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Can crypto assets be considered effective risk mitigation tools in alternative investment portfolio strategies?

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To my family and my brother Riccardo, the light that always has and always will illuminate my path.

Abstract

It can be argued that cryptocurrencies have always been seen just as extremely volatile financial instruments, whose regulation has been in a gray area for their whole existence. During the pandemic, many began to view cryptocurrencies as safe haven assets, to be relied upon when most markets were in decline. “The shocks experienced by stock and bond markets over time and especially during the COVID-19 pandemic has led to an evaluation of bitcoin as a wealth protection asset, a role that gold has played until now.” State Monika Chopra and Chhavi Mehta of the International Management Institute of New Delhi. After the pandemic, many have reconsidered, beginning to realise the correlation of these assets to stock markets.

Despite this important correlation and their qualities, cryptocurrencies remain in a regulatory grey area, which makes their inclusion in alternative asset classes difficult and their inclusion into alternative investment fund portfolios even harder.

This thesis therefore seeks to find the reasons why these instruments are not fully recognised as alternative assets, and analyses the benefits of including them within alternative portfolios.

This paper shows cryptocurrencies under a different light, exposing the opportunities of risk mitigation which could benefit Alternative Investment Funds if crypto were to be introduced in such portfolios.

The analysis, starting from the more technical blockchain features, will examine the regulatory framework of Alternative Investment funds, focusing on the european law represented by the AIMFD.

In the empirical and final chapter of the thesis, an experiment of such inclusion will demonstrate that it is possible to utilise crypto assets in order to mitigate the risk to which an alternative portfolio is exposed, thanks to diversification and maximization of portfolio efficiency. In particular, using a dataset of indices representative of the various alternative sectors and the cryptocurrency market, it will form and compare the efficient frontiers of a standard alternative portfolio (without cryptocurrencies in it) and an alternative portfolio that includes the BGCI, an index representative of the crypto sector, demonstrating that the frontier obtained with alternative assets and crypto together surprisingly reaches lower levels of volatility than the portfolio that does not include them.

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1. Introduction

Motivation

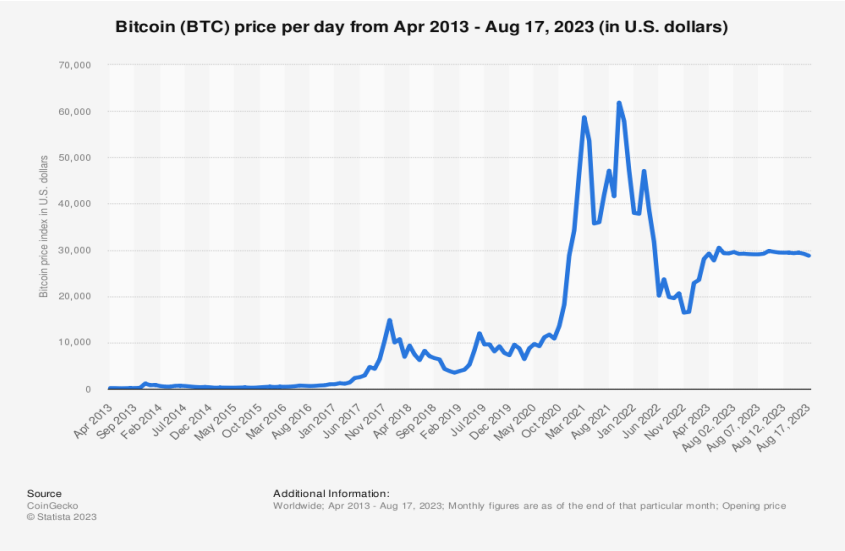
The Blockchain has had a huge impact on the financial markets, thanks to the birth of new assets such as cryptocurrencies and NFTs (Non Fungible Tokens).
However, the uniqueness of these new instruments makes them more dangerous not only from the point of view of volatility and reliability, but also from the point of view of regulation and risk management.
Over the years, these tools have always been the topic of many debates, starting from their high volatility up to topics of a more technical nature, for example the technology needed to administer them.
For example, in the world of blockchain, control and possession of assets are two concepts that are impossible to separate, as these tokens do not always represent a monetary value, but also a recognition trait of belonging or a certificate of control over a real asset.
This fact, especially for alternative investment funds, is problematic. In fact, investment funds are made up of various bodies, which can be managed internally or by outsourcing. Among these bodies, there is a body that must necessarily be independent from the control of the fund managers, the body that maintains possession of the investments. These entities are often banks or service providers, and are called depository banks.
The constraint of having to cede possession of the assets to a custodian bank could be a serious obstacle for blockchain assets, in addition to the lack of regulations and the need to maintain a low level of volatility.
This thesis aims to evaluate regulations exploring how this sector, despite being extremely well known, often lacks adequate rules. At the same time, the thesis will try to dispel the myth that motivates the absence of these assets from alternative investment

portfolios by arguing that they too raise the volatility threshold levels that investment managers must maintain.

Objectives and Questions

The objective of this thesis is to investigate the opportunities and threats of the inclusion of cryptocurrencies within alternative fund portfolios by investigating the risk management and portfolio optimization approaches that big players are adopting or think they might adopt in the not-so-distant future when all alternative investment funds will include these new securities in their investments. In order to accomplish such investigation, the thesis will try to answer to a number of questions.

The first point that is essential to evaluate when considering these assets as a means of diversifying and hedging "traditional" alternative positions is to see how these are correlated with the various relevant sectors. Initially bitcoin, to which the entire crypto market is extremely correlated, was considered as a security highly correlated to gold, despite the systematic fluctuations of the sector in fact, bitcoin had continued to grow more and more, reaching high peaks at times when traditional markets usually suffered large losses. During the first real period of global crisis that this sector has experienced once it has reached a certain degree of maturity, i.e. the expansion of the COVID-19 pandemic, all those who had believed in Bitcoin as an asset similar to gold thought they had the certain proof that Bitcoin as well was an asset that in times of extreme crisis and global stalemate moved in the opposite way, in fact it reached its highest peaks between 2020 and 2021 as can be seen in the following graph.

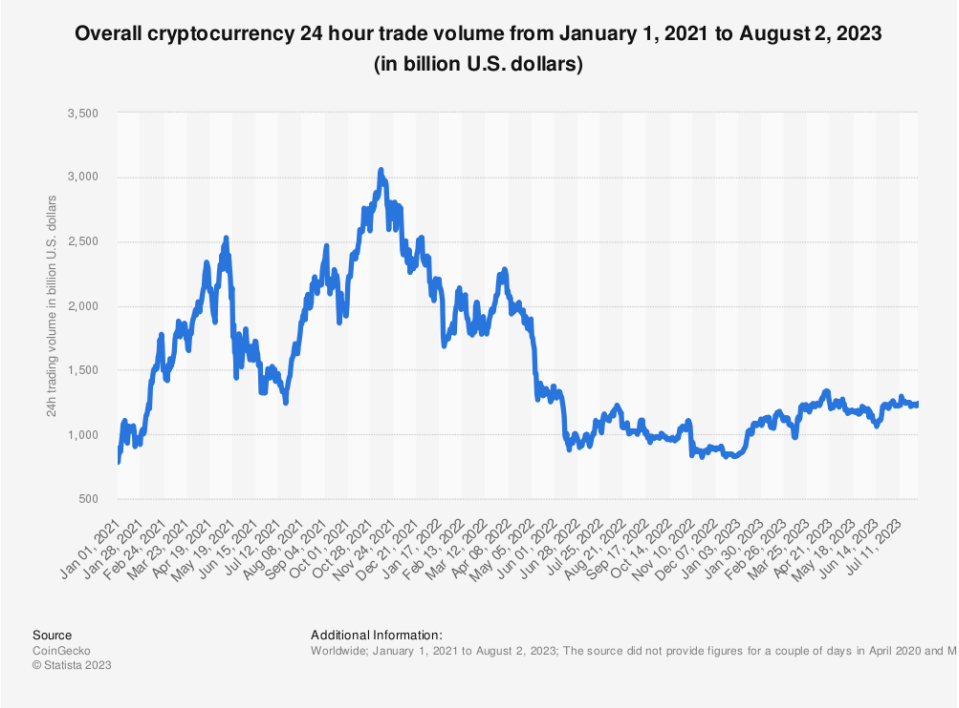


Graph 1 - Bitcoin All Time Highs

"Given the skyrocketing returns earned by bitcoin, it has received widespread attention as an investment asset. The shocks experienced by stock and bond markets over time and especially during the COVID-19 pandemic has led to an evaluation of bitcoin as a wealth protection asset, a role that gold has played until now." State Monika Chopra and Chhavi Mehta of the International Management Institute New Delhi, New Delhi, India. *Can Bitcoin and the other cryptocurrencies really be considered as a safe heaven asset after all?*

What is important to underline, however, is that despite the pandemic and quarantine period that most of the population has undergone, it has been a moment of economic difficulty for the lower-level classes, especially employees of private companies in difficulty with paying the salaries without being able to produce, the quarantine period for the upper classes was a period of "boredom" and the impossibility of catching entertainment and above all spending money. According to some currents of thought, it was precisely this that caused the volumes of transactions on the blockchain to rise exponentially, creating a flourishing period not only for cryptocurrencies, which saw an extreme ease in raising funds to launch new projects, but also for the digital art market which in that year achieved an impressive expansion, during that period in fact some of the largest sales of artworks in history took place, precisely through the blockchain, in

the form of NFTs, which stands for non fungible token, an innovative tool which, among many features, has the ability to be associated with an image, which is thus made immutable and recognizable as original.



Graph 2 - Crypto Market Transactions Volume

After this period of prosperity for the Blockchain sector, as we can see from the graph above, one of the most relevant moments to discuss the volatility of cryptocurrencies is certainly the crash of 2022, caused by various scandals such as the collapse of the Terra-Luna system and later of the FTX exchange, added to the beginning of the conflict between Russia and Ukraine, a period in which it was increasingly discovered that this sector also had an important correlation with the high-tech markets and, in general, with the more traditional securities market.

Clearly, a distinction should be made between the extraordinary risks of the sector itself, such as infrastructure failures which, although they may have caused a market crash, were determined by accidental circumstances, such as the collapse of the Terra-Luna system, from the systematic risks common to all markets such as the rising inflation, the result of the macroeconomic period we are living in, the post pandemic recovery and the

conflict. Being aware of their volatility, *can crypto assets be considered effective risk mitigation tools in alternative investment portfolio strategies? Is it the extreme volatility of cryptocurrencies that discourages managers of many alternative investment funds from including them in their portfolios?*

Outline of the thesis

The thesis will start by describing the main technologies and methodologies which will be fundamental in order to understand in full the arguments it is going to tackle, starting with a brief introduction to the blockchain technology and its assets and analyzing more in depth cryptocurrencies and NFTs which are the relevant assets that could be considered as relevant targets for alternative investment funds.

Once determined how these assets work and how could they be managed, the next step will be to understand the regulatory side of those assets as it could be fundamental to assess which kind of fund could actually consider them as a target for their portfolio. After the overview on blockchain assets and technologies, the next step is to address some fundamental portfolio theory, notions important to then be able to develop the analysis of which this thesis is all about.

Now that the basic arguments have been covered, we will test empirically the benefits of diversifying an alternative asset portfolio through the introduction of blockchain assets, specifically, using index representing the fluctuations of the many alternative sectors and the BGCI, an index provided by Bloomberg which represents the top 10 performing cryptocurrencies, updated monthly in order to track the overall results of the crypto market.

In the end, the thesis will draw the conclusions to assess if and in which case, the introduction of these new assets into alternative portfolios should be considered, by answering the questions mentioned in the previous subchapter: *Can Bitcoin and the other cryptocurrencies really be considered as a safe heaven asset after all? Can crypto*

assets be considered effective risk mitigation tools in alternative investment portfolio strategies? Is it the extreme volatility of cryptocurrencies that discourages managers of many alternative investment funds from including them in their portfolios?

2. Overview of Blockchain and its relevant assets

Overview of the blockchain technology

Blockchain technology is a registration and sharing data system based on a distributed and immutable ledger. In short, it is a data structure which writes information in blocks cryptographically linked among them in a growing chain.
Each block contains a series of transactions or datas, together with a code called “hash” which identifies the preceding block. This link grants the integrity of the chain, so that any alteration of any block would require the alteration of all the following blocks, making it systematically impossible to tamper the chain without being detected.

The much-acclaimed security of the blockchain is due to a number of features which can be summarized by the following list:

- Decentralization: The blockchain is distributed among several nodes or participants instead of being controlled by a central authority. This makes it harder for an attacker to tamper with it as each node owns a copy of the ledger, so whether a node were to be compromised, the other copies of all past transaction would not be targeted.

- Cryptography: Data of a blockchain are encrypted and linked together through advanced algorithms, this makes it impossible for hackers to manipulate or even read the data without owning the appropriate key.

- Distributed control: In order for new blocks to be added to the chain, participants need to reach a consensum. This can happen through different ways, the two most relevant are the Proof of Work (PoW) and the Proof of Stake (PoS). In both cases, it is required a high computational power or a high quantity of token in order to validate the transactions, this makes it very complex for an attacker to takeover.

- Immutability: Once a block has been added to the blockchain, it is extremely difficult to change it. Since each block is hashed to the previous block, any change would require recalculating the hashes of all subsequent blocks. This mechanism makes the blockchain resistant to attempts to manipulate historical data.

- Transparency: Because all transactions are recorded in the blockchain and are accessible to all network participants, blockchain technology offers a high degree of transparency. This makes it more difficult to conceal fraudulent activity.

Introduction to Cryptocurrencies

Cryptocurrencies are forms of digital money based on cryptographic technology, enabling peer-to-peer financial transactions through a decentralized network. These virtual currencies are created and managed through complex cryptographic algorithms, ensuring the security and authenticity of transactions.

A key feature of cryptocurrencies is their decentralization. Unlike traditional currencies issued by central institutions, cryptocurrencies are not controlled by a single entity. Instead, transactions are verified and recorded through a technology called blockchain.

An example of a well-known cryptocurrency is Bitcoin, created in 2009 by an individual or group under the pseudonym Satoshi Nakamoto. Bitcoin pioneered

cryptocurrencies and is considered the pioneer of the industry. In addition to Bitcoin, there are many other cryptocurrencies, each with its own specific characteristics and purposes. Some of these cryptocurrencies seek to improve transaction scalability (like Litecoin), others focus on privacy (like Monero) or smart contract platform (like Ethereum).

Cryptocurrencies have been adopted across various industries, including online commerce, investing, international money transfers, and even the emerging world of non-fungible tokens (NFTs). However, cryptocurrencies are not without challenges. Price volatility, uncertain regulation, and concerns about the security of trading platforms are just some of the issues faced by this ever-changing industry.

Introduction to NFTs

Non-fungible tokens (NFTs) are a unique form of digital asset based on blockchain technology. Unlike traditional cryptocurrencies, which are interchangeable with other units of equal value, each NFT is unique and cannot be substituted for one another on a basis of equal value. This makes them ideal for representing one-of-a-kind digital items such as digital artwork, video, music, virtual collectibles, and more.

NFTs leverage blockchain technology to ensure the authenticity, ownership and traceability of these digital assets. Each NFT is associated with a smart contract on the blockchain, which contains specific information about the object represented. This smart contract establishes who owns the NFT, allows its authenticity to be verified, and records the history of past transactions. In essence, an NFT functions as a "digital certificate of ownership" for its corresponding digital object.

The popularity of NFTs has increased dramatically in recent years, attracting the attention of artists, digital creators, collectors and investors. Digital artworks sold as NFTs fetched sizable numbers at some auctions, sparking discussions about valuation

and market sustainability. Additionally, NFTs have been used in industries such as video games, where they can represent unique or unlockable in-game items.

However, the NFT market has also raised questions about environmental sustainability, as many blockchains used to create NFTs require a significant amount of energy. Understanding the property rights associated with NFTs and the legal implications in different countries is another important aspect to consider in this rapidly evolving field.

Impact of cryptocurrencies on financial markets

Cryptocurrencies have had a major impact on the financial markets, bringing with them new opportunities and challenges. These digital assets have ushered in a wave of change, prompting many to explore new ways to invest and diversify their portfolios. Their growth has generated significant interest, both from traditional investors and those seeking alternatives to traditional currencies.

Cryptocurrencies have also raised questions about regulation as financial authorities seek to understand how best to adapt existing regulations to this new financial reality. The price volatility of cryptocurrencies has been in the spotlight, with some seeing in the opportunity to profit from price fluctuations, while others are concerned about the risk it entails.

The technological innovations that are emerging thanks to cryptocurrencies, such as blockchain technology, have the potential to transform entire industries beyond the financial markets. For example, blockchain could revolutionize the management of supply chains, improve transparency in transactions and enable new decentralized business models.

This impact can be broken down into several key areas:

Financial Innovation: Cryptocurrencies have spurred innovation within the financial sector. Concepts like decentralized finance (DeFi) have caught on, offering traditional financial services based on blockchain technology.

Investment Diversification: Cryptocurrencies have offered investors a new way to diversify their portfolios. Traditional financial assets such as stocks and bonds often don't follow the same trend as cryptocurrencies, potentially allowing for greater risk management through diversification.

Global Accessibility: Cryptocurrencies have made financial participation possible for people who do not have access to traditional banking services. This is particularly relevant for financial inclusion in regions with limited banking infrastructure.

Disintermediation: Cryptocurrencies can reduce the need for intermediaries in financial transactions. Peer-to-peer transactions are possible without involving banks or payment processors, potentially generating cost savings and greater efficiency.

Volatility: Cryptocurrencies are known for their high price volatility. This volatility can offer trading opportunities, but it also introduces risks for investors, especially those accustomed to more stable traditional assets.

Regulatory Challenges: The emergence of cryptocurrencies has prompted regulatory responses around the world. Governments and financial regulators are figuring out how to regulate this new asset class, which has both benefits and risks.

Institutional Adoption: More and more traditional financial institutions are turning to cryptocurrencies. Institutional investors, such as hedge funds and asset management firms, are exploring cryptocurrency-related investments and services, potentially further legitimizing this asset class.

Integration with Traditional Markets: Cryptocurrencies are becoming increasingly integrated with traditional financial markets. For example, some cryptocurrency trading platforms offer futures and options contracts, allowing investors to speculate on price movement.

Currency Alternatives: While not yet widely accepted as a form of payment, some cryptocurrencies are being considered as possible alternatives to traditional fiat currencies, especially in regions with unstable economies or hyperinflation.

Technological Development: The rise of cryptocurrencies has spurred the research and development of blockchain technology, which has applications beyond the financial sector, such as supply chain management, healthcare and more.

Now that all the technical notions have been covered, the following step of the thesis is an experiment.

The aim of the thesis is to find out whether crypto assets could be considered as risk mitigation tools for alternative asset portfolios, which are typical for alternative investment funds.

Regulations aside, another big barrier that investment managers consider when dealing with the proposal to introduce cryptocurrencies into alternative portfolios is their extreme volatility.

The following experiment aims to assess whether a portfolio which contains such assets could still perform with lower/equal riskiness to standard alternative portfolios.

3. Some regulatory notions

Cryptocurrencies regulations in Europe

The regulatory framework for cryptocurrencies in Europe is a complex and evolving landscape across multiple jurisdictions within the EU. Steps have been taken by the EU to create a harmonized approach to crypto regulation, although individual member states may still have their own specific regulations and interpretations. Here are some key points about the regulatory framework for cryptocurrencies in Europe:

EU introduced AMLD5, making it necessary for cryptocurrency exchanges and wallet providers to perform customer due diligence (KYC) as well as report suspicious transactions. Member states are expected to implement these regulations into their national laws.

The Markets in Crypto Assets (MiCA) regulation has been proposed by the EU to create a comprehensive regulatory framework for cryptocurrencies and stablecoins. Adopted, it would create standard regulations for digital asset management, trading, and administration.

Complying with European Union (EU) rules in a single nation enables crypto service providers to work legally across all members states of the ecomonic and political union, as mandated by MiCA.

In addition to EU regulations, some individual member states may have their own regulations for dealing with cryptocurrencies. Countries like Malta and Estonia have taken a proactive approach to creating positive regulatory conditions for the cryptocurrency sector.

EU countries have different tax regulations on cryptocurrencies. In different countries, crypto gains can be treated as either capital gain or income. The EU has put forward rules to standardize taxation on cryptocurrencies.

Consumer protection is a key issue that matters. To investors of cryptocurrencies, the EU has cautioned them about risks and advised to exercise care.

Some European Union member states have launched innovative zones (regulatory sandboxes) allowing their supervision of cryptocurrency business activities while driving development with a focus on compliance management.
Crypto businesses must follow AML and CFT regulations. Customers must be identified and suspect behavior reported under these regulations.
Europen Union examines the need to create rules for security tokens tied to tangible assets. Existing securities regulations might apply to these tokens.
Stablecoins are also under scrutiny. Stablecoin issuing entities could soon face regulatory measures, especially regarding their reserve assets, from the EU for more secure transactions while protecting customers.
The European Union is interested in promoting the use of blockchain technology for various purposes beyond cryptocurrencies, such as supply chain management, identity verification, and administrative processes.
To establish global standards for cryptocurrencies and reduce related risks, the EU collaborates with international organizations and other countries.
The regulatory landscape for cryptocurrencies in Europe is constantly evolving. The EU is working on creating a unified framework to address crypto challenges and opportunities, ensuring consumer protection and financial stability. Cryptocurrency stakeholders must be aware of changing regulatory environment at both EU and individual member state levels because national approaches differ, causing a fluctuating market condition.

Alternative Investments Funds Regulations

Alternative asset investment funds have different regulatory frameworks depending on the area they operate in and the particular kind of fund. Regulatory bodies like the U.S. Securities and Exchange Commission (SEC) or the European Securities and Markets Authority (ESMA) establish guidelines which funds must abide by to create rules. Absence of clear regulations and inconsistency in classifying cryptocurrency as an investment asset pose a problem for alternative funds exploring this option. The

regulatory bodies might lack clear guidelines on how to attribute value, report, and account for such assets under traditional fund rules.

Both the extreme price volatility and speculative nature of cryptocurrencies are properties that have been discussed extensively. Funds for investing are obliged to manage risks and safeguard the interests of their clients. The high volatility and uncertainty surrounding cryptocurrencies can make it difficult to meet these requirements.

Investment funds, including alternative asset ones, usually have a custodian bank responsible for safekeeping of fund assets. Traditional custodians, experienced with conventional securities and assets, may lack the infrastructure and expertise for cryptocurrencies.

When it comes to cryptocurrencies, AML and KYC can present compliance challenges. Due diligence on the source of funds and transactions is a key factor when it comes to regulatory authorities. The pseudonymous nature of cryptocurrencies can make ensuring compliance with regulations more challenging.

Limited liquidity in some cryptocurrencies could make it hard to meet investor redemption requests. Holding illiquid assets can complicate the redemption process for investors in alternative investment funds.

Cryptocurrency taxation can be complicated and vary in different areas. Crypto holdings can present challenges for funds in accurately reporting and managing tax liabilities.

Cryptocurrency markets are vulnerable to manipulation and fraud. Market integrity issues worry regulators, which may cause funds to hesitate in investing in these securities.

4. The research of a more efficient portfolio

Introduction to Portfolio Models

Portfolio management is a critical discipline in the world of finance and investment, playing a pivotal role in helping individuals, organizations, and institutions make informed decisions about how to allocate their financial resources. Portfolio models are essential tools used by financial analysts, investors, and fund managers to optimize investment strategies, balance risk and return, and ultimately achieve their financial goals. At its core, a portfolio model is a mathematical and statistical framework that enables investors to systematically construct and manage a collection of financial assets, such as stocks, bonds, real estate, or other investment instruments. These models are designed to assist in the decision-making process by providing insights into the allocation of resources among various assets, with the primary objective of maximizing returns while managing risk.

This chapter lays the foundation for the analysis presented in this thesis, which aims to compare two efficient frontiers within a set of portfolios. To comprehend the intricacies of this exercise, a comprehensive understanding of essential financial theories and concepts is crucial. This chapter is organized into three main sections:

Modern Portfolio Theory (MPT): This section provides an overview of the seminal work of Harry Markowitz and the development of Modern Portfolio Theory, which serves as the theoretical framework for portfolio optimization.

Efficient Frontier: In this section, we delve into the concept of the efficient frontier, which plays a pivotal role in portfolio analysis. It defines the boundary of achievable risk-return trade-offs for portfolios and serves as the basis for comparing different portfolio strategies.

Capital Market Theory: This section introduces the Capital Market Line (CML) and the Security Market Line (SML), two crucial concepts derived from Capital Market Theory. These lines help investors evaluate the risk and return of portfolios in the context of the broader financial market.

Modern Portfolio Theory (MPT)

Modern Portfolio Theory (MPT), developed by Harry Markowitz in the 1950s, revolutionized the field of finance by introducing a systematic approach to portfolio construction. MPT posits that investors are primarily concerned with two factors: expected return and risk. Key components of MPT include:

Expected Return: This represents the anticipated profit from an investment. In MPT, expected return is calculated by considering historical returns, future expectations, and asset weights within a portfolio.

Risk: MPT measures risk as the variability or volatility of an asset's returns. It quantifies risk using variance or standard deviation, emphasizing the importance of diversification to reduce overall portfolio risk.

Correlation: MPT recognizes that the correlation or covariance between assets affects portfolio risk. Assets with low or negative correlations can provide diversification benefits, reducing overall risk.

Efficient Frontier: MPT introduces the concept of the efficient frontier, which plots portfolios on a risk-return graph. The efficient frontier represents the set of portfolios that offer the highest expected return for a given level of risk or the lowest risk for a given level of return.

Efficient Frontier

The Efficient Frontier is a fundamental concept in portfolio theory. It illustrates the trade-off between risk and return in portfolio construction. Key aspects include:

Risk-Return Trade-off: Portfolios lying on the efficient frontier showcase the optimal risk-return trade-off. Investors can choose portfolios that match their risk tolerance, knowing they are achieving the highest return for that level of risk.

Diversification: Efficient portfolios are created through diversification, spreading investments across a mix of assets. Diversification reduces unsystematic risk (specific to individual assets) while retaining the potential for higher returns.

Portfolio Optimization: Efficient frontier analysis involves mathematical optimization techniques, such as the Mean-Variance Optimization, to determine the weights of each asset in the portfolio. These weights aim to maximize expected return for a given level of risk or minimize risk for a given level of return.

Capital Market Theory

Capital Market Theory extends MPT by incorporating the broader financial market. It introduces two key concepts:

Capital Market Line (CML): The CML combines the risk-free rate with the efficient frontier. It represents the optimal portfolios achievable by combining a risk-free asset with a risky portfolio. The CML helps investors understand the trade-off between risk and return in the context of a risk-free asset.

Security Market Line (SML): The SML is a graphical representation of the Capital Asset Pricing Model (CAPM). It shows the expected return for an asset or portfolio based on its systematic risk (beta) and the expected return of the overall market. The

SML assists investors in evaluating whether an asset or portfolio offers an appropriate risk-adjusted return.

In conclusion, these theories form the backbone of portfolio optimization, enabling investors to make informed decisions about portfolio construction and risk-return trade-offs. The next chapter will delve into the experiment needed to answer the question *"Can crypto assets be considered effective risk mitigation tools in alternative investment portfolio strategies?"*
The experiment will compare the two efficient frontiers formed by a set of portfolios of alternative assets with another set of portfolios containing the same securities plus the BGCI index, representing the cryptocurrency market.

Methodology

In this sub-chapter, we outline the methodology employed to conduct the analysis in this thesis while explaining the importance and the results of our test. We will systematically explain the steps followed to complete the exercise, which involves creating the variance-covariance matrix, constructing envelope portfolios, and ultimately deriving the efficient frontiers of the two sets of assets and comparing the results. The process comprises the following key stages:

Identifying Alternative Assets Sectors and Indexes:

Due to the large variety of assets that could be used to analyze various sector trends in the alternative assets market, we will use one index to represent each individual sector.

The representative index that will be used for the analysis of the Blockchain assets is:

- The BGCI Index (Bloomberg Galaxy Crypto Index):

In order to analyze the behavior of cryptocurrencies, as stated above, it is important to understand how much the specific risk of each different blockchain and infrastructure can have an impact on their price fluctuations.
Therefore, to analyze the crypto market while avoiding running into data distorted by the specific risk of a single cryptocurrency that peaked and failed shortly thereafter, we will not use a particular cryptocurrency, but rather take advantage of the BCGI index, which is a benchmark designed to measure the performance of the largest cryptocurrencies traded in USD.
The composition of the index is built as follows: Cryptocurrency weightings are based on market capitalization (calculated as product of circulating supply and price), subject to weighting restrictions applied monthly such that no cryptocurrency constitutes more than 35% of the Index or constitutes less than 1%. Between rebalancings, weights may fluctuate to levels outside these limits.
The Index methodology systematically determines whether a cryptocurrency is eligible for inclusion in the Index based on the following criteria:

1. Trades in USD
2. Not deemed a security by the US Security Exchange Commission
3. Priced by Digital Asset Research, from minimum two vetted sources
4. Universe: top 25 assets by market cap
5. 3 month inclusion buffer in and out. Accelerated exclusion when falling out of top 30
6. Expert judgment when DAR pricing no longer available
7. Hard forks1 considered using the same criteria as any established cryptocurrency
8. 12 largest eligible assets by market capitalization selected (35%/1% cap/floor scheme)
9. Ability to custody and trade the assets, as determined by Galaxy Digital (Member of the partnership which created the index, Bloomberg and Galaxy Digital)
10. Underlying price by DAR, or by Bloomberg approved sources

Name	Index Name	Ticker
BGCI	Bloomberg Galaxy Crypto Index	BGCI
BTC	Bloomberg Galaxy Bitcoin Index	BTC
ETH	Bloomberg Galaxy Ethereum Index	ETH
B500	Bloomberg US Large Cap Total Return Index	B500T
US Agg	Bloomberg US Agg Total Return Value Unhedged USD	LBUSTRUU
BCOM	Bloomberg Commodity Index Total Return	BCOMTR
Gold	Bloomberg Gold Subindex Total Return	BCOMGCTR
60/35/5	60% Bloomberg DM Large-Map Cap Index + 35% Global Agg Index + 5% Bloomberg Commodity Index	BMADM635

	BGCI	BTC	ETH	B500T	US Agg	BCOM	Gold	60/35/5
BGCI	1.00							
BTC	0.90	1.00						
ETH	0.94	0.73	1.00					
B500T	0.18	0.18	0.15	1.00				
US Agg	-0.08	-0.08	-0.07	-0.01	1.00			
BCOM	0.07	0.07	0.06	0.27	-0.14	1.00		
Gold	0.09	0.02	0.12	0.04	0.23	0.37	1.00	
60/35/5	0.19	0.19	0.17	0.92	0.04	0.42	0.21	1.00

Graph 3 - BGCI Multi Asset Correlation Matrix

The representative indexes that will be used for the analysis of the alternative assets are the following:

Real Estate - (FTSE EPRA/NAREIT United States (FTUNUS) (Real Estate Investment Trusts):

This index tracks the performance of Real Estate Investment Trusts (REITs), which are companies that own and manage income-generating real estate properties. The ticker includes various types of properties like commercial, residential, and industrial, providing insight into the overall REIT market's fluctuations.

Commodities - Bloomberg Commodity Spot Index (BCOMSP) (Broad Commodity Market):

The Bloomberg Commodity Index reflects the performance of a broad range of commodities, including metals, energy, agriculture, and more. It's a benchmark for

tracking changes in commodity prices, offering a glimpse into global resource market dynamics.

Private Equity - Private Equity (PRIVEXD):

This index measures the performance of private equity investments in the world. It provides insight into the returns generated by investing in privately held companies, helping assess the attractiveness of private equity as an asset class.

Infrastructure - Vanguard Global Infrastructure Index ETF (VBLD) (Global Infrastructure Companies):

This index represents the performance of companies involved in various infrastructure sectors, such as transportation, utilities, and energy. It offers insights into the financial health and growth of global infrastructure-related businesses.

The indexes mentioned above will be used to compare the performance of the alternative sector, against the same group of assets plus the index representing the crypto market. Our aim is to assess if it is possible to find a portfolio that includes Blockchain based assets into the alternative assets sector reaching equal or hopefully lower levels of risk.

Definition of the timeline

The rationale behind selecting the period spanning from January 1, 2020, to January 1, 2022, for our analysis lies in a multitude of significant factors and considerations that collectively contribute to the depth and relevance of our study.

This timeframe encapsulates a dynamic landscape characterized by a series of pivotal market events that reverberated across both the alternative investment market and the cryptocurrency sector. These events hold intrinsic value as they allow us to delve into

the nuanced responses exhibited by these markets in the face of extraordinary circumstances.

The outbreak of the COVID-19 pandemic in early 2020 stands as a defining moment, casting a long shadow of market volatility and economic uncertainty. This event alone renders this period an ideal backdrop for scrutinizing market behaviors in times of crisis.

Within this timeframe, Bitcoin, the foremost cryptocurrency, underwent its third halving event in May 2020. The historical significance of such halving events, typically associated with pronounced impacts on Bitcoin's price and market dynamics, accentuates the relevance of this period for study.

Moreover, the emergence and ascent of the DeFi (Decentralized Finance) sector within the cryptocurrency market during this timeframe draw our attention. DeFi experienced substantial growth and innovation, captivating the interest of investors seeking alternative investment avenues within the crypto space.

Crucially, our chosen period encompasses a rich tapestry of diverse market conditions. It spans from the initial stages of the pandemic-induced market crash to the subsequent recovery and, ultimately, a period marked by relative market stability. This diversity of market states lends depth to our analysis, enabling us to gain insights into how alternative investments and cryptocurrencies perform under varying circumstances.

Furthermore, the decision to work with relatively recent data offers a distinct advantage. It ensures that our analysis is grounded in current, up-to-date information, a paramount consideration when assessing rapidly evolving markets like cryptocurrencies.

While the period under examination covers a span of just over a year, it affords a sufficient temporal scope to discern and assess trends, patterns, and shifts in both the

alternative investment market and the crypto sector. This temporal breadth facilitates an evaluation of performance across different economic and market cycles.

It is noteworthy that this period coincided with heightened interest in both alternative investments and cryptocurrencies, attracting attention from retail and institutional investors alike. This confluence of investor interest adds a layer of complexity to our analysis, providing insights into investor sentiment and behavior during a period of amplified attention.

The availability and reliability of historical data pertaining to both alternative investments and cryptocurrencies throughout this period further bolster the robustness of our analysis. This wealth of data ensures that our study is firmly rooted in accurate and comprehensive information.

Ultimately, the decision to analyze both the alternative investment market and the crypto market within this specific timeframe is motivated by the rich opportunities it presents for meaningful comparisons. This approach enables us to assess their relative performance, identifying potential correlations or divergences in their behavior. The resulting analysis promises to yield valuable insights into these dynamic markets during a period of exceptional significance.

Definition of a good estimate for the risk-free rate

One of the most common approaches to find a good estimate for the risk-free rate is to use the yields of government bonds, typically those with minimal default risk. In the United States, for example, the yield on U.S. Treasury securities, such as Treasury bills, notes, or bonds, is often considered the risk-free rate. These bonds are generally regarded as risk-free because they are backed by the full faith and credit of the U.S. government.
Now, as we established our dataset timeline to be between the first of January 2020 and January first 2022, the choice we are left with is an array of estimates ranging from

1.50% and 0%. On the other hand, it is important to understand how would the experiment go if instead of the Treasury bills, we would choose another kind of security, meaning another whole array of choice. For these reasons, at the end of the chapter, we will perform a sensitivity analysis to determine whether this experiment would work as well with different values of our Rf.

Building the Dataset

The first step to obtain the performance of the various alternative sectors and the crypto sector and be able to measure them, identifying variance and returns necessary to plot the efficient frontier, is to find the data.
It may seem obvious, but finding the prices of different indices and making them comparable is not so immediate, it first requires having access to databases such as Bloomberg, then it is necessary to clean the data. Once all the data has been transferred to an Excel file, given that the prices of these indices are not all published with the same frequency, it is necessary to eliminate all superfluous data that does not allow comparable prices for each day. For example, the BGCI is an index whose price is updated every day, while much more commonly other indices are updated only for 5 or 6 days of the week. The reason why some sectors are not considered in this experiment in fact is also because the corresponding index data was difficult to retrieve or updated its price once a month or week, making such an analysis inconclusive.

In the illustration below we will show a small part of the prices of the securities used for the analysis.

BGCI	Commodities	Real Estate	Private Equity	Infrastructures
318,22	357,85	3184,80	1559,62	60,39
307,00	353,49	3196,10	1556,25	60,51
301,86	353,11	3189,30	1561,52	60,89
316,85	354,41	3211,60	1561,44	61,05
322,10	352,80	3247,90	1570,69	60,75
359,40	353,32	3236,90	1573,09	61,34
366,24	352,17	3266,80	1578,74	61,41
361,50	350,32	3299,50	1594,97	61,87
374,10	351,23	3304,40	1603,56	62,29
367,53	348,55	3337,70	1609,99	62,95
364,71	346,20	3310,10	1609,63	63,40
349,44	344,24	3337,60	1596,80	62,81
352,27	340,24	3327,30	1601,24	63,75
378,67	335,84	3315,40	1591,95	64,29
387,26	333,81	3310,20	1593,91	64,54
402,94	330,65	3307,90	1595,88	64,47
391,36	329,32	3270,30	1589,18	65,46

Picture 1 - Excel datasets

Constructing the Log Returns of the assets

Once we have obtained the prices and cleaned the data, to conduct this analysis what we need are the returns of the various assets, useful for obtaining average returns, standard deviation etc.

Infrastructures	Ln(Pt/Pt-1) BGCI	Ln(Pt/Pt-1) Commodities	Ln(Pt/Pt-1) Real Estate	Ln(Pt/Pt-1) Private Equity	Ln(Pt/Pt-1) Infrastructures
60,39					
60,51	-0,0359	-0,0123	0,0035	-0,0022	0,0020
60,89	-0,0169	-0,0011	-0,0021	0,0034	0,0063
61,05	0,0485	0,0037	0,0070	-0,0001	0,0026
60,75	0,0164	-0,0046	0,0112	0,0059	-0,0049
61,34	0,1096	0,0015	-0,0034	0,0015	0,0097
61,41	0,0189	-0,0033	0,0092	0,0036	0,0011
61,87	-0,0130	-0,0053	0,0100	0,0102	0,0075
62,29	0,0343	0,0026	0,0015	0,0054	0,0068
62,95	-0,0177	-0,0077	0,0100	0,0040	0,0105
63,40	-0,0077	-0,0068	-0,0083	-0,0002	0,0071
62,81	-0,0428	-0,0057	0,0083	-0,0080	-0,0093
63,75	0,0081	-0,0117	-0,0031	0,0028	0,0149
64,29	0,0723	-0,0130	-0,0036	-0,0058	0,0084
64,54	0,0224	-0,0061	-0,0016	0,0012	0,0039
64,47	0,0397	-0,0095	-0,0007	0,0012	-0,0011
65,46	-0,0292	-0,0040	-0,0114	-0,0042	0,0152

Picture 2 - Excel datasets 2

To calculate the returns we use the log returns, which are the most suitable for the analysis we need to accomplish as they have the advantage of being additive over time. When you sum the log returns of multiple time periods, you get the total log return for the entire period. This property simplifies the analysis of asset returns over longer time horizons, making it easier to calculate and interpret cumulative returns.
Also, log returns are symmetric around zero, meaning that positive and negative returns have the same absolute value when expressed in log returns. This property can be beneficial when dealing with assets that have both positive and negative returns, as it treats gains and losses equally.

Calculating Simple Measures on our Data

Now we are calculating simple measures such as mean, standard deviation, the minimum and the maximum of our log returns.

	Ln(Pt/Pt-1) BGCI	Ln(Pt/Pt-1) Commodities	Ln(Pt/Pt-1) Real Estate	Ln(Pt/Pt-1) Private Equity	Ln(Pt/Pt-1) Infrastructures
Mean	0,0043	0,0007	0,0004	0,0010	0,0001
Standard Deviation	0,0506	0,0103	0,0221	0,0171	0,0118
Minimum	-0,2961	-0,0427	-0,2167	-0,1385	-0,0752
Maximum	0,1983	0,0323	0,0855	0,1193	0,0723
N. Observation	492	492	492	492	492

Picture 3 - Variance-covariance Matrix

Now that we have all we need to start building the frontiers on which we will be performing our analysis, we can proceed to building our matrices.

Variance-Covariance Matrix and Mean Returns

To begin our analysis, we construct the variance-covariance matrix for a portfolio consisting of our four distinct asset classes: Commodities, Real Estate, Private Equity, and Infrastructures, using the indexes mentioned in the paragraph *"Identifying Alternative Assets Sectors and Indexes".* Additionally, we compute the vector of mean returns for these assets as we can see in the illustration below.

	Commodities	Real Estate	Private Equity	Infrastructures			
	CALCULATING THE FRONTIER						
	Variance-Covariance, S					Mean Returns E(R)	E(R) minus Constant c
commodities	0,0001	8,7E-05	8,24086E-05	5,0276E-06		0,069%	-0,881101%
real estate	8,7E-05	0,0005	0,000267291	6,14575E-06		0,041%	-0,909011%
private equity	8,24086E-05	0,00026729	0,0003	4,89515E-05		0,100%	-0,849755%
infrastructures	5,0276E-06	6,1464E-06	4,89515E-05	0,0001		0,012%	-0,937755%
	Constant, c	0,950%					

Picture 4 - Variance-covariance Matrix

The variance-covariance matrix is essential for understanding the relationships between asset returns and their respective volatilities, thereby enabling us to quantify portfolio risk effectively. The mean returns vector represents the expected returns for each asset.

Calculation of Envelope Portfolios

To construct the efficient frontier, we calculate two envelope portfolios: one with a constant of zero to make our calculations easier and the other with the chosen constant of 0.95. These envelope portfolios play a pivotal role in determining the feasible set of portfolios that can be achieved by combining risky assets with a risk-free asset.

computing an envelope portfolio with constant = 0

z		Envelope por. x
5,187389655		0,816488398
-2,41616739		-0,38030161
4,285862416		0,674589181
-0,70379213		-0,11077597
	Sum	1

computing an envelope portfolio with constant = 0,950%

z		Envelope por. y
-83,2936079		0,563423826
-12,4421921		0,08416285
17,39272819		-0,11764981
-69,491656		0,470063138
	Sum	1

Picture 5 - Calculating Envelope Portfolios

Each row of the vectors x and y represent the weight of the corresponding asset inside the portfolio. The weights will be varying from the ones we can see as of now, thanks to some variables that will be introduced in the following steps during the construction of the frontiers.

Having two envelope portfolios is sufficient as they provide the key anchor points on the efficient frontier.

Basic Calculations for Envelope Portfolios

In this subsection, we conduct essential calculations for the two envelope portfolios, denoted as "x" and "y." These calculations encompass computing their respective means, standard deviations, and covariances. These metrics are crucial in evaluating the risk and return characteristics of the portfolios.

computing an envelope portfolio with constant = 0

z		Envelope por. x
5,187389655		0,816488398
-2,41616739		-0,38030161
4,285862416		0,674589181
-0,70379213		-0,11077597
	Sum	1

computing an envelope portfolio with constant = 0,950%

z		Envelope por. y
-83,2936079		0,563423826
-12,4421921		0,08416285
17,39272819		-0,11764981
-69,491656		0,470063138
	Sum	1

E(x)	0,11%	E(y)	0,04%
Var(x)	0,00016831	Var(y)	6,18102E-05
Sigma(x)	1,3%	Sigma(y)	0,7862%
Cov(x,y)	5,7028E-05		
Corr(x,y)	0,55910485		

Picture 6 - Calculating Relevant Measures

Calculating the Entire Envelope of the Feasible Set

Utilizing the convex combinations of the two envelope portfolios (x and y), we determine the entire envelope of the feasible set. By varying the weights assigned to these portfolios, we are able to calculate a continuum of portfolios. This complete set encompasses the efficient frontier.

Visualization of the Efficient Frontier

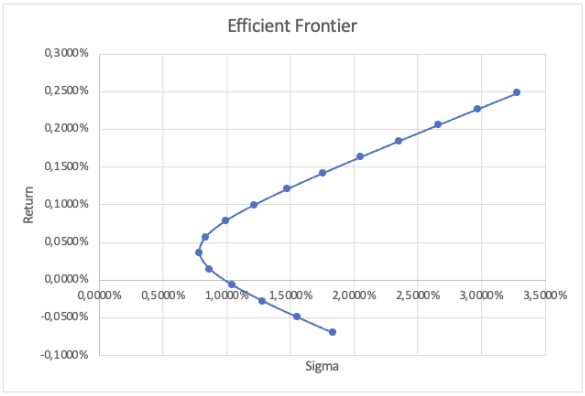
To facilitate a comprehensive understanding of the efficient frontier, we employ the data table functions of Excel. These functions enable us to generate a number of results which are important to build a graphical representation of the frontier by varying the variable assigned to control the weights of the two portfolios. The resulting graph provides a visual depiction of the risk-return trade-offs available to investors and serves

as a valuable tool for portfolio decision-making. For us, this is very important because it allows us to see the minimum volatility (sigma, on the x-axis). The more to the left the curve arrives on the graph, the lower the levels of volatility the set of assets mixed together can achieve.

A single portfolio calculation	
proportion of x	0,3
E(rp)	0,06%
σp2	6,9387E-05
σp	0,83%

Data table: We vary the proportion of x to produce a graph of the frontier

Proportion of x	Sigma	Return
	0,8330%	0,0574%
-1,5	1,8366%	-0,0698%
-1,2	1,5506%	-0,0486%
-0,9	1,2823%	-0,0274%
-0,6	1,0456%	-0,0062%
-0,3	0,8668%	0,0150%
0	0,7862%	0,0362%
0,3	0,8330%	0,0574%
0,6	0,9892%	0,0787%
0,9	1,2133%	0,0999%
1,2	1,4747%	0,1211%
1,5	1,7568%	0,1423%
1,8	2,0510%	0,1635%
2,1	2,3529%	0,1847%
2,4	2,6597%	0,2059%
2,7	2,9701%	0,2271%
3	3,2829%	0,2483%



Picture 7 - Plotting the Efficient Frontier

The results obtained through these steps allowed us to construct the efficient frontier that you can see above. As you can see in Image 1 of this chapter, the curve was constructed using only the standard indexes of the alternative sector, commodities, real estate, private equity and infrastructures. The question that is important to ask now is what the curve we can see now would look like if within these sectors we included the BCGI index, which as we defined earlier, represents the cryptocurrency market.
To do this, it will be necessary to complicate our calculations slightly by going to create a variance-covariance matrix with 5 variables instead of 4. In the following image you can see what we get if we go to follow the same steps for the portfolio also containing the cryptocurrency index.

Replicating the process for the new mix of sectors

	Commodities	Real Estate	Private Equity	Infrastructures	BGCI		
CALCULATING THE FRONTIER							
	Variance-Covariance, S					Mean Returns	E(R) minus Constant c
commodities	0,0001	8,7E-05	8,24086E-05	5,0276E-06	0,000150315	0,069%	-0,881101%
real estate	8,7E-05	0,0005	0,000267291	6,14575E-06	0,00025283	0,041%	-0,909011%
private equity	8,24086E-05	0,000267291	0,0003	0,000049	0,000268194	0,100%	-0,849755%
infrastructures	5,0276E-06	6,14636E-06	4,89515E-05	0,0001	0,0001	0,012%	-0,937755%
BGCI	0,000150315	0,00025283	0,000268194	5,03563E-05	0,002557945	0,432%	-0,518168%
	Constant, c	0,950%					

Picture 8 - Variance-covariance Matrix

Once again, we calculate two envelope portfolios: one with a constant of zero to make our calculations easier and the other with the chosen constant of 0.95.

computing an envelope portfolio with constant = 0

z		Envelope por. x
3,948002624		0,723310553
-2,424448766		-0,444181412
3,426631344		0,627790518
-0,845146419		-0,154838632
1,353201258		0,247918972
	Sum	1

computing an envelope portfolio with constant = 0,950%

z		Envelope por. y
-87,09861089		0,578410857
-12,46761644		0,082795864
14,75483		-0,09798496
-69,92562331		0,464367219
4,154420459		-0,027588981
	Sum	1

Picture 9 - Calculating Envelope Portfolios

Now as before, we replicate essential calculations for the two envelope portfolios, denoted as "x" and "y". This time the results will include the risk and returns of the Crypto market as well.

E(x)	0,20%	E(y)	0,03%
Var(x)	0,000365916	Var(y)	6,12823E-05
Sigma(x)	1,9%	Sigma(y)	0,7828%
Cov(x,y)	4,98248E-05		
Corr(x,y)	0,332726308		

Picture 10 - Relevant Measures

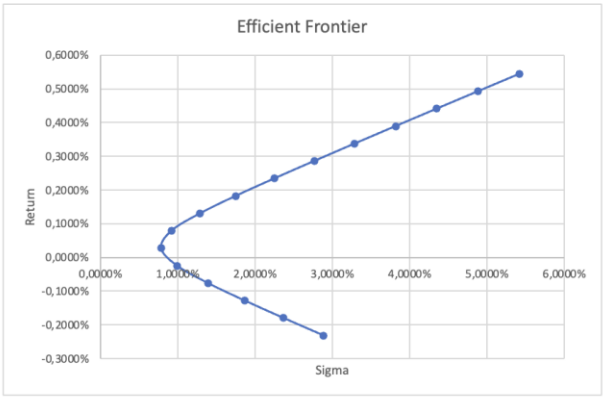
The result we obtain now will be (together with the previous curve) the subject of our study to consider how the addition of the BCGI index within the portfolio can change the performance of an investment, always remembering that what is important for us to demonstrate is that there is the possibility of creating alternative investment portfolios containing cryptocurrencies that perform similarly (risk-wise) to common alternative portfolios.

A single portfolio calculation

proportion of x	0,3
E(rp)	0,08%
σp2	8,38872E-05
σp	0,92%

Data table: We vary the proportion of x to produce a graph of the frontier

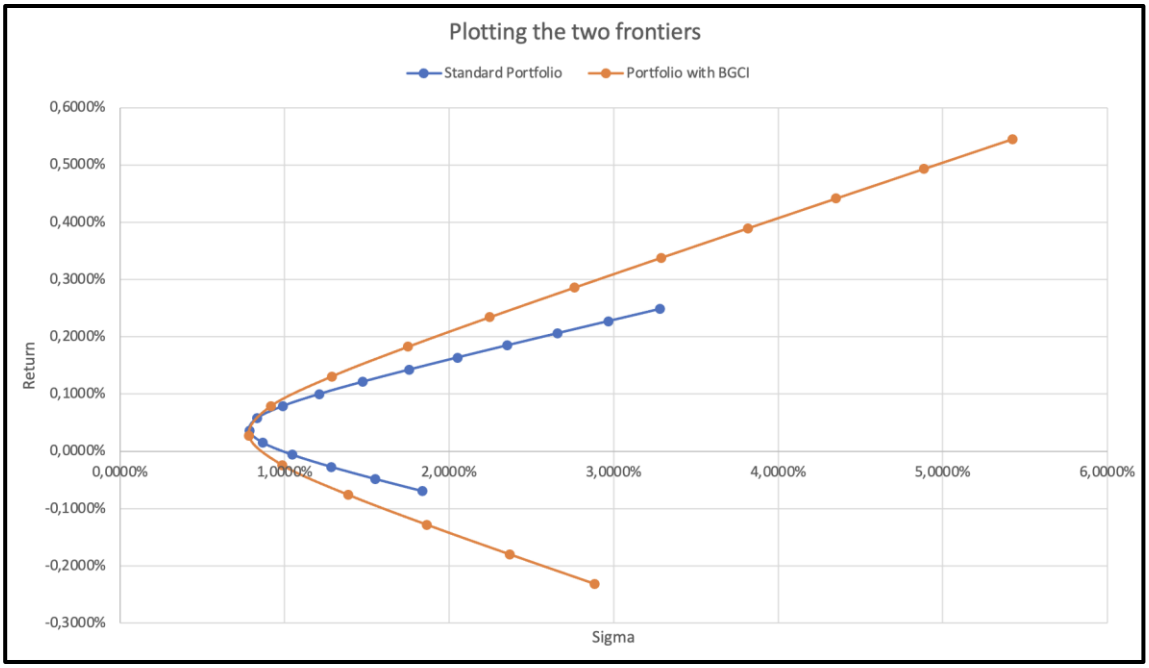
Proportion of x	Sigma	Return
	0,9159%	0,0790%
-1,5	2,8855%	-0,2316%
-1,2	2,3674%	-0,1798%
-0,9	1,8634%	-0,1281%
-0,6	1,3891%	-0,0763%
-0,3	0,9881%	-0,0246%
0	0,7828%	0,0272%
0,3	0,9159%	0,0790%
0,6	1,2863%	0,1307%
0,9	1,7492%	0,1825%
1,2	2,2482%	0,2342%
1,5	2,7639%	0,2860%
1,8	3,2883%	0,3377%
2,1	3,8179%	0,3895%
2,4	4,3508%	0,4413%
2,7	4,8859%	0,4930%
3	5,4226%	0,5448%



Picture 11 - Plotting the Efficient Frontier

Comparing the two efficient frontiers

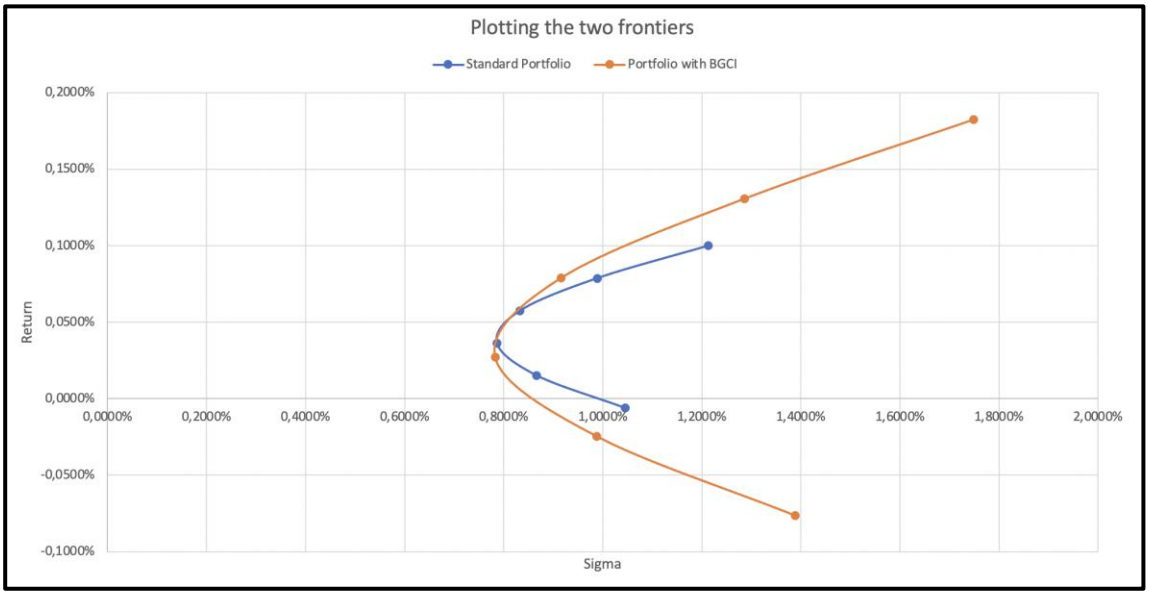
Now that we have plotted the efficient frontiers of the two sets of sectors and have thus calculated the various measures relevant to performing the analysis, we can compare the two curves by joining them within the same graph.



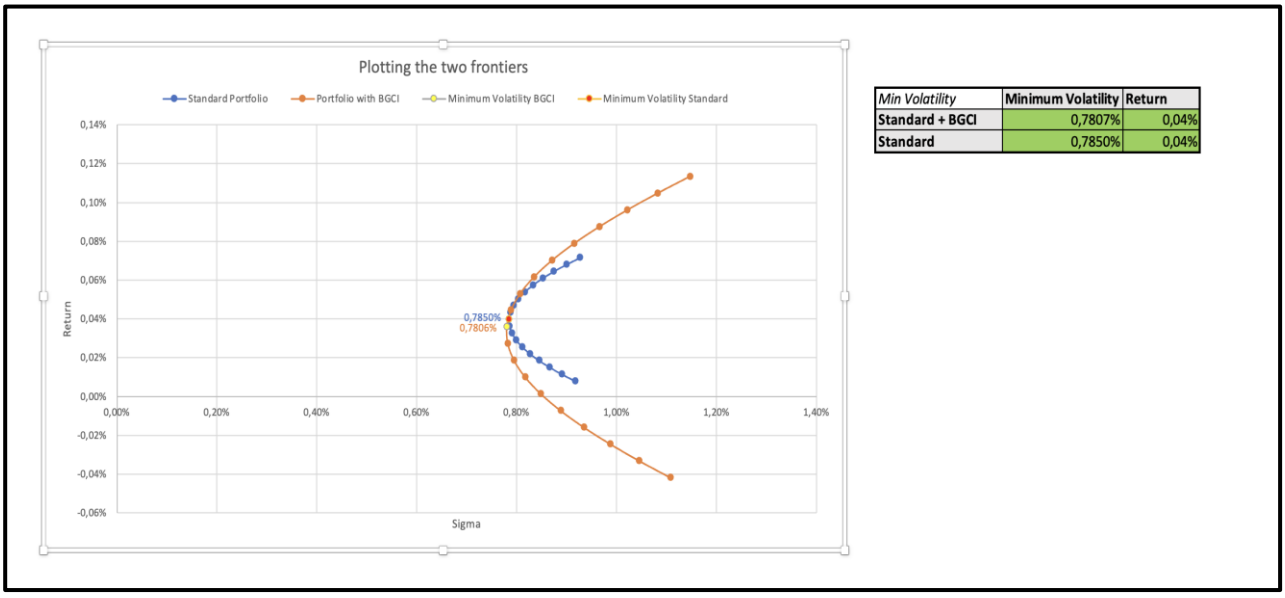
Picture 12 - Comparing the Efficient Frontiers

As we can see from the graph above it is clear that something immediately catches the eye, the minimum of the two curves, respectively on the x axis, seems to be very similar, if not almost coincide.

To carry out a more careful analysis we will "zoom" on the graph, selecting a lower portion of the array, i.e. plotting only the portfolios around the minimums of the two curves.



Picture 13 - Reducing the Dataset to Focus on the Minimum



Min Volatility	Minimum Volatility	Return
Standard + BGCI	0,7807%	0,04%
Standard	0,7850%	0,04%

Picture 14 - Comparing the Minimum of the two curves

By expanding the number of different portfolios generated, precisely from 17 combinations to 91, we are able to identify points increasingly closer to the minimum of both curves. What matters, however, is that the lowest level of risk, therefore the point on the efficient frontier which has a lowest sigma value, is reached by the efficient

frontier which contains within it the standard indices of the alternative sectors plus the BGCI index, representing of the blockchain asset market.

Sensitivity Analysis to the constant c, the risk-free rate

Every time we generate the two curves that define the efficient frontiers of the two portfolio models presented, we are basing the results on a very strong assumption: the constant c which corresponds to the risk-free rate is equal to 0.95% since the data on the rates of American treasury bills we found that this figure could be ideal for representing the entire period analyzed.
Nonetheless, by plotting the two curves as the constant varies, we observe how the curves take on different aspects, more or less broad. It therefore remains important to verify whether the result obtained, i.e. that the portfolio containing the cryptocurrencies actually reaches lower levels of volatility, is the result of a circumstance created by this constant level of risk-free rate or whether it is actually a real and replicable dynamic for any economic period, meaning any fluctuation in the risk-free rate from the estimate we used to represent it in the financial year just carried out.

To carry out this sensitivity analysis we will once again use Excel's "data table" functions, but this time making the results dependent on two variables: the first, placed this time on the horizontal axis of the matrix, represents the portion of the portfolio portion of portfolio y used to reach a precise point within the table. The second variable will be the level of the risk-free rate.

The first tab will represent the sensitivity analysis for the frontier based on the set of alternative assets, while the second one will represent the set of alternative assets plus the BGCI.

	3,00	2,70	2,40	2,10	1,80	1,50	1,20	0,90	0,60	0,30	0,00	-0,30	-0,60	-0,90	-1,20	-1,50	Minimum Volatility
0,95%	3,2829%	2,9701%	2,6597%	2,3529%	2,0510%	1,7568%	1,4747%	1,2133%	0,9892%	0,8330%	0,7862%	0,8668%	1,0456%	1,2823%	1,5506%	1,8366%	0,7862%
0,90%	3,2879%	2,9743%	2,6632%	2,3555%	2,0529%	1,7579%	1,4751%	1,2131%	0,9886%	0,8324%	0,7863%	0,8682%	1,0484%	1,2862%	1,5555%	1,8424%	0,7863%
0,85%	3,2935%	2,9791%	2,6671%	2,3585%	2,0550%	1,7592%	1,4756%	1,2129%	0,9879%	0,8317%	0,7865%	0,8698%	1,0514%	1,2906%	1,5610%	1,8490%	0,7865%
0,80%	3,2999%	2,9844%	2,6714%	2,3619%	2,0575%	1,7607%	1,4762%	1,2127%	0,9871%	0,8310%	0,7867%	0,8716%	1,0549%	1,2955%	1,5672%	1,8564%	0,7867%
0,75%	3,3072%	2,9906%	2,6764%	2,3658%	2,0602%	1,7623%	1,4768%	1,2124%	0,9862%	0,8301%	0,7870%	0,8738%	1,0589%	1,3012%	1,5743%	1,8649%	0,7870%
0,70%	3,3155%	2,9976%	2,6822%	2,3703%	2,0634%	1,7643%	1,4775%	1,2121%	0,9851%	0,8291%	0,7873%	0,8762%	1,0636%	1,3077%	1,5826%	1,8747%	0,7873%
0,65%	3,3253%	3,0058%	2,6889%	2,3755%	2,0671%	1,7665%	1,4784%	1,2117%	0,9839%	0,8280%	0,7877%	0,8791%	1,0690%	1,3153%	1,5921%	1,8860%	0,7877%
0,60%	3,3367%	3,0155%	2,6968%	2,3816%	2,0715%	1,7692%	1,4794%	1,2112%	0,9825%	0,8267%	0,7882%	0,8826%	1,0754%	1,3243%	1,6034%	1,8995%	0,7882%
0,55%	3,3504%	3,0271%	2,7063%	2,3889%	2,0767%	1,7723%	1,4806%	1,2107%	0,9808%	0,8252%	0,7889%	0,8869%	1,0832%	1,3352%	1,6170%	1,9155%	0,7889%
0,50%	3,3671%	3,0412%	2,7178%	2,3979%	2,0831%	1,7762%	1,4820%	1,2100%	0,9788%	0,8233%	0,7898%	0,8921%	1,0927%	1,3484%	1,6335%	1,9351%	0,7898%
0,45%	3,3879%	3,0587%	2,7321%	2,4090%	2,0910%	1,7810%	1,4839%	1,2092%	0,9762%	0,8211%	0,7911%	0,8988%	1,1046%	1,3649%	1,6542%	1,9596%	0,7911%
0,40%	3,4145%	3,0812%	2,7504%	2,4231%	2,1011%	1,7871%	1,4862%	1,2082%	0,9730%	0,8184%	0,7929%	0,9076%	1,1201%	1,3862%	1,6806%	1,9909%	0,7929%
0,35%	3,4495%	3,1108%	2,7746%	2,4419%	2,1145%	1,7952%	1,4892%	1,2068%	0,9687%	0,8149%	0,7956%	0,9195%	1,1409%	1,4146%	1,7158%	2,0323%	0,7956%
0,30%	3,4981%	3,1518%	2,8081%	2,4679%	2,1330%	1,8064%	1,4935%	1,2049%	0,9629%	0,8104%	0,8001%	0,9368%	1,1701%	1,4542%	1,7648%	2,0900%	0,8001%
0,25%	3,5698%	3,2124%	2,8575%	2,5063%	2,1604%	1,8230%	1,4997%	1,2021%	0,9545%	0,8044%	0,8080%	0,9638%	1,2144%	1,5135%	1,8375%	2,1754%	0,8044%
0,20%	3,6862%	3,3107%	2,9378%	2,5686%	2,2049%	1,8499%	1,5099%	1,1976%	0,9411%	0,7963%	0,8242%	1,0107%	1,2886%	1,6114%	1,9569%	2,3150%	0,7963%
0,15%	3,9080%	3,4983%	3,0911%	2,6876%	2,2899%	1,9014%	1,5293%	1,1891%	0,9169%	0,7868%	0,8656%	1,1095%	1,4368%	1,8026%	2,1877%	2,5835%	0,7868%
0,10%	4,4968%	3,9964%	3,4985%	3,0045%	2,5164%	2,0388%	1,5811%	1,1667%	0,8611%	0,8001%	1,0284%	1,4120%	1,8569%	2,3284%	2,8131%	3,3051%	0,8001%
0,05%	10,5778%	9,1550%	7,7339%	6,3156%	4,9025%	3,5010%	2,1341%	0,9626%	1,1719%	2,4279%	3,8067%	5,2117%	6,6262%	8,0453%	9,4669%	10,8900%	0,9626%
0,00%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%	1,2974%
-0,05%	2,3280%	2,1652%	2,0042%	1,8455%	1,6898%	1,5380%	1,3914%	1,2517%	1,1216%	1,0049%	0,9066%	0,8333%	0,7921%	0,7879%	0,8213%	0,8881%	0,7879%
-0,10%	2,6372%	2,4255%	2,2160%	2,0092%	1,8063%	1,6087%	1,4184%	1,2391%	1,0760%	0,9379%	0,8370%	0,7879%	0,8001%	0,8710%	0,9881%	1,1373%	0,7879%
-0,15%	2,7843%	2,5494%	2,3168%	2,0873%	1,8619%	1,6423%	1,4312%	1,2331%	1,0553%	0,9096%	0,8135%	0,7856%	0,8326%	0,9435%	1,0990%	1,2831%	0,7856%
-0,20%	2,8702%	2,6218%	2,3758%	2,1329%	1,8943%	1,6620%	1,4387%	1,2297%	1,0434%	0,8942%	0,8029%	0,7901%	0,8591%	0,9931%	1,1700%	1,3732%	0,7901%
-0,25%	2,9264%	2,6693%	2,4145%	2,1629%	1,9157%	1,6749%	1,4436%	1,2274%	1,0357%	0,8845%	0,7973%	0,7953%	0,8792%	1,0281%	1,2184%	1,4338%	0,7953%
-0,30%	2,9662%	2,7028%	2,4418%	2,1840%	1,9307%	1,6840%	1,4471%	1,2259%	1,0304%	0,8780%	0,7939%	0,8001%	0,8945%	1,0538%	1,2535%	1,4772%	0,7939%
-0,35%	2,9957%	2,7277%	2,4621%	2,1997%	1,9419%	1,6907%	1,4497%	1,2247%	1,0264%	0,8732%	0,7918%	0,8042%	0,9065%	1,0735%	1,2799%	1,5098%	0,7918%
-0,40%	3,0186%	2,7470%	2,4778%	2,2119%	1,9506%	1,6960%	1,4517%	1,2238%	1,0234%	0,8696%	0,7903%	0,8077%	0,9162%	1,0889%	1,3006%	1,5351%	0,7903%
-0,45%	3,0368%	2,7623%	2,4903%	2,2216%	1,9575%	1,7002%	1,4532%	1,2231%	1,0209%	0,8668%	0,7893%	0,8106%	0,9240%	1,1014%	1,3171%	1,5554%	0,7893%
-0,50%	3,0516%	2,7748%	2,5005%	2,2295%	1,9631%	1,7036%	1,4545%	1,2225%	1,0190%	0,8646%	0,7885%	0,8132%	0,9305%	1,1117%	1,3307%	1,5720%	0,7885%
-0,55%	3,0639%	2,7852%	2,5090%	2,2360%	1,9678%	1,7064%	1,4556%	1,2220%	1,0174%	0,8627%	0,7879%	0,8154%	0,9361%	1,1202%	1,3421%	1,5858%	0,7879%
-0,60%	3,0743%	2,7940%	2,5161%	2,2416%	1,9717%	1,7088%	1,4565%	1,2216%	1,0160%	0,8611%	0,7875%	0,8173%	0,9408%	1,1275%	1,3517%	1,5974%	0,7875%
-0,65%	3,0831%	2,8015%	2,5222%	2,2463%	1,9751%	1,7108%	1,4573%	1,2212%	1,0148%	0,8598%	0,7871%	0,8190%	0,9448%	1,1338%	1,3599%	1,6074%	0,7871%
-0,70%	3,0908%	2,8080%	2,5275%	2,2504%	1,9780%	1,7126%	1,4580%	1,2209%	1,0138%	0,8587%	0,7868%	0,8205%	0,9484%	1,1393%	1,3670%	1,6161%	0,7868%
-0,75%	3,0975%	2,8136%	2,5321%	2,2540%	1,9805%	1,7141%	1,4585%	1,2206%	1,0130%	0,8577%	0,7866%	0,8218%	0,9515%	1,1441%	1,3733%	1,6237%	0,7866%
-0,80%	3,1034%	2,8186%	2,5362%	2,2571%	1,9828%	1,7155%	1,4591%	1,2204%	1,0122%	0,8569%	0,7864%	0,8230%	0,9543%	1,1483%	1,3788%	1,6304%	0,7864%
-0,85%	3,1087%	2,8230%	2,5398%	2,2599%	1,9848%	1,7167%	1,4595%	1,2202%	1,0115%	0,8561%	0,7863%	0,8240%	0,9567%	1,1521%	1,3837%	1,6363%	0,7863%
-0,90%	3,1134%	2,8270%	2,5430%	2,2624%	1,9865%	1,7178%	1,4599%	1,2200%	1,0109%	0,8554%	0,7861%	0,8250%	0,9590%	1,1554%	1,3881%	1,6416%	0,7861%
-0,95%	3,1176%	2,8305%	2,5459%	2,2646%	1,9881%	1,7187%	1,4603%	1,2198%	1,0103%	0,8548%	0,7860%	0,8259%	0,9610%	1,1585%	1,3920%	1,6464%	0,7860%
																	0,7856%

Picture 15 - Sensitivity Analysis 1

The tab above as we said, represents the variation of our efficient frontier that happens when we raise or lower the risk-free rate. Each single line represents the efficient frontier we would obtain if the risk-free rate were to be the one we can see at the leftmost cell in each row.

	3,00	2,70	2,40	2,10	1,80	1,50	1,20	0,90	0,60	0,30	0,00	-0,30	-0,60	-0,90	-1,20	-1,50	Minimum Volatility
0,95%	5,4226%	4,8859%	4,3508%	3,8179%	3,2883%	2,7639%	2,2482%	1,7492%	1,2863%	0,9159%	0,7828%	0,9881%	1,3891%	1,8634%	2,3674%	2,8855%	0,7828%
0,90%	5,4298%	4,8921%	4,3559%	3,8219%	3,2911%	2,7656%	2,2489%	1,7489%	1,2851%	0,9146%	0,7831%	0,9910%	1,3939%	1,8697%	2,3750%	2,8943%	0,7831%
0,85%	5,4380%	4,8989%	4,3615%	3,8263%	3,2943%	2,7676%	2,2497%	1,7485%	1,2838%	0,9131%	0,7835%	0,9943%	1,3993%	1,8768%	2,3835%	2,9042%	0,7835%
0,80%	5,4471%	4,9067%	4,3679%	3,8313%	3,2979%	2,7698%	2,2506%	1,7481%	1,2823%	0,9114%	0,7839%	0,9981%	1,4055%	1,8848%	2,3931%	2,9154%	0,7839%
0,75%	5,4576%	4,9156%	4,3752%	3,8369%	3,3020%	2,7723%	2,2515%	1,7476%	1,2807%	0,9095%	0,7845%	1,0024%	1,4125%	1,8939%	2,4041%	2,9281%	0,7845%
0,70%	5,4696%	4,9258%	4,3835%	3,8435%	3,3068%	2,7753%	2,2527%	1,7471%	1,2787%	0,9073%	0,7851%	1,0073%	1,4206%	1,9044%	2,4167%	2,9427%	0,7851%
0,65%	5,4836%	4,9376%	4,3932%	3,8511%	3,3122%	2,7786%	2,2540%	1,7465%	1,2765%	0,9048%	0,7859%	1,0132%	1,4301%	1,9167%	2,4314%	2,9597%	0,7859%
0,60%	5,5000%	4,9516%	4,4047%	3,8600%	3,3187%	2,7826%	2,2556%	1,7457%	1,2739%	0,9019%	0,7870%	1,0201%	1,4412%	1,9311%	2,4487%	2,9798%	0,7870%
0,55%	5,5196%	4,9682%	4,4183%	3,8707%	3,3264%	2,7874%	2,2574%	1,7448%	1,2707%	0,8984%	0,7883%	1,0284%	1,4546%	1,9483%	2,4694%	3,0037%	0,7883%
0,50%	5,5434%	4,9884%	4,4349%	3,8837%	3,3358%	2,7932%	2,2597%	1,7437%	1,2670%	0,8943%	0,7901%	1,0387%	1,4709%	1,9693%	2,4945%	3,0327%	0,7901%
0,45%	5,5730%	5,0134%	4,4555%	3,8997%	3,3474%	2,8003%	2,2625%	1,7424%	1,2623%	0,8892%	0,7926%	1,0516%	1,4912%	1,9953%	2,5257%	3,0688%	0,7926%
0,40%	5,6106%	5,0453%	4,4816%	3,9202%	3,3621%	2,8094%	2,2660%	1,7407%	1,2563%	0,8829%	0,7962%	1,0683%	1,5171%	2,0286%	2,5655%	3,1147%	0,7962%
0,35%	5,6600%	5,0873%	4,5161%	3,9471%	3,3816%	2,8214%	2,2707%	1,7385%	1,2485%	0,8749%	0,8015%	1,0907%	1,5515%	2,0725%	2,6179%	3,1752%	0,8015%
0,30%	5,7281%	5,1450%	4,5634%	3,9842%	3,4083%	2,8379%	2,2772%	1,7354%	1,2378%	0,8643%	0,8100%	1,1224%	1,5993%	2,1331%	2,6901%	3,2585%	0,8100%
0,25%	5,8275%	5,2293%	4,6327%	4,0383%	3,4474%	2,8621%	2,2866%	1,7309%	1,2223%	0,8497%	0,8249%	1,1701%	1,6698%	2,2221%	2,7959%	3,3804%	0,8249%
0,20%	5,9867%	5,3643%	4,7435%	4,1250%	3,5100%	2,9007%	2,3017%	1,7238%	1,1977%	0,8291%	0,8544%	1,2498%	1,7844%	2,3655%	2,9659%	3,5760%	0,8291%
0,15%	6,2823%	5,6150%	4,9494%	4,2861%	3,6263%	2,9725%	2,3298%	1,7105%	1,1532%	0,7999%	0,9251%	1,4064%	2,0015%	2,6344%	3,2834%	3,9404%	0,7999%
0,10%	7,0215%	6,2423%	5,4646%	4,6892%	3,9176%	3,1525%	2,4000%	1,6775%	1,0484%	0,7848%	1,1681%	1,8288%	2,5605%	3,3165%	4,0834%	4,8560%	0,7848%
0,05%	12,1865%	10,6279%	9,0706%	7,5154%	5,9638%	4,4197%	2,8951%	1,4530%	0,8497%	2,0528%	3,5478%	5,0834%	6,6315%	8,1849%	9,7412%	11,2991%	0,8497%
0,00%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%	1,9129%
-0,05%	3,9233%	3,6154%	3,3087%	3,0038%	2,7010%	2,4014%	2,1062%	1,8176%	1,5393%	1,2779%	1,0465%	0,8690%	0,7832%	0,8184%	0,9614%	1,1735%	0,7832%
-0,10%	4,4375%	4,0509%	3,6658%	3,2826%	2,9021%	2,5255%	2,1549%	1,7940%	1,4500%	1,1384%	0,8936%	0,7814%	0,8555%	1,0783%	1,3794%	1,7181%	0,7814%
-0,15%	4,6717%	4,2494%	3,8286%	3,4098%	2,9938%	2,5821%	2,1771%	1,7833%	1,4102%	1,0793%	0,8421%	0,7883%	0,9495%	1,2449%	1,6019%	1,9875%	0,7883%
-0,20%	4,8056%	4,3629%	3,9217%	3,4825%	3,0463%	2,6145%	2,1898%	1,7772%	1,3876%	1,0470%	0,8190%	0,8056%	1,0154%	1,3479%	1,7339%	2,1446%	0,8056%
-0,25%	4,8924%	4,4364%	3,9820%	3,5296%	3,0803%	2,6355%	2,1980%	1,7733%	1,3731%	1,0268%	0,8067%	0,8217%	1,0617%	1,4168%	1,8207%	2,2473%	0,8067%
-0,30%	4,9531%	4,4879%	4,0242%	3,5626%	3,1041%	2,6502%	2,2038%	1,7705%	1,3630%	1,0129%	0,7995%	0,8351%	1,0957%	1,4659%	1,8820%	2,3195%	0,7995%
-0,35%	4,9980%	4,5259%	4,0554%	3,5870%	3,1217%	2,6610%	2,2080%	1,7685%	1,3556%	1,0028%	0,7948%	0,8460%	1,1215%	1,5026%	1,9276%	2,3731%	0,7948%
-0,40%	5,0325%	4,5552%	4,0794%	3,6058%	3,1352%	2,6694%	2,2113%	1,7669%	1,3499%	0,9952%	0,7917%	0,8551%	1,1418%	1,5311%	1,9629%	2,4144%	0,7917%
-0,45%	5,0599%	4,5784%	4,0985%	3,6207%	3,1460%	2,6760%	2,2139%	1,7656%	1,3453%	0,9892%	0,7895%	0,8626%	1,1581%	1,5538%	1,9909%	2,4472%	0,7895%
-0,50%	5,0821%	4,5973%	4,1139%	3,6328%	3,1547%	2,6814%	2,2160%	1,7646%	1,3417%	0,9844%	0,7878%	0,8690%	1,1714%	1,5723%	2,0137%	2,4739%	0,7878%
-0,55%	5,1006%	4,6129%	4,1268%	3,6428%	3,1619%	2,6859%	2,2177%	1,7638%	1,3386%	0,9804%	0,7866%	0,8744%	1,1826%	1,5878%	2,0326%	2,4961%	0,7866%
-0,60%	5,1161%	4,6261%	4,1376%	3,6512%	3,1680%	2,6896%	2,2192%	1,7631%	1,3361%	0,9771%	0,7856%	0,8790%	1,1921%	1,6008%	2,0486%	2,5148%	0,7856%
-0,65%	5,1294%	4,6373%	4,1468%	3,6584%	3,1732%	2,6928%	2,2204%	1,7625%	1,3339%	0,9743%	0,7849%	0,8831%	1,2002%	1,6119%	2,0623%	2,5307%	0,7849%
-0,70%	5,1408%	4,6470%	4,1548%	3,6647%	3,1777%	2,6956%	2,2215%	1,7620%	1,3320%	0,9718%	0,7843%	0,8866%	1,2073%	1,6215%	2,0741%	2,5445%	0,7843%
-0,75%	5,1508%	4,6555%	4,1617%	3,6701%	3,1816%	2,6980%	2,2225%	1,7615%	1,3304%	0,9697%	0,7838%	0,8898%	1,2135%	1,6300%	2,0844%	2,5565%	0,7838%
-0,80%	5,1596%	4,6629%	4,1678%	3,6749%	3,1851%	2,7002%	2,2233%	1,7611%	1,3290%	0,9679%	0,7834%	0,8926%	1,2189%	1,6374%	2,0934%	2,5671%	0,7834%
-0,85%	5,1674%	4,6696%	4,1733%	3,6791%	3,1881%	2,7020%	2,2240%	1,7608%	1,3277%	0,9663%	0,7830%	0,8951%	1,2238%	1,6440%	2,1015%	2,5765%	0,7830%
-0,90%	5,1744%	4,6755%	4,1781%	3,6829%	3,1909%	2,7037%	2,2247%	1,7604%	1,3265%	0,9648%	0,7827%	0,8973%	1,2281%	1,6499%	2,1087%	2,5849%	0,7827%
-0,95%	5,1806%	4,6808%	4,1824%	3,6863%	3,1933%	2,7052%	2,2253%	1,7602%	1,3255%	0,9635%	0,7825%	0,8993%	1,2320%	1,6552%	2,1151%	2,5924%	0,7825%
																	0,7814%

Picture 16 - Sensitivity Analysis 2

In the rightmost column we can see the minimum levels of sigma obtained by changing the risk-free rate.
In each one of the tables, there is one efficient frontier highlighted.

The highlighted efficient frontier represents the frontier which reaches the minimum level of volatility for both the sets of sectors, which happen respectively at -0,15% for the standard alternative assets portfolio and at -0,10% for the portfolio containing the BGCI Index.

The sensitivity analysis accomplished in this last exercise demonstrates that the result we obtained does not depend fully on our arbitrary choice of the risk free rate levels, as a matter of fact, during the timeline we chose, U.S. 5-years Treasury bills charts show that the rate should have been around the same level we set to perform our test. Furthermore, even changing the risk free rate, the lowest levels of volatility are always reached by the portfolio containing the BGCI index, demonstrating that the introduction of blockchain assets to our test alternative portfolio actually lowers its level of risk.

5. Conclusion and Recomendations

Can Bitcoin and the other cryptocurrencies really be considered as a safe heaven asset after all?

While Bitcoin and cryptocurrencies offer unique characteristics that could potentially make them safe havens in specific circumstances, their status as such is far from universally accepted. They remain highly speculative and volatile assets, and investors should exercise caution and conduct thorough research before considering them as a safe-haven component in their portfolios. Moreover, cryptocurrencies can't be deemed safe haven investments due to their extreme price volatility, lack of historical track record as stores of value, regulatory uncertainties, and their tendency to correlate with traditional assets during market turmoil.

Can crypto assets be considered effective risk mitigation tools in alternative investment portfolio strategies?

To answer this question, it was necessary to rely on a model and make appropriate assumptions.

We therefore built a model to verify whether, by adding crypto assets to a standard portfolio of alternative instruments, it was possible to obtain a similar or even lower risk performance than what we would have without cryptocurrencies.

During this journey, we considered a model that naturally simplifies the large amount of concepts and debates that are still undisputed: certainly greater awareness and recognition on the part of the various states could allow structures such as investment funds to introduce these assets within their portfolios, avoiding excessive taxation which could end the popularity of these instruments is certainly important advice as the blockchain sector is constantly evolving and as we know, innovation is often also motivated by economic convenience.

Beyond discussions on topics that are difficult to deal with in a simple thesis, by focusing on the results obtained in the exercises carried out, we can say that we have obtained sufficient data to answer the question posed with confidence: *yes.* Crypto assets can be used as risk mitigation tools, what matters is to be aware of their nature and what affects their performance.
Each cryptocurrency, on the other hand, must be considered as a market in its own right, with its specific dynamics and properties. The exercise aims to simplify everything by adding an index that fluctuates in a highly correlated manner to bitcoin and ethereum, to which the vast majority of cryptocurrencies are highly correlated. However, it remains true that, taken individually, many cryptocurrencies have a much higher volatility than that which characterizes ETH and BTC and in particular the BGCI index, it is therefore important to undertake in-depth due diligence before investing in these instruments.
Another simplification in our exercise which is naturally important to deal with is the fact that there are cryptocurrencies, already mentioned in the previous chapters, which maintain their value stable and equal to that of a fiat currency, the stablecoins. USDC and TUSD are examples. These instruments naturally have a much lower volatility than other coins, in fact, being within the top 10 of the cryptocurrencies with the highest market cap, they are found within the BGCI index portfolio, which is therefore stabilized by decreasing the average volatility of the wallet.

Is it the extreme volatility of cryptocurrencies that discourages managers of many alternative investment funds from including them in their portfolios?

The high level of price volatility associated with cryptocurrencies is a key factor that often dissuades many managers of alternative investment funds from even considering them for inclusion in their portfolios. The substantial price fluctuations that cryptocurrencies like Bitcoin and Ethereum experience over short periods can make them appear unpredictable and risky compared to more established alternative asset classes. However, as we assessed in chapter 3, volatility is not the only issue, and sometimes as we experimented in the last chapter of this paper, the introduction of these

assets into alternative portfolios could even lower the overall risk, assuming we are taking into account a well balanced portfolio whose investments are reviewed constantly and in a timely manner as it happens for the weights in the BGCI index. Cryptocurrency markets often operate in a less regulated environment compared to traditional financial markets. The lack of clear regulatory oversight can be a deterrent for institutional investors and fund managers who prefer investing in well-regulated assets. Furthermore, the safekeeping and management of cryptocurrencies, where possession and control cannot really be distinguished, can be a concern if associated with the obligation to transfer holding of assets to a depositary bank as imposed by the Alternative Investment Fund Managers Directive (AIFMD).

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Payment Services Directive (PSD2)

Markets in Crypto-Assets Regulation (MiCA or MICAR)

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BCGI index Fact Sheet - https://assets.bbhub.io/professional/sites/10/BGCI-Factsheet-Mar-22.pdf