Diversifying Your Portfolio with Cryptocurrency – Does It Improve Sharpe Ratios for Institutional Investors?

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ABSTRACT,
Although cryptocurrency has been known to yield enormous returns, institutional investors are still not so confident about directly investing into cryptocurrency assets due to volatility and other risks that come with it. This paper considers whether cryptocurrency has a place in an already well-diversified portfolio of an institutional investor, mainly consisting of traditional assets such as stocks, bonds, and commodities. Results suggest Bitcoin, Ethereum, Binance Coin, Cardano and even a portfolio of cryptocurrencies as possible diversification options in terms of the risk-return tradeoff. Despite the fact that acquisition of cryptocurrency considerably increases total portfolio volatility, the significantly increased returns more than make up for it, as indicated by increased Sharpe ratios. In support of previous literature, it was observed that cryptocurrencies have low to no correlation to traditional assets suggesting cryptocurrency as a potential hedge to traditional market downturns. In addition, it was observed that there is not enough evidence to suggest that the acquisition of Bitcoin leads to significantly increased portfolio returns, implying that Bitcoin should not be the only cryptocurrency considered. A suggestion was made that investing in multiple cryptocurrencies might be the most viable option as this way the investor gets the best of both worlds – significantly higher returns and lower volatility.

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Keywords
Cryptocurrency, institutional, portfolio, alternative, diversification, Sharpe.

1. INTRODUCTION

Cryptocurrency is an emerging topic that has been receiving a lot of attention from the media and investors ever since Bitcoin was first proposed by Nakamoto (2008). This ground-breaking technology was created with a purpose of combating the major drawbacks of traditional fiat currency system such as high transaction fees and longer settlement periods (Lee, Guo, Want, 2017). Bitcoin, on the other hand, runs on a peer-to-peer system, where transactions can happen without the need of some higher authority, thus eliminating aforementioned problems. Recently, we have been witnessing the emergence of a wider variety of coins besides Bitcoin, otherwise known as altcoins, such as Ethereum, Cardano, Solana, Binance Coin, Cosmos, etc. These coins are created to either tackle the weaknesses of Bitcoin, such as high energy usage, or to create entirely new possibilities that were never offered by Bitcoin in the first place, such as smart contracts. Blockchain technology opens up many doors for new opportunities that can be implemented in our everyday lives, but with that also comes quite a big share of uncertainty and risks.

Even with the growth within retail investors and increasing worldwide attention, institutional investors are still not so confident about directly investing into cryptocurrency mostly due to legal, tax, and accounting reasons (Tan & Low, 2017). Companies such as financial institutions, insurance companies, hedge funds and similar still tend to focus on more traditional, time-proven asset classes such as stocks, bonds, commodities. It is possible that due to the volatility barrier, institutional investors overlook the appeals of cryptocurrency and other digital assets such as portfolio diversification benefits, innovativeness and other. As institutional investment is necessary for adoption, this paper, in a way, is meant to provide concrete and clear proof that reassures institutional investors that cryptocurrency benefits might outweigh the potential risks that come with it and propose cryptocurrency as an asset class that, at least, should be taken into consideration. In order to do that, we are going to look into the following research question:

RQ. ***Does diversifying the portfolio with cryptocurrency improve Sharpe ratios for institutional investors?***

Another objective of this paper is to see whether previous literature findings still stand true a few years later in such a fast-moving field of cryptocurrency. It is important to note that a lot of available literature only take Bitcoin into account overlooking alternative cryptocurrencies, which have completely different functions and, thus, dynamics. While there are papers that take into account a wider range of cryptocurrencies, they either overlook coins that are relevant today, such as Cardano, or take into account coins which are not so relevant anymore, such as MaidSafeCoin. There were papers that analyzed all the coins of at least $1 million market capitalization, which is an enormous sample size arguably unsuitable for institutional investment research. Other papers did not have a fixed start time period for individual cryptocurrencies, meaning their time frames were not identical, which could lead to some potential implications on the results, especially when comparing cryptocurrencies to each other. Unlike previous research, this paper considers a small yet focused sample size with the same time period tailored to institutional investment intention of cryptocurrencies that are relevant today, ultimately, answering the before proposed Research Question. In other words, we are going to look whether the addition of cryptocurrencies to an already well-diversified portfolio of stocks, bonds, and commodities provides diversification benefits in terms of the risk-return tradeoff.

1.1 Current State of Cryptocurrency

To provide some more background, cryptocurrency, at its current state, is more looked at as an asset one could acquire, rather than a currency one would use. As of April 2022, we cannot just simply go to a store and pay for our groceries in Bitcoin or any other cryptocurrency. So far, El Salvador is the only country in the world that recognizes Bitcoin as legal tender, while other jurisdictions choose to treat it as a digital asset. Unlike traditional assets, however, cryptocurrencies have no physical representation, have no association with any higher authority and are based on an algorithm which is able to trace all transactions (Corbet et al., 2019). Furthermore, they have extremely unstable markets, but, it can be argued, that this exact volatility is also the reason we see many enormous price jumps reported in the media, which, in turn, attract many (mostly) retail investors. For example, for the period of April 1st, 2020 to April 1st, 2021, the price of Bitcoin jumped from $6,606.78 to $59,095.81, resulting in a 794% return on investment over a span of just one year, which is not something that is offered by more traditional asset classes. However, Urquhart (2016) provides evidence suggesting that the market of Bitcoin is rather inefficient, meaning its price does not accurately resemble its true value, which does describe potential bubble-like properties.

The rest of the paper will proceed as follows: Section 2 briefly introduces currently available literature on cryptocurrency and institutional investments and raises a few hypotheses. Section 3 discusses data selection and reasoning alongside with chosen methodology and research design. Section 4 presents the results based on descriptive statistics and testing. Section 5 discusses findings and implications. Lastly, Section 6 provides a summary and concludes the paper.

2. LITERATURE REVIEW

Despite cryptocurrency still being a relatively new topic, there is quite a lot of literature available with the number of published articles growing rapidly, especially within the last few years. However, as this is such a fast-moving space, where change can happen instantaneously, it is important to keep doing research on a regular basis and not only look for new groundbreaking results, but to also see if previous findings still stand true at current market conditions. This paper considers a wide array of previous research that has been done on various cryptocurrency topics such as cryptocurrency as an asset class, its risk and returns, correlation with other assets and, even, factors influencing institutional investment with diverse selection of methodologies such as various statistical analyzes, surveys and literature reviews. A brief summary of reviewed literature, its main topics methodologies and findings can be observed in Table 1. The empirical results will be discussed as follows: Section 2.1 discusses the main findings on cryptocurrency as a financial asset, Section 2.2 looks at additional noteworthy findings that institutional investors and anyone studying cryptocurrency finance should be aware of, Section 2.3 summarizes the literature review and raises hypotheses.

2.1 Cryptocurrency as a Financial Asset

2.1.1 Correlation

There seems to be a general agreement between researchers suggesting low correlation between cryptocurrency and traditional assets. Briere, Oosterlinck, Szafarz (2015) analyzed a Bitcoin investment in a diversified portfolio consisting of various traditional assets such as stocks, bonds, hard currencies, commodities, hedge funds and real estate, with the results showing remarkably low correlation suggesting Bitcoin as a partial hedge against traditional market crises. Shahzad et al. (2019) explored whether Bitcoin exhibits a safe-haven

Authors	Topic	Methodology	Findings
Bialkowski (2020)	Managing cryptocurrency risk with stop-loss rules	Statistical analysis	Stop-loss rules to decrease volatility, more feasible for institutional investors
Briere, Oosterlinck, Szafarz (2015)	Bitcoin addition to an already diversified portfolio	Mean-variance spanning	Bitcoin diversification benefits, low correlation with traditional assets
Corbet, Meegan, Larkin, Lucey, Yarovaya (2018)	Relationship between cryptocurrencies and other financial assets	Generalized variance decomposition	Diversification benefits, higher returns, low correlation with traditional assets
Corbet, Lucey, Urquhart, Yarovaya (2019)	Cryptocurrency as a financial asset	Literature review	Literature gaps, cryptocurrency as an asset class trilemma, unique cryptocurrency issues
Hu, Parlour, Rajan (2018)	Cryptocurrency return properties and secondary market returns	Statistical analysis	Alternative cryptocurrency returns strongly correlated with Bitcoin
Lee, Guo, Wang (2017)	Risk and return characteristics of a portfolio of cryptocurrencies (CRIX index)	Statistical analysis	Higher returns, low correlation with traditional assets, diversification benefits
Liu, Tsyvinski (2021)	Cryptocurrency risks and returns	Multiple empirical methods	Low correlation with traditional assets, higher Sharpe ratios, drivers for price
Platanakis, Urquhart (2019)	Including Bitcoin in a stock-bond portfolio	Out-of-sample analysis	Introducing Bitcoin to a portfolio leads to substantially higher risk-adjusted returns
Shahzad, Bouri, Roubaud, Kristoufek, Lucey (2019)	Bitcoin's safe-haven properties	Bivariate cross-quintilogram approach	Bitcoin higher returns, Sharpe ratios, potential hedge to extreme market conditions
Sun, Dedahanov, Shin, Li (2021)	Cryptocurrency in PE company portfolios and factors affecting investment intention	Survey	Innovativeness, brand familiarity, price consciousness and brand trust are the main drivers of investment intention

Table 1: Previous literature on cryptocurrency as a financial asset and its institutional investment

characteristic for stock market investments, with the results suggesting weak safe-haven properties, meaning it could be used as a tool to hedge against extreme stock market conditions due to being isolated from traditional markets. Lee, Guo, Wang (2017), on the other hand, took an alternative approach and explored risk-return characteristics using a portfolio of cryptocurrencies represented by the CRIX index, with the results suggesting very low correlation for cryptocurrency against traditional asset classes. Liu, Tsyvinski (2021) looked into cryptocurrency risk and return characteristics as well, agreeing with low correlation due to the fact that cryptocurrency returns have low exposure to traditional asset classes. Lastly, Corbet et al. (2018) supports the fact that cryptocurrencies are relatively isolated from the traditional financial and economic assets by showing evidence of cryptocurrency being isolated from market shocks.

2.1.2 Returns

Essentially every single paper that conducted any sort of statistical analysis does suggest cryptocurrency having significantly larger returns than traditional asset classes. Platanakis, Urquhart (2019) examined benefits of including Bitcoin in a portfolio of stocks and bonds by employing eight most popular portfolio construction techniques at three different levels of risk aversion and found that, across all allocation strategies, inclusion of Bitcoin leads to substantially higher risk-adjusted returns. Lee, Guo, Wang (2017) found evidence that incorporation of the CRIX index will improve the performance of a portfolio that mainly consists of mainstream assets. Cryptocurrency having significantly larger returns is also supported by previously mentioned authors such as Briere, Oosterlinck, Szafarz (2015); Corbet et al. (2018); Shahzad et al. (2019).

2.1.3 Risk-Return Tradeoff

In addition, the same papers show support to cryptocurrency having portfolio diversification benefits in terms of risk-return tradeoff, often represented by larger Sharpe ratios. In fact, Briere, Oosterlinck, Szafarz (2015) provide evidence that inclusion of even a small proportion of Bitcoin may dramatically improve the risk-return tradeoff. Platanakis, Urquhart (2019) provide evidence that including Bitcoin to a portfolio in an out-of-sample setting increases Sharpe, along with, Omega and Sortino ratios. Shahzad et al. (2019) found that Bitcoin has the highest Sharpe ratio against stocks. Lee, Guo, Wang (2017) conducted a sentiment analysis which indicates that the CRIX index has a relatively high Sharpe ratio. Lastly, Liu, Tsyvinski (2021) found that cryptocurrency Sharpe ratios are higher at daily and weekly levels compared to stocks.

2.2 Additional Findings

While this section does not directly influence the upcoming hypotheses, previous cryptocurrency literature provides us with a few of additional findings that institutional investors should be aware of concerning cryptocurrency problems, market price drivers and institutional investment factors. Corbet et al. (2019) carried out an empirical literature review on cryptocurrency as a financial asset class and proposed the 'cryptocurrency asset class trilemma', which consists of 1) bubble-like properties, 2) regulatory disorientation, 3) cybercriminality. The authors suggested regulation as one of the key factors affecting the price of cryptocurrencies. In fact, only negative and not positive regulatory events significantly affect cryptocurrency prices as discussed by Liu, Tsyvinski (2021). Sun, Dedahanov, Shin, Li (2021) investigated the role of cryptocurrencies in private equity company portfolios and factors affecting investing intention, proposing that the main drivers to investment intention are, in order of impact, innovativeness, brand familiarity, price consciousness, and brand trust. The authors argue that price volatility does not necessarily lower institutional investors' confidence in cryptocurrency as long as the market can offer timely and accurate price change information to meet investors'

price consciousness. In addition to that, Bialkowski (2020) found evidence that institutional investors can significantly lower volatility by employing stop-loss rules of automatically buying or selling cryptocurrency assets when the market hits a certain price, arguing that this could make cryptocurrency more feasible for institutional investors. Lastly, Hu, Parlour, Rajan (2018) studied the relationship between Bitcoin and alternative cryptocurrencies with the results showing that market returns of all other cryptocurrencies are strongly correlated with those of Bitcoin, indicating Bitcoin as a driving force for the cryptocurrency market and imposing further implications for cryptocurrency portfolio diversification and risk assessment.

2.3 Hypotheses

Based on literature findings in Section 2.1, low correlation between cryptocurrency and traditional asset classes can be expected, therefore raising the first hypothesis:

H1. ***Cryptocurrency has low correlation to traditional asset classes.***

Low correlation isolates cryptocurrency from traditional market shocks, thus, providing diversification benefits in terms of hedging risk.

Secondly, significantly larger individual cryptocurrency returns suggest that including cryptocurrency to a portfolio consisting of traditional asset classes may also significantly increase total portfolio returns, therefore:

H2. ***Addition of cryptocurrencies to a portfolio leads to significantly higher portfolio returns.***

If true, suggesting that cryptocurrency should be considered by investors looking to increase their total portfolio's performance.

Lastly, previous literature suggests evidence on diversification benefits in terms of the risk-return tradeoff, therefore:

H3. ***Addition of cryptocurrencies to a portfolio leads to a higher Sharpe ratio.***

Being the core hypothesis of the paper, the Sharpe ratio characterizes the risk-return tradeoff as its computation takes into account both the returns and the risk. A large Sharpe ratio indicates that returns outweigh the risk and proposes an asset as a viable choice for diversification.

3. DATA AND METHODOLOGY

3.1 Data Selection and Reasoning

3.1.1 Cryptocurrencies

The data was collected on a daily basis from a 3-year period, specifically January 1st 2019 to January 1st 2022, including values of market price and market capitalization. Cryptocurrency data was pulled from CoinGecko – the second most referred to cryptocurrency price tracking website, which, unlike CoinMarketCap, provides simple and free access to historical data. Selected cryptocurrencies include coins that, as of January 1st 2022, are in the top ten in terms of market capitalization or, in other words, have a market cap larger than $28,000,000,000 in order to avoid potential liquidity issues. Since institutional investors are not so keen on cryptocurrency yet in the first place, it is very unlikely that they are going to consider coins with lower market capitalization, unless they are directly involved in the development of some specific project. Coins that are excluded are coins that were not publicly launched before January 1st 2019 or, in other words, do not fit the required 3-year period. Since we are only looking at investment over time, stable coins are also excluded due to the fact that other ways of making back your return on investment in the cryptocurrency world such as staking, and lending are not considered in this research. This, however, could be something future research should explore. The selection criteria leaves us with a small, focused yet realistic sample of five different cryptocurrencies that could be of interest to an institutional investor: Bitcoin (BTC), Ethereum (ETH), Binance Coin (BNB), Cardano (ADA), Ripple (XRP).

3.1.2 Traditional Assets

For the selection of traditional assets, S&P indices are chosen to individually represent most popular institutional investment classes of stocks, bonds, and commodities. S&P indices are chosen due to the fact that they cover a wide range of different investment instruments, are time-proven, respected and commonly known. As indices themselves, in a way, are portfolios of different assets, this makes it a perfect choice to represent an already diversified portfolio of an institutional investor. For the exact same time period daily pricing data was pulled from S&P Global – the official S&P website that includes reliable and easily accessible historical data of all S&P indices. Originally, the goal was to include the Bloomberg U.S. Aggregate Bond Index (previously known as Barclays U.S. Aggregate Bond Index) to represent bonds, but, unfortunately, Bloomberg requires licensing to access historical data, which was unavailable.

The S&P500 index was chosen to represent institutional investors' stock allocation as it is arguably the most popular index which contains 500 of the largest publicly traded U.S. companies and adds up to approximately 80% of market capitalization. S&P U.S. Aggregate Bond Index was chosen as an alternative to the Bloomberg U.S. Aggregate Bond Index in order to represent the bond allocation. Lastly, S&P GSCI index was chosen to represent the commodity asset class as it is widely recognized and, more importantly, contains precious metals such gold and silver to which cryptocurrency is often compared to.

3.2 Methodology

Following data collection, various data analyses and tests were conducted in order to test whether the hypotheses stand true. First of all, all cryptocurrencies and asset classes were analyzed individually through descriptive statistics in order to summarize the characteristics of the data set and draw some first conclusions in terms of returns and volatility. Following, the risk-return tradeoff was explored for individual cryptocurrencies and traditional asset classes. The risk-return tradeoff was represented by the Sharpe ratio and computed with the following formula:

$$SR = \frac{R_A - R_f}{\sigma_A},$$

where R_A stands for return of portfolio or, in our case, average yearly return, R_f stands for the annual risk-free rate, which will be a constant throughout all of the assets explored and assumed to be 2%, and σ_p stands for volatility, which is annualized standard deviation calculated with the following formula:

$$\sigma_A = \sigma \times \sqrt{t},$$

where σ is the standard deviation of the data and t is number of periods or observations. To be more precise, t stands for 1096 days for cryptocurrencies, 756 days for S&P 500 and S&P GSCI indices, and 751 days for the S&P U.S. Agg.

Afterwards, the daily return data was transformed to weekly return data in order to make up for the difference of days in the data set between cryptocurrencies and traditional asset classes due to the fact that traditional markets are closed on the weekends and holidays. This gives us a new data set consisting of 157 weeks, making 157 our new t value, which will be used in further calculations. Having the same number of observations allows for more accurate comparison between cryptocurrencies and traditional assets starting with correlation testing. In order to see

whether Hypothesis 1 stands, cryptocurrency and traditional asset class pairs were tested for their Pearson's *R* coefficient on their weekly returns. Following that we are going to take a look at correlation coefficients between cryptocurrencies themselves to see whether there are any underlying dynamics between chosen cryptocurrencies as previous literature suggests that alternative cryptocurrency returns are strongly correlated with the returns of Bitcoin (Hu, Parlour, Rajan, 2018).

To ultimately answer the Research Question at issue, eight different portfolio allocations will be built and analyzed. The portfolios will be equally weighted for the simple reason that, if we were to build value weighted portfolios, they would be too dependent on the S&P 500 index due to its enormous market capitalization. It is important to note that these portfolio allocations are not necessarily realistic in the eyes of an institutional investor, but should, nevertheless, be viable for the purpose of this research of strictly finding out if the addition of cryptocurrency to an already well-diversified portfolio comes with diversification benefits. The first portfolio will consist only of the S&P indices serving as a benchmark portfolio to which all other portfolios will be compared to. This portfolio imitates an institutional investors' portfolio before addition of cryptocurrency. Following, cryptocurrencies are going to be added and replaced individually making five different portfolios consisting of traditional assets with each cryptocurrency. Lastly, we are going to take a look at whether including multiple cryptocurrencies or a portfolio of cryptocurrencies provides us with better returns or risk-return tradeoff benefits compared to just having one cryptocurrency. There will be two portfolios imitating this strategy with one being equally weighted and the other one being value weighted within the cryptocurrency allocation, whereas the full portfolio allocation stays the same.

Now that the portfolios are built we are going to conduct a portfolio analysis, where we are going to look at each of the portfolio's returns and volatility. To test Hypothesis 2, mean difference t-tests with assumed unequal variances are going to be conducted for portfolios including cryptocurrency against the benchmark portfolio consisting of only traditional investment instruments. Lastly, to test Hypothesis 3 and to answer the Research Question, portfolio volatilities and Sharpe ratios are going to be calculated using the formulas displayed at the start of this section.

4. RESULTS

4.1 Descriptive Statistics

As portrayed in Table 2, we can instantly observe significant differences between cryptocurrencies and traditional asset classes in terms of average daily and yearly returns. Binance Coin turned out to be by far the most profitable cryptocurrency for the time period of 2019-2022 with an average daily return of 0.58% and an average yearly return of 517%. On the contrary, XRP turned out to be the least profitable cryptocurrency even though it also had the largest volatility of all. If we set out to compare the most popular assets out of the two dimensions, Bitcoin daily returns are more than three times as large as the daily returns of the S&P 500, however, it is important to note that its volatility is also more than twice as large. Binance Coin, having the second largest volatility, also yielded the largest daily return of 73.79% on February 19th 2021. Alternatively, the largest daily loss of -43.05% was observed from Ethereum on March 12th 2020.

Clearly, the higher cryptocurrency returns come with its own drawbacks in volatility as all cryptocurrency markets have significantly higher volatility compared to the observed S&P indices. These differences in daily return graphs can be observed in Figure A1 in the Appendix. As expected, a conclusion can be made that cryptocurrency yields larger returns but have extremely volatile markers whereas traditional asset classes come with smaller yet more stable returns.

4.2 Individual Risk and Return

Previous section suggested that there is a certain tradeoff when it comes to cryptocurrency that the investor should be aware of. Table 3 takes into account both the returns and the volatility to provide us with the Sharpe ratio for each of the individual assets. All cryptocurrencies, except for XRP, more than made up for their market volatility as suggested by their high Sharpe ratios. Binance Coin turned out to be the best investment with a Sharpe ratio of 4.59, where a ratio larger than 2 is already considered very good. Following Binance Coin we have Cardano with the second largest Sharpe ratio of 3.25, Ethereum with a Sharpe ratio of 3.02, Bitcoin with a Sharpe ratio of 2.03 and XRP with the lowest cryptocurrency Sharpe ratio of 0.61.

S&P 500 was observed to have the largest Sharpe ratio of 0.99 out of traditional asset classes followed by the very stable S&P U.S. Agg with a Sharpe ratio of 0.74 and surprisingly underwhelming S&P GSCI with a Sharpe ratio of 0.54, which, matter of fact, turned out to be the worst asset observed in terms of risk return tradeoff. A conclusion can be drawn from this that cryptocurrency should, in fact, be considered as potential investment instrument by the institutional investors. Previous data suggests that cryptocurrency returns more than make up for their extreme volatility and while that does not guarantee the same results in the future it does imply a pattern that has been

	BTC	ETH	BNB	ADA	XRP	S&P 500	S&P U.S. Agg.	S&P GSCI
Mean	0.31%	0.43%	0.58%	0.48%	0.26%	0.09%	0.02%	0.06%
Annual mean	150%	288%	517%	357%	73%	24%	5%	16%
Median	0.20%	0.31%	0.27%	0.32%	0.00%	0.15%	0.02%	0.15%
Maximum	19.25%	24.53%	73.79%	30.89%	52.71%	9.38%	1.15%	7.99%
Minimum	-35.19%	-43.05%	-42.85%	-40.81%	-42.28%	-11.98%	-1.50%	-11.77%
Standard deviation	0.038266	0.049578	0.058853	0.057121	0.061225	0.014148	0.002209	0.015785
Standard error	0.001156	0.001498	0.001778	0.001725	0.001849	0.000515	0.000081	0.000574
Volatility	0.730731	0.946759	1.123871	1.090790	1.169177	0.224440	0.035044	0.250420
Skewness	-0.41282	-0.52334	1.790736	0.323293	1.367626	-0.73439	-0.75053	-1.22072
Kurtosis	8.824394	7.868116	27.63315	5.011541	16.29813	17.43173	7.755061	11.40513
Observations	1096	1096	1096	1096	1096	756	751	756

Table 2: Descriptive statistics for daily returns

Asset	Avg. Yearly Return	Volatility	Sharpe Ratio
Cryptocurrencies			
Bitcoin	150%	0.730731	2.03
Ethereum	288%	0.946759	3.02
BNB	517%	1.123872	4.59
Cardano	357%	1.090791	3.25
XRP	73%	1.169177	0.61
Traditional Assets			
S&P 500	24%	0.224440	0.99
S&P U.S. Agg	5%	0.035044	0.74
S&P GSCI	16%	0.250421	0.54

Table 3: Individual risk and return analysis

relatively consistent in the cryptocurrency space ever since the start of it.

4.3 Correlation

4.3.1 Cryptocurrencies and Traditional Assets

In agreement with Hypothesis 1 and previous literature findings, Table 4 does, in fact, suggest low to no correlation between returns of cryptocurrency and traditional asset classes. The highest observed correlation comes from the Cardano and the S&P GSCI pair with a R value of 0.337, which would still be considered low. Every single cryptocurrency, except for XRP, has its highest correlation with the S&P GSCI index, which could potentially be explained by the comparison of cryptocurrencies to commodities such as gold and silver. The Binance Coin and S&P U.S. Agg pair seems to be the only pair with a negative correlation, however, as the R value itself is extremely low negative correlation cannot be assumed.

	BTC	ETH	BNB	ADA	XRP
S&P 500	0.189	0.284	0.250	0.291	0.203
S&P U.S. Agg	0.043	0.074	-0.015	0.006	0.024
S&P GSCI	0.316	0.315	0.281	0.337	0.188

Table 4: Correlation between weekly returns of cryptocurrencies and traditional asset classes

4.3.2 Individual Cryptocurrencies

As Hu, Parlour, Rajan (2018) found evidence that alternative cryptocurrency coin market returns are strongly correlated with Bitcoin market returns, it would be wise to take a look if there are any underlying correlation dynamics within cryptocurrencies themselves which could hold potential implications towards institutional investors building a cryptocurrency portfolio. However, if we take a look at Table 5, only Ethereum has its strongest correlation with Bitcoin, which, also, is the only pair with an R value higher than 0.7. Binance Coin has its highest correlation with Cardano, Cardano has its highest correlation with Ethereum and XRP has its highest correlation with Cardano.

	BTC	ETH	BNB	ADA	XRP
BTC		0.785	0.594	0.628	0.461
ETH	0.785		0.569	0.690	0.548
BNB	0.594	0.569		0.599	0.459
ADA	0.628	0.690	0.599		0.563
XRP	0.461	0.548	0.459	0.563	

Table 5: Correlation between weekly returns of cryptocurrencies

This suggests that the alternative cryptocurrency markets could be becoming less and less dependent on Bitcoin as the overall cryptocurrency market develops over the years. This would make cryptocurrency a more flexible investment instrument allowing for more strategic choices such as hedging risk by acquiring a larger variety of cryptocurrencies each providing different functions. The possibility of decreasing Bitcoin dominance and correlation with alternative cryptocurrencies should be something future researchers investigate further as the topic is outside the scope of this paper.

4.4 Portfolio Analysis

Finally, moving on to the core essence of this paper of looking at what is the impact of adding cryptocurrency to an already well-diversified portfolio consisting of traditional assets including stocks, bonds, and commodities. Table A1 in the Appendix provides an overview of how the eight different portfolios were built and allocated.

4.4.1 Portfolio Returns

As portrayed in Table 6, every single portfolio containing at least one cryptocurrency coin clearly leads to higher returns overall. Portfolio diversified with Binance Coin seems to have yielded the highest return in general, with an average weekly return of 1.22% and an average yearly return of 63.87%. On the contrary, XRP seems to be the worst cryptocurrency to diversify with as it yielded the lowest return out of all portfolios outside of the benchmark portfolio. Each of the portfolios, except for the one including Bitcoin as their only cryptocurrencies, experienced their highest gains in the year 2021, making 2021 the most successful year out of the 3-year period.

Mean difference t-test assuming unequal variances with an α value of 0.05 suggest that acquisition of Ethereum, Binance Coin, Cardano, and portfolio of cryptocurrencies result in significantly larger returns. The implication on Hypothesis 2 is the fact that not all cryptocurrencies lead to significantly larger returns as there is not enough evidence to support the hypothesis for Bitcoin and XRP in this particular case. Conclusion being that, although Bitcoin is the most popular cryptocurrency there is, Bitcoin should not be the only cryptocurrency institutional investors are looking at as alternative coins simply yield significantly higher returns. On the other hand, it is important to note that Bitcoin is by far the safest and least volatile cryptocurrency as explored in Table 3 and finding that next Binance Coin is not particularly easy.

4.4.2 Portfolio Risk and Return

Even though particular cryptocurrencies can bring enormous returns, that does not necessarily make them good investment instruments. For the final step of this research, we are going to investigate the risk-return tradeoff of portfolios including cryptocurrency against the benchmark portfolio allowing us to see whether including cryptocurrency to an already well-diversified portfolio really does bring diversification benefits in terms of risk-return tradeoff by increasing portfolio's Sharpe ratio.

As shown in Table 7, the benchmark portfolio gives us a Sharpe ratio of 1.04 with lowest average weekly, yearly returns, while, also, having the lowest volatility, as expected. Therefore, cryptocurrencies in portfolios with a Sharpe ratio larger than 1.04 will be considered as good diversification options in terms of the risk-return tradeoff.

No.	Portfolio	Avg. Weekly Return	2019	2020	2021	Avg. Yearly Return
1.	Benchmark	0.28%	16.48%	8.47%	19.44%	14.79%
Inclusion of Individual Cryptocurrencies						
2.	With Bitcoin	0.75%	34.24%	46.50%	36.69%	39.15%
3.	With Ethereum	0.96%	18.93%	62.38%	69.79%	50.37%
4.	With Binance Coin	1.22%	42.10%	43.92%	105.59%	63.87%
5.	With Cardano	1.05%	16.07%	65.56%	84.00%	55.21%
6.	With XRP	0.67%	3.05%	26.78%	75.27%	35.04%
Inclusion of a Portfolio of Cryptocurrencies						
7.	With a Portfolio of Cryptocurrencies (Equally weighted)	0.93%	22.88%	49.03%	74.27%	48.72%
8.	With a Portfolio of Cryptocurrencies (Value weighted)	0.85%	28.81%	51.07%	52.88%	44.25%

Table 6: Portfolio returns

4.4.2.1 Diversifying with Bitcoin

Being the most popular cryptocurrency and the most plausible institutional investment option as of 2022, Bitcoin seems to be a relatively safe choice. Due to its low volatility, compared to other cryptocurrencies, and steady returns Bitcoin gives us a portfolio with a Sharpe ratio of 1.61 being the first cryptocurrency to be classified as a good diversification instrument supporting Hypothesis 3.

4.4.2.2 Diversifying with Ethereum

Ethereum is also a possible choice for diversification as including Ethereum to a portfolio consisting of stocks, bonds, and commodities does indeed increase the portfolio's Sharpe ratio to 1.74 supporting Hypothesis 3. We can see a slight increase in volatility compared to the Bitcoin portfolio but the increased returns clearly more than make up for it.

4.4.2.3 Diversifying with Binance Coin

This portfolio, despite having the second largest volatility out of all, results in the highest Sharpe ratio observed. Sharpe ratio of 1.92 does not only support Hypothesis 3, but, also, concludes Binance Coin as the single best cryptocurrency to diversify with in terms of the risk-return tradeoff based on 2019-2022 market pricing data.

4.4.2.4 Diversifying with Cardano

Yet another portfolio with extremely high volatility and returns suggests Cardano as another diversification choice as the Sharpe ratio of 1.70 supports Hypothesis 3. Although it is a runner-up in terms of returns themselves, the high volatility makes it a little bit less optional to institutional investors falling behind Ethereum as an asset as indicated by the Sharpe ratio.

4.4.2.5 Diversifying with XRP

Being the first, and the only, portfolio with a Sharpe ratio less than 1.04 makes XRP the only cryptocurrency that does not support Hypothesis 3. Acquisition of XRP to a portfolio consisting of traditional asset classes negatively affects the portfolio in terms of risk-return tradeoff as the returns are simply not enough to make up for the highest volatility of all.

4.4.2.6 Diversifying with All Five Cryptocurrencies

Diversifying the portfolio with multiple cryptocurrencies leads to increased Sharpe ratios of 1.83 and 1.78, suggesting portfolio of cryptocurrencies as a plausible diversification option and supporting Hypothesis 3. In fact, these portfolios lead to the second and third largest Sharpe ratios out of all, falling a place behind the Binance Coin portfolio. That is due to the fact that a wider variety of cryptocurrencies cover the best of both worlds as the allocation of Bitcoin lowers the volatility while the allocation of alternative coins increase the total returns. Equally weighted portfolio does come with higher returns due to larger

No.	Portfolio	Avg. Yearly Return	Volatility	Sharpe Ratio
1.	Benchmark	14.79%	0.122484	1.04
Inclusion of Individual Cryptocurrencies				
2.	With Bitcoin	39.15%	0.230587	1.61
3.	With Ethereum	50.37%	0.277235	1.74
4.	With Binance Coin	63.87%	0.322691	1.92
5.	With Cardano	55.21%	0.312164	1.70
6.	With XRP	35.04%	0.334054	0.99
Inclusion of a Portfolio of Cryptocurrencies				
7.	With a Portfolio of Cryptocurrencies (Equally weighted)	48.72%	0.255783	1.83
8.	With a Portfolio of Cryptocurrencies (Value weighted)	44.25%	0.237755	1.78

Table 7: Portfolio risk and return analysis

allocation of Binance Coin and Cardano, while the value weighted portfolio is less volatile due to the fact that Bitcoin and Ethereum make up for 88.67% of the cryptocurrency allocation. This implies that institutional investors could built an optimal cryptocurrency portfolio based on their risk aversion.

5. DISCUSSION

Whichever way you look at it, acquiring cryptocurrency does come with its share of risks and there is no way around it. However, the low correlation between cryptocurrency and traditional asset classes such as stocks, bonds, and commodities indicate the potential of diversification benefits provided by cryptocurrencies. For example, if the stock market goes down that does not necessarily mean that the cryptocurrency will go down as well making cryptocurrencies a viable instrument to hedge risk.

Adding cryptocurrency to a traditional portfolio of an institutional investor will always increase the portfolio's volatility, however, this paper in support with numerous previous literature findings suggest that increased returns more than make up for it as indicated by the increased Sharpe ratios. For the period of January 1st 2019 to January 1st 2022, Binance Coin, portfolio of cryptocurrencies, Ethereum, Cardano and Bitcoin, in order of impact, are possible diversification options in terms of risk-return tradeoff, whereas XRP hurts the portfolio. As indicated by the ranking, Bitcoin should not be the only cryptocurrency considered, despite its successful history and popularity. Although it is the least volatile, alternative cryptocurrencies come with two to three times larger returns, thus, also having more significance in a portfolio. In addition, as observed in Section 4.4.1, Bitcoin and XRP are the only cryptocurrencies that do not significantly increase portfolio returns. On the contrary, although Binance Coin turned out to be by far the most profitable while also having the largest Sharpe ratio, that does not necessarily mean that the pattern will continue in the following years, especially with its enormous volatility. It is easy to state that certain coins are the best options in hindsight, but in reality it is very difficult to find that next altcoin that is going to yield returns of over 500%. Section 4.4.2 suggests that diversifying with multiple cryptocurrencies could be the way to go as, this way, institutional investors can get larger returns while also having some control over the volatility. According to investors risk-preference, risk averse investors could delegate a larger allocation to coins like Bitcoin and Ethereum for a more stable growth, while risk tolerant investors could give a larger allocation to other alternative cryptocurrencies in hopes for higher-than-average returns.

Moving forward, future researchers should examine optimal cryptocurrency portfolio building. This concerns the allocation between traditional assets and cryptocurrencies, and allocation between cryptocurrencies themselves. Future researchers should study dynamics between cryptocurrencies with different functions such as smart contracts, DeFi, NFT, Metaverse and many more. Perhaps, to achieve an optimal cryptocurrency portfolio a certain percentage should be allocation to certain cryptocurrency types. On the other hand, perhaps, building a perfect allocation in a cryptocurrency portfolio is not even possible. With cryptocurrency still being an up-and-coming investment class much more research has to be done on it even on topics we have not though about yet before we can truly learn more about it and understand it.

6. CONCLUSION

This paper considered whether cryptocurrency has a place in institutional investor's portfolio by looking at whether inclusion of cryptocurrency increases the Sharpe ratio of an already well-diversified portfolio. Results suggest that, although cryptocurrency increases portfolio's volatility quite drastically, the increase in returns more than makes up for it. The Sharpe ratios were increased by the following cryptocurrencies, in order of impact: Binance Coin, portfolio of cryptocurrencies, Ethereum, Cardano, Bitcoin suggesting these assets as viable options for institutional investors in terms of risk-return tradeoff. It was concluded that the best option for investors is to diversify with multiple cryptocurrencies rather than one as this way large returns can still be achieved while, also, lowering and, to an extent, controlling volatility.

Correlation between cryptocurrencies and traditional assets has also been tested to see whether previous literature findings still stand true a few years later with the results showing low to no correlation. In addition, we looked at correlation between cryptocurrencies themselves with Ethereum being the only cryptocurrency to have its highest correlation with Bitcoin, suggesting that the cryptocurrency market is becoming less dependent on Bitcoin over the years.

Conducted mean difference t-test analysis suggest Binance Coin, Cardano, Ethereum and portfolio of cryptocurrencies as assets that significantly increase portfolio returns upon acquisition. With Bitcoin and XRP not having enough evidence to support this as well, we can conclude that Bitcoin should not be the only cryptocurrency considered with the goal of strictly increasing portfolio returns.

There are some noteworthy limitations encountered within this research that need to be taken into account. First and foremost, this research only considers buying and selling cryptocurrencies at a higher price as means to make profit, whereas other possibilities of making extra return in the cryptocurrency space such as staking, lending, futures and many more are disregarded. Secondly, the equally weighted portfolios are not necessarily realistic in the hands of an institutional investor. Allocating 25% of the total portfolio to cryptocurrency is not something that is likely to be observed in a real-life context, but nevertheless, was assumed to strictly find out whether including cryptocurrency to an already well-diversified portfolio brings positive impact. Lastly, this paper only considers volatility as a risk and does not examine other factors such as strict governmental regulation, which could drastically hurt the cryptocurrency market. Investors must be fully aware of these other risks before acquiring a cryptocurrency asset.

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8. APPENDIX

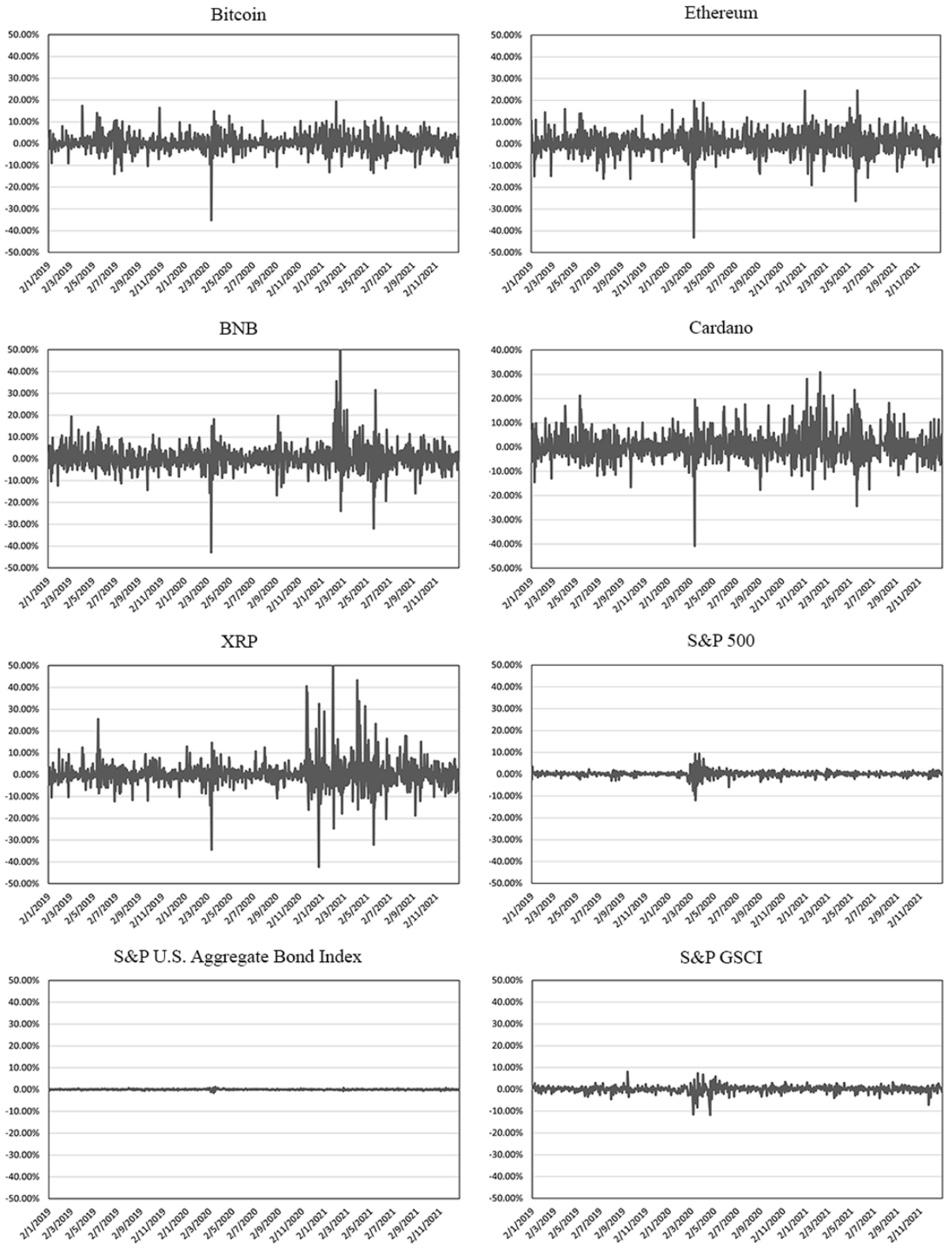

Figure A1: Volatility and daily returns

No.	Portfolio	S&P 500	S&P U.S. Agg	S&P GSCI	BTC	ETH	BNB	ADA	XRP
1.	Benchmark	0.33	0.33	0.33					
Inclusion of Individual Cryptocurrencies									
2.	With Bitcoin	0.25	0.25	0.25	0.25				
3.	With Ethereum	0.25	0.25	0.25		0.25			
4.	With Binance Coin	0.25	0.25	0.25			0.25		
5.	With Cardano	0.25	0.25	0.25				0.25	
6.	With XRP	0.25	0.25	0.25					0.25
Inclusion of a Portfolio of Cryptocurrencies									
7.	With a Portfolio of Cryptocurrencies (Equally weighted)	0.25	0.25	0.25	0.05	0.05	0.05	0.05	0.05
8.	With a Portfolio of Cryptocurrencies (Value weighted)	0.25	0.25	0.25	0.5904	0.2963	0.0582	0.0284	0.0266

Table A1: Structuring and allocation of the eight different portfolios