times. In the meantime, the maximum drawdowns rise by 2,37 times, implying that risk-sensitive investors might consider it too high. Especially, as the

allocation increases from 0% to 8%, the maximum drawdowns experience a relatively modest rise of less than 3.5%. However, when the allocation is increased from 9% to 10%, the maximum drawdowns show a more significant escalation, growing by 7.78%. The Calmar ratio tends to increase for the first three percent of allocation and starts to drop afterwards. As crypto asset allocations increase beyond 3%, more pronounced price fluctuations of these assets may lead to greater peaks and drops.

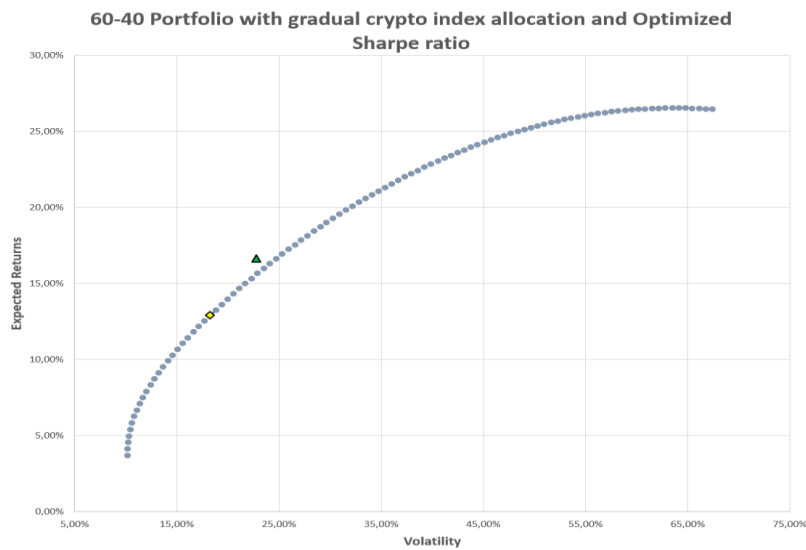
Finally, Figure 2 shows the optimal portfolio represented by a yellow dot from a Sharpe ratio standpoint, which would reach 0,6548. This number slightly changes from the one (Highlighted by the green triangle) displayed on Table 6 as the way to allocate crypto index into the portfolio differs. In Table 7, constraints were set up as reducing the weight of the bonds index and the stocks index according to the 60-40 of MPT (30,8% bonds, 46,2% stocks). Data from Table 6 shows the optimal way to maximize the Sharpe ratio without any constraint related to the allocation of the available assets.

**Table 7 Key metrics by Crypto index allocation for the period 10.2014-02.2023**

<b>Crypto index allocation</b>	<b>Annualized volatility</b>	<b>Annualized return</b>	<b>Sharpe ratio</b>	<b>Max drawdowns</b>	<b>Calmar ratio</b>
0%	10,15%	3,69%	0,2671	40,07%	9,21%
1%	10,16%	4,13%	0,3099	43,40%	9,51%
2%	10,21%	4,56%	0,3508	46,97%	9,71%
3%	10,30%	4,99%	0,3894	51,33%	9,73%
4%	10,44%	5,42%	0,4253	56,22%	9,64%
5%	10,61%	5,84%	0,4583	61,51%	9,50%
6%	10,83%	6,27%	0,4881	67,23%	9,32%
7%	11,08%	6,69%	0,5148	73,42%	9,10%
8%	11,37%	7,10%	0,5385	80,12%	8,86%
9%	11,68%	7,51%	0,5592	87,33%	8,60%
10%	12,03%	7,92%	0,5771	95,11%	8,33%
23%	18,23%	12,92%	0,6548	267,78%	4,83%

Source: Author production, 2023

**Figure 2 60-40 Portfolio with gradual crypto index allocation and Optimized Sharpe ratio without constraint**



Source: Author production, 2023

Considering the MPT, some limitations have to be enlightened with regards to the results described. One fundamental assumption derived from the MPT is that asset returns follow a normal distribution (a bell-shaped curve). In reality, extreme events (positive and negative) occur more often on the financial market, exhibiting heavy tails and skewness. The dependence of MPT on the normal distribution assumption might result in an underestimated risk since it is possible that it does not completely represent the possibility of rare but impactful events to happen. Additionally, the expected returns found do not take transaction costs into account, which means that the portfolio returns might be overestimated. Finally, the model assumes that investors are fully rational and will only base their decisions on the maximization of the risk-return ratio; in fact, behavioral biases and emotional factors may affect the decision taken by investors. These deviations from rational behavior can result in suboptimal investment decisions and asset mispricing, which may compromise the construction of efficient portfolios.

Although the limitations mentioned above are to be acknowledged, the results obtained during the study indicate that the use of the model of portfolio diversification is desirable and feasible. Different investment combinations were successfully found by applying the model of portfolio diversification.

## 5. Discussion

### 5.1 Diversification effect of crypto assets

This research seeks to enlarge the limited available research on crypto assets beyond Bitcoin. Our research enhances the overall understanding of crypto assets within the context of portfolio diversification. The primary hypothesis stating that crypto assets are an effective way to diversify a portfolio and obtain a superior Sharpe ratio is confirmed by the existing literature. Hougan and Lawant (2021) partially demonstrate it but their analysis concerns only Bitcoin; however, as it is considered as the main asset in the crypto asset class, it seems relevant to consider it. Through their research, the Sharpe ratio of a quarterly rebalanced 2,5% allocation to Bitcoin portfolio returned 0,75 compared to 0,54 for the same portfolio without Bitcoin allocation. Grujić, Mekinjić and Vujičić Stefanović (2021) also demonstrated that adding Bitcoin to a portfolio composed of developed economy main stock indices allows for a sharp increase in expected returns while keeping almost similar risks. Boiko et al. (2021) and Wang and Ngene (2020) examined the former hypothesis with several crypto assets and confirmed the strong improvement in performance when adding crypto assets to a diversifying portfolio. Ma et al. (2020) confirmed the improvement as well and went further, stating that ETH was an even better means of diversification compared to Bitcoin during the examined period. Finally, Ozturk (2020) asserted that Bitcoin's comparatively low correlation with other asset classes, such as commodities or gold, could provide an opportunity for diversification over a longer period of time. Based on our research and calculations, this hypothesis is confirmed, as we were able to find an interesting improvement in the Sharpe ratio when adding the crypto index: it went from 0,3373 without allocation to 0,6869 with 26,74% of the crypto index.

### 5.2 Decorrelation with traditional assets

Regarding the second hypothesis, which was that crypto assets are uncorrelated with financial assets such as stocks, bonds, commodities, etc. but correlated with each other, Watorek et al. (2020) indicated that most of liquid crypto assets, such as BTC or ETH, usually display a low correlation with traditional assets. Ehlers and Gauer (2019) demonstrate that crypto assets and fiat currencies tend to have zero correlations with each other, leading to a more diverse and well-performing portfolio when including both types of assets. The results found in this paper validate the latter hypothesis. The correlation matrix calculated displays interesting outcomes about the crypto assets; Cardano seems to be the best crypto asset to diversify, as its correlation with every other

asset is strongly negative. Furthermore, the data computed confirms that crypto assets are not correlated to the stocks market and bonds markets. However, they are positively correlated within their class except for Chainlink (close to 0) and Cardano, as mentioned earlier. This tends to confirm the findings of Burniske and White (2017) and Hougan and Lawant (2021).

### **5.3 Risks analysis**

Since the past few years, incorporating crypto assets into portfolios has attracted interest from retail and institutional investors as a means of diversification. Risk management is a crucial component of any investment strategy, and it is even more important in the context of crypto assets. An analysis of the Sharpe ratio provides a comprehensive view of the ability of assets to generate excess returns relative to the level of risk assumed. This section will provide a risk analysis of the asset studied in this paper, as listed in the previous chapter.

During the research period, annual returns on crypto assets varied considerably. Bitcoin outperformed Litecoin with an average annual rate of return of 42,11%, while Litecoin registered a more modest growth of 2,72%. Ripple had one of the largest annual returns at 59,23% but this also reflects how volatile it is. It is essential to observe, however, that crypto assets also exhibit significant levels of volatility. Monero and Tezos exhibited exceptionally high volatility, with respective values of 209% and 107,63%. Ethereum and Bitcoin, in contrast, exhibited relatively lower levels of volatility.

High Sharpe ratios, such as those exhibited by Binance Coin and Cardano, indicate an attractive combination of optimistic returns and reduced volatility. For investors seeking the optimal equilibrium between returns and risk, these assets offer a valuable diversification opportunity. The negative Sharpe ratios observed with Bitcoin Cash, on the other hand, indicate a mismatch between returns and risk. Despite the fact that crypto assets can generate positive returns, their elevated volatility may make them unsuitable for investors with a low tolerance for risk due to their higher inherent risk levels.

Finally, the understanding of the volatility and risk patterns of crypto assets is significantly influenced by the presence of asymmetry and the characteristics of the return distribution. The elevated kurtosis values seen in Ripple and Monero prompt apprehension over the probability of extreme occurrences, hence suggesting an augmented amount of sudden volatility risk. The presence of positive skewness in the returns of Litecoin and Ripple suggests a tendency towards above-average returns, maybe accompanied by significant positive spikes. This phenomenon may lead to

episodes of accelerated expansion as well as abrupt downturns. Investors should be conscious of the potential disparity in returns when creating their investment portfolios.

#### **5.4 Recommendations**

The discussion reveals that simply adding crypto assets to a portfolio in a haphazard manner falls short of enabling investors to truly optimize their performance. The process is far more intricate, particularly when dealing with the unique dynamics of crypto assets. This study proposes that as crypto assets gain broader acceptance and are progressively integrated into investment portfolios, their positive impact on overall performance becomes a distinct possibility.

The examination of risk metrics demonstrates the need to thoughtfully evaluate the allocation of these new assets. Although the return profile of these assets is attractive, we would recommend risk-averse investors to incorporate a maximum of 2–3%. Our results demonstrate that every asset studied for this paper presents a high kurtosis above 3, meaning thicker tails in the return distribution and hence more frequent positive and negative extreme events. As Monero and Ripple present, respectively 104,79 and 51.10, we would recommend avoiding them. If there is a desire to be invested in crypto assets targeting the crypto index, it might be a wise decision. On the other hand, conservative investors would appreciate assets with negative skewness, such as Cardano. Indeed, as soon as the data for this asset was available, our computations showed that it took up an important part of the allocation of our crypto index. This is explained as well by its strong negative correlation with another asset, which plays the perfect role of a diversification factor. A conservative investor will be better mentally prepared in case of bad performance when he/she is aware that some of his investments present a high probability of getting a small increase in the long run and sometimes support a big drop as the asset goal is to generate stable income.

We agreed with the results found by Hougan and Lawant (2021) when they created a rebalanced portfolio with 2,5% Bitcoin. This amount would be good enough, as the decorrelated nature of the assets still provides an interesting source of diversification. As the allocation goes above this percentage, it is essential to denote the exponential increase of the maximum drawdowns. Consequently, it is essential to comprehend the inherent risks associated with crypto assets. As stated by Bakry et al. (2021) with Bitcoin's price evolution in 2017 and 2021, excessive allocation in the portfolio would expose investors to catastrophic losses during certain market phases.

As demonstrated by Markowitz (1952), diversification is the key to a strong, balanced portfolio, even for investors seeking high returns. Hence, a suitable allocation strategy should be considered in light of the previously presented empirical analysis and the preferences of investors who are willing to adopt volatility in exchange for higher returns. Consideration should be given to an allocation strategy that favors a more aggressive posture towards the crypto index despite market volatility. Past data suggests that larger allocations to the crypto index demonstrate a prudent balance of risk and reward. We suggest allocating between 6 and 10%. This range provides an attractive opportunity to maximize returns while remaining resilient against market volatility. Sharpe ratios range from 0,49 to 0,58, with a maximum annual volatility of 12%. Nonetheless, consequent maximal drawdowns are unavoidable and occasionally very significant, averaging 80%. The research demonstrates that the duration of the maximum drawdown period is 2024 days. This highlights the significance of adopting a long-term perspective. The consistent positivity of the Calmar ratio over the stipulated time period lends credence to the theory that the market is recovering from adverse conditions. Investors who choose to accept this increased exposure must maintain a keen awareness of market trends and take a proactive approach to portfolio management by continually re-evaluating their allocation.

## Conclusion

The aim of this thesis is to provide an additional analysis of the impact of crypto assets on portfolio diversification to the existing literature. The hypotheses put forward are that crypto assets are a new asset class that can be used to diversify a portfolio, according to Harry Markowitz's modern portfolio theory. The second is that these assets are uncorrelated with traditional assets such as equities and bonds. These hypotheses have been positively confirmed by existing studies and the collected and analysed data.

To test the first hypothesis, an index of crypto assets was created by optimizing the weight of each of its components based on variations in historical returns. This index was then introduced into a standard 60% equities and 40% bonds portfolio, and Sharpe ratio optimization tests were conducted. The weighted average of all returns of the financial instruments constituting the portfolio had been computed and use to find the annual return of the portfolio. To calculate the annual risk of the portfolio, a covariance matrix has been edited. The risk-free rate was calculated with the US Treasury bonds 3-months annualized.

This thesis shows encouraging results regarding the first hypothesis. Despite certain limitations of the Markowitz model, it is desirable and possible to apply the latter to crypto assets. These limitations notably concern transaction costs, which are non-existent according to the model, and therefore the calculated returns are overestimated, as well as the assumption that all investors are fully rational and will therefore maximize the Sharpe ratio. In reality, however, each investor has his or her own risk tolerance, is biased by certain information and/or behavior, and will not necessarily choose the most optimal portfolio in terms of risk and return. Finally, comparisons with other papers should also be questioned, as the results found using this model are highly dependent on the duration of observations and the assets chosen.

To test the second hypothesis, the correlation between the assets making up the index and the crypto asset index was compared with equities and bonds. Except for Cardano, which is negatively correlated with the entire sample, all examined crypto assets exhibit a strong correlation among themselves and a correlation close to 0 with equities and bonds which corroborate the second hypothesis. Therefore, it is prudent to investigate the possibility of including crypto asset in a diversified portfolio.

Finally, it came to light that a standard 60/40 portfolio is significantly outperformed by crypto assets in terms of return and risk. The Sharpe ratio increases from 0.2671 to 0.6548 when 23% of the crypto assets index is included, assuming less than 20%

volatility and an annual return of 13%. The Sharpe ratio increases to 0.6869 when the constraint of including the three indices is removed. The portfolio would comprise 27% crypto assets and 73% equities, with an annual return of 16.64% and volatility of 22.8%.

Further research could examine the same portfolios but with a different way of including the index. It might be interesting to compare these results with the inclusion of the index via a trend-following strategy. A model including transaction costs could also prove highly relevant and better reflect reality. The asset selection process may be improved as well by picking crypto assets based on the quality of the project behind the asset instead of focusing only on their market capitalization. As of now, institutional and retail investors will have to keep in mind that the traditional way of buying financial assets is not meant to be for crypto assets but should remain attentive because they are ready to flood the investors' portfolios in a very short time frame. Hougan and Lawant (2021) perfectly summarize the situation: the emergence of a new asset class that provides such high returns is very rare in the financial market landscape, and their burgeoning is exciting for the future.

## Bibliography

- BAKRY, Walid, AUDIL Rashid, SOMAR Al-Mohamad and EL-KANJ, Nasser, 2021. Bitcoin and Portfolio Diversification: A Portfolio Optimization Approach. *Journal of Risk and Financial Management* [online]. 2021. Retrieved from: <https://doi.org/10.3390/jrfm14070282>
- BIANCHI, Robert, DREW, Michael and WHITTAKER, Tim, 2017. Is “Listed Infrastructure” a fake asset class? [online]. July 2017. Retrieved from: [https://edhec.infrastructure.institute/wp-content/uploads/2018/08/bianchi\\_whittaker2017.pdf](https://edhec.infrastructure.institute/wp-content/uploads/2018/08/bianchi_whittaker2017.pdf) [accessed 6 August 2023].
- Bitcoin Cash USD (BCH-USD) Price History & Historical Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/BCH-USD/history/> [accessed 19 August 2023].
- Bitcoin USD (BTC-USD) Price History & Historical Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/BTC-USD/> [accessed 19 August 2023].
- Bitcoin vs the Biggest Companies and Assets in the World by Market Cap – CoinMarketCap, no date [online]. Retrieved from: <https://coinmarketcap.com/largest-companies/> [accessed 18 August 2023].
- BNB USD (BNB-USD) Price History & Historical Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/BNB-USD/> [accessed 19 August 2023].
- BODIE, Zvi, KANE, Alex and MARCUS, Alan J, 2012. *Essentials of Investments*. 9th. McGraw-Hill Education. ISBN 978-0-07-803469-5.
- BOIKO, Viktor, TYMOSHENKO, Yelizaveta, KONONENKO, Anna, RUSINA, Yuliia and GONCHAROV, Dmitrii, 2021. The Optimization of the cryptocurrency portfolio in view of the risks. *Journal of Management Information and Decision Sciences* [online]. Vol 24, no 4, pp. 1-9. Retrieved from: <http://socrates.vsau.org/repository/getfile.php/28335.pdf> [accessed 29 July 2023].
- BULLMANN, Dirk, KLEMM, Jonas and PINNA, Andrea, 2019. In Search for Stability in Crypto-Assets: Are Stablecoins the Solution? SSRN Scholarly Paper Rochester, NY. No 230, pp 1-55. DOI 10.2139/ssrn.3444847.
- BURNISKE, Chris and TATAR, Jack, 2018. *Cryptoassets: The Innovative Investor’s Guide to Bitcoin and Beyond*. [online]. Retrieved from: [http://www.ir.juit.ac.in:8080/jspui/bitstream/123456789/7834/1/Cryptoassets\\_%20The%20Innovative%20Investor%E2%80%99s%20Guide%20to%20Bitcoin%20and%20Beyond.pdf](http://www.ir.juit.ac.in:8080/jspui/bitstream/123456789/7834/1/Cryptoassets_%20The%20Innovative%20Investor%E2%80%99s%20Guide%20to%20Bitcoin%20and%20Beyond.pdf) [accessed 29 July 2023].
- BURNISKE, Chris and WHITE, Adam, 2017. *Bitcoin Ringing the Bell For a New Asset Class*. [online]. Retrieved from: [https://research.ark-invest.com/hubfs/1\\_Download\\_Files\\_ARK-Invest/White\\_Papers/Bitcoin-Ringing-The-Bell-For-A-New-Asset-Class.pdf?hsCtaTracking=b61e33ed-207f-4a68-8c36-c30137cf54ea%7C4429a5e8-db0c-46e4-a9e9-e4d1a41fcb68](https://research.ark-invest.com/hubfs/1_Download_Files_ARK-Invest/White_Papers/Bitcoin-Ringing-The-Bell-For-A-New-Asset-Class.pdf?hsCtaTracking=b61e33ed-207f-4a68-8c36-c30137cf54ea%7C4429a5e8-db0c-46e4-a9e9-e4d1a41fcb68) [accessed 15 July 2023].
- CALDERON, Matias, 2023. Tic tac, le temps presse pour la SEC qui doit se décider sur cet ETF Bitcoin. *BeinCrypto France* [online]. 8 August 2023. Retrieved from: <https://fr.beincrypto.com/marches/209720/tic-tac-sec-doit-decider-approbation-etf-bitcoin/> [accessed 10 August 2023].
- Cardano USD (ADA-USD) Price History & Historical Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/ADA-USD/history/> [accessed 19 August 2023].

BRAUN, Helene, 2023. Cathie Wood and Mike Novogratz Are Both Bullish on Spot Bitcoin ETF Approvals, [online]. Retrieved from: <https://www.coindesk.com/markets/2023/08/08/cathie-wood-and-mike-novogratz-are-both-bullish-on-spot-bitcoin-etf-approvals/> [accessed 10 August 2023].

Chainlink USD (LINK-USD) Price History & Historical Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/LINK-USD/> [accessed 19 August 2023].

CHEN, James, 2021. Financial Asset Definition and Liquid vs. Illiquid Types. [online]. Retrieved from: <https://www.investopedia.com/terms/f/financialasset.asp> [accessed 12 August 2023].

CORON, J.-S., 2006. What is cryptography? IEEE Security & Privacy. Vol. 4, no. 1, pp. 70–73. DOI 10.1109/MSP.2006.29.

Crypto Around the World: Which Countries Use the Most Cryptocurrency? – Worldcoin, 2023. [online]. Retrieved from: <https://worldcoin.org/articles/which-country-trades-the-most-cryptocurrency> [accessed 15 July 2023].

Cryptocurrency futures and options – CME Group, 2023 [online]. Retrieved from : <https://www.cmegroup.com/markets/cryptocurrencies.html#explore-our-cryptocurrency-products>. [accessed 10 August 2023].

Cryptocurrency Prices, Charts and Market Capitalizations -, CoinMarketCap, no date [online]. Retrieved from: <https://coinmarketcap.com/> [accessed 29 July 2023].

EHLERS, Stefan and GAUER, Kolja, 2019. Beyond Bitcoin: A Statistical Comparison of Leading Cryptocurrencies and Fiat Currencies and Their Impact on Portfolio Diversification. . Vol. 22, no. 1, pp. 114–125. DOI 10.3905/jai.2019.1.072.

Ethereum USD (ETH-USD) Price History & Historical Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/ETH-USD/history/> [accessed 19 August 2023].

FOLEY, Sean, KARLSEN, Jonathan R and PUTNIŅŠ, Tālis J, 2019. Sex, Drugs, and Bitcoin: How Much Illegal Activity Is Financed through Cryptocurrencies? The Review of Financial Studies. Vol. 32, no. 5, pp. 1798–1853. DOI 10.1093/rfs/hhz015.

GANTI, Akilesh, 2023. What Are Asset Classes? More Than Just Stocks and Bonds, 2023. [online]. Retrieved from: <https://www.investopedia.com/terms/a/assetclasses.asp> [accessed 15 July 2023].

GREER, J., Robert, 1997. What is an Asset Class, Anyway? The journal of portfolio management [online]. Vol 23, no 2, pp. 86-90. Retrieved from: <https://www.pm-research.com/content/ijpormgmt/23/2/86> [accessed 8 February 2023].

GRUJIĆ, Miloš, MEKINJIĆ, Boško, VUJIČIĆ STEFANOVIĆ, Dragana, 2021. Testing of portfolio optimization through investment in stock investments in stock market indices and Bitcoin. University of Business Studies, Banja Luka. Vol. 69, pp. 318-332. DOI: 10.5937/EKOPRE2106318G.

HOUGAN, Matt and LAWANT, David, 2021. Cryptoassets: The Guide to Bitcoin, Blockchain, and Cryptocurrency for Investment Professionals. SSRN Scholarly Paper 3792541. Rochester, NY. 3792541. DOI 10.2139/ssrn.3792541.

Institutional investors to regulators: we need clarity on digital assets – Coinbase, 2023 [online]. Retrieved from: <https://www.coinbase.com/blog/institutional-investors-to-regulators-we-need-clarity-on-digital-assets> [accessed 14 July 2023].

Introduction au taux de référence du Bitcoin - CME Group, 2016 [online]. Retrieved from: <https://www.cmegroup.com/content/cmegroup/fr/education/courses/introduction-to-bitcoin/introduction-to-bitcoin-reference-rate.html> [accessed 10 August 2023].

iShares Core US Aggregate Bond ETF Historical Data, 2023. Investing.com [online]. Retrieved from: <https://www.investing.com/etfs/ishares-barclays-agg-historical-data> [accessed 19 August 2023].

Litecoin USD (LTC-USD) Price History & Historical Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/LTC-USD/> [accessed 19 August 2023].

LIU, Evie, 2022. A Year After Canada Launched Its First Bitcoin ETF, U.S. Investors Are Still Waiting. [online]. Retrieved from: <https://www.barrons.com/articles/bitcoin-etf-canada-sec-51645226649> [accessed 10 August 2023].

MA, Yechi, AHMAD, Ferhana, LIU, Miao, and WANG, Zilong, 2020. Portfolio optimization in the era of digital financialization using cryptocurrencies. *Technological Forecasting & Social Change*. Vol 161, pp.1-12. DOI: 10.1016/j.techfore.2020.120265

MALKIEL, Burton G., 2015. A Random Walk Down Wall Street. 11. W. W. NORTON & COMPANY. ISBN 0-393-04781-4.

MARKOWITZ, Harry, 1952. Portfolio Selection. *The Journal of Finance*. [online]. Vol 7, no 1, pp. 77-91. Available from: [https://edisciplinas.usp.br/pluginfile.php/7560592/mod\\_resource/content/1/HarryMarkowitz\\_1952.pdf](https://edisciplinas.usp.br/pluginfile.php/7560592/mod_resource/content/1/HarryMarkowitz_1952.pdf) [accessed 8 February 2023].

MOISSON, Ed, 2023. Europe's first bitcoin ETF set to launch after 12-month delay. *Financial Times* [online]. Retrieved from: <https://www.ft.com/content/1d1de06a-a904-4db3-9017-4c061bd6854d> [accessed 10 August 2023].

Monero USD (XMR-USD) Price History & Historical Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/XMR-USD/history/> [accessed 19 August 2023].

MONGARS, Philippe and MARCHAL-DOMBRAT, Christophe, 2006. Commodities: an asset class in their own right? *Banque de France*. No. 9, pp. 31–38. Retrieved from: [https://publications.banque-france.fr/sites/default/files/medias/documents/financial-stability-review-09\\_2006-12.pdf](https://publications.banque-france.fr/sites/default/files/medias/documents/financial-stability-review-09_2006-12.pdf) [accessed 4 August 2023].

NAKAMOTO, Satoshi, 2008. Bitcoin: A Peer-to-Peer Electronic Cash System. [online]. Retrieved from : <http://bitcoin.org/bitcoin.pdf> [accessed 8 February 2023].

NARAYANAN, Arvind, BONNEAU, Joseph, FELTEN, Edward, MILLER, Andrew and GOLDFEDER, Steven, 2016. *Bitcoin and Cryptocurrency Technologies: A Comprehensive Introduction*. Princeton University Press. ISBN 0-691-17169-6.

OBERHOFER, George, 2001. Hedge funds – a new asset class or just a change in perspective? *Alternative Investment Management Association*. December Newsletter.

OZTURK, Serda Selin, 2020. Dynamic Connectedness between Bitcoin, Gold, and Crude Oil Volatilities and Returns. *Journal of Risk and Financial Management*. Vol. 13, no. 11, p. 275. DOI 10.3390/jrfm13110275.

RAM, Asheer, Jaywant, 2019. "Bitcoin as a new asset class". *Meditari Accountancy Research*. February 2019. Vol 27, no 1, pp.147-168. DOI: 10.1108/MEDAR-11-2017-0241.

Regulation (EU) 2023/1114 of the European Parliament and of the Council of 31 May 2023 on markets in crypto-assets, and amending Regulations (EU) No 1093/2010 and (EU) No 1095/2010 and Directives 2013/36/EU and (EU) 2019/1937 (Text with EEA relevance), OJ L 150, 2023 [online]. Retrieved from: <http://data.europa.eu/eli/reg/2023/1114/oj/eng> [accessed 13 July 2023].

SHARPE, William F., 1966. Mutual Fund Performance. *The Journal of Business*. Vol. 39, no. 1, pp. 119–138. DOI [10.2307/2328831](https://doi.org/10.2307/2328831)

SHIPWAY, Ian, 2009. Modern Portfolio Theory. *Trusts & Trustees*. Vol. 15, no. 2, pp. 66–71. DOI [10.1093/tandt/ttn129](https://doi.org/10.1093/tandt/ttn129).

SÖDERBERG, Gabriel, 2018. Are Bitcoin and other crypto-assets money? *Economic commentaries*, *Sveriges Riksbank*. March 2018. No 5, pp. 1. Retrieved from : <https://www.riksbank.se/globalassets/media/rapporter/ekonomiska-kommentarer/engelska/2018/are-bitcoin-and-other-crypto-assets-money.pdf> [accessed 13 July 2023].

SPDR S&P 500 ETF Trust (SPY) Stock Historical Prices & Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/SPY/history/> [accessed 19 August 2023].

Stellar USD (XLM-USD) Price History & Historical Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/XLM-USD/history/> [accessed 19 August 2023].

Tezos USD (XTZ-USD) Price History & Historical Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/XTZ-USD/> [accessed 19 August 2023].

TODOROV, Karamfil, 2021. Launch of the first US bitcoin ETF: mechanics, impact, and risks. *BIS Quarterly Review* [online]. Retrieved from: [https://www.bis.org/publ/qtrpdf/r\\_qt2112t.htm](https://www.bis.org/publ/qtrpdf/r_qt2112t.htm) [accessed 16 August 2023].

United States 3-Month Bond Historical Data, 2023Investing.com [online]. Retrieved from: <https://www.investing.com/rates-bonds/u.s.-3-month-bond-yield-historical-data> [accessed 31 July 2023].

WANG, Jinghua and NGENE, Geoffrey M., 2020. Does Bitcoin still own the dominant power? An intraday analysis. *International Review of Financial Analysis*. Vol. 71, pp. 1–12. DOI [10.1016/j.irfa.2020.101551](https://doi.org/10.1016/j.irfa.2020.101551).

WATOREK, Marcin, DROŹDŹ, Stanisław, KWAPIEŃ, Jarosław, MINATI, Ludovico, OŚWIECIMKA, Paweł and STANUSZEK Marek, 2021. Multiscale characteristics of the emerging global cryptocurrency market. *Physics Reports*. Vol. 901, pp. 1–82. DOI [10.1016/j.physrep.2020.10.005](https://doi.org/10.1016/j.physrep.2020.10.005).

XRP USD (XRP-USD) Price History & Historical Data - Yahoo Finance, no date [online]. Retrieved from: <https://finance.yahoo.com/quote/XRP-USD/history?p=XRP-USD> [accessed 19 August 2023].