ENHANCING INVESTMENT PORTFOLIO PERFORMANCE WITH CRYPTO

by

Bohdan Vasyliv

A thesis submitted in partial fulfillment of the requirements for the degree of

MA in Business and Financial Economics

Kyiv School of Economics

2022

Thesis Supervisor: _____ Professor: Olesia Verchenko

Approved by _____

Head of the KSE Defense Committee, Professor [Type surname, name]

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Date _____

ACKNOWLEDGMENTS

I would like to express my thanks to Professor Olesia Verchenko for all the help and expertise provided throughout this work. I would also like to thank Professor Anrii Drobot for his extraordinary work during the classes and all the effort put into his students. Additionally, I would like to thank all the KSE community for a wonderful time spent at KSE.

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LIST OF ABBREVIATIONS

MPT Modern Portfolio Theory

PMPT Post-Modern Portfolio Theory

BTC Bitcoin

ETH Ethereum

XRP Ripple

BNB Binance Coin

DOGE Doge Coin

ADA Cardano

S&P 500/GSPC Standard and Poor's 500 Index

AGG iShares Core U.S. Aggregate Bond ETF

TG Tangent Portfolio

RF Risk Free Rate

CHAPTER 1. INTRODUCTION

For investors to make money on the financial market they must keep up with the trends and constantly look for way to improve their portfolio performance to meet their expected returns or beat the market.

Cryptocurrencies are a new asset classes that has been able to provide great returns to some investors and serve as a diversification tool for the other. Therefore, one needs to understand how to use this new asset class to enhance his/her portfolio performance. But for an investor to do so one must reply on some theories and do the necessary research before making any investment decisions.

One of the most important and pioneering portfolio creation and management theories is Modern Portfolio Theory by Markovitz (1952). It allows non-correlated assets to be combined in an efficient way to optimize returns given a certain level of risk.

For a long time, investors were combining risk-free investments with risk portfolios consisting of various asset classes like stocks, private equity, corporate bonds, commodities and so on. But around a decade ago Bitcoin was introduced to the world and a new asset class emerged: cryptocurrencies.

Cryptocurrencies has drawn a lot of attention in the recent times. A lot of enthusiasts have tried investing in this newly emerged asset class. Many of them failed. Therefore, it's important to mention that prior to making any diversifications an investor must gain sufficient understanding of the market and what is driving it.

Having said that, cryptocurrencies or crypto, for short, are a great tool for diversifying classic or old-school investment portfolios. One of the most important reasons for that is non-correlation with the classic asset classes like stocks or bonds.

Therefore, this paper is aimed at understanding how to combine crypto with asset classes that are widely used using MPT and Cointegration analysis. How to maximize returns from those portfolios given a certain level of risk an investor is going to be comfortable with. And testing pair trading strategies based on cointegration.

CHAPTER 2. INDUSTRY OVERVIEW AND RELATED STUDIES

2.1. Industry overview.

Crypto currency is decentralized digital currency designed to be used over the internet. Bitcoin was the first crypto to be introduced to the market in 2008. And so far, has remained the biggest and the most influential one. There are other popular cryptocurrencies like Ethereum (ETH), Binance Coin (BNB) or Ripple (XRP). Each crypto has some purpose or represent a specific project. Although some investors tend to agree that 90% are the same. And that the differences between crypto projects can be neglected and don't contribute in any way to application of cryptocurrencies in the real world.

Crypto enables transaction online without a third party involved (bank or payment processer). And allowing to transfer any amount of money with no restrictions or high fees almost instantly around the world. Most of the cryptocurrencies are also not controlled by the government or any central authority or individual. Which makes it decentralized and private.

Blockchain is a distributed ledger technology behind cryptocurrencies. It's a list of records, called blocks, that are connected using cryptography. Each block contains some information about transactions and cannot be amended after it has been approved by the network. The fact that blockchain records cannot be changed expands this technology beyond crypto world and finds its application in such spheres as music and land administration.

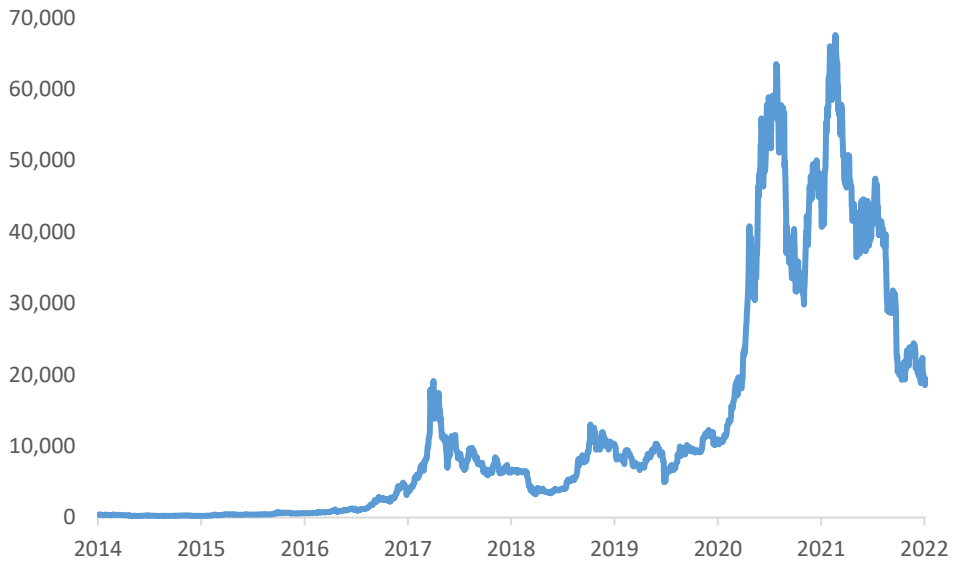
It's important to mention that if it wasn't for its extremely high volatility and sky-rocketing prices, crypto market would probably go unnoticed until now. Bitcoin has been traded on various crypto exchanges around the world since 2010 and has

experienced a lot of volatility over time attracting a lot of get-rich-quick enthusiasts along with professional and institutional investors.

Crypto exchange is a marketplace where people can buy and sell different cryptocurrencies. They are like brokerages, but only for crypto instead of stocks or bonds. One can deposit fiat money and then exchange it for crypto or deposit crypto and exchange it for fiat. Users can withdraw money to their bank account or digital wallets.

The fact that Bitcoin has increased from 1$ USD in April 2011 to 67,000$ USD in November 2021 naturally makes a lot of people interested not only in Bitcoin but in the other cryptos in general. However, other cryptocurrencies are not going to be reviewed in this thesis as most of them are highly correlated with Bitcoin and don't exist for a long enough time to be fitted into the models used in this paper.

Figure 1. Bitcoin prices USD, 2014-2022.



Source: Finance.yahoo.com, Bitcoin USD (BTC-USD)

2.2. Related Studies

Cryptocurrencies have been mostly used by computer nerds initially. And to this day they are not widely used in different walks of life. Therefore, a lot of people neither any idea how to use them nor how they work nor what drives their price, etc. For those reasons most of the information about crypto is in a form of informal articles or videos on the internet as the people creating this content neither have PhD nor are trying to present the information as if they have one. But there are some good papers that stand out. Most of them have been published recently.

However, most of the studies and theories necessary for portfolio analysis have been published long time before Bitcoin was created. For example, Portfolio Selection by Harry Markowitz published in 1952 featured Modern Portfolio Theory, which cemented the foundation for portfolio analysis and optimization. It's explained in the paper that overall portfolio volatility decreases if combining non-correlated assets. A new term has also been introduced: Sharpe ratio. It's a comparison of the returns on an investment with its risk. The hight the ratio the better. The higher the ratio the more returns an investor is receiving for the same amount of risk taken.

The Postmodern Portfolio by Grayscale published in 2022 is the most recent paper on involvement of Bitcoin and cryptocurrencies with classic asset classes. It uses the abovementioned MPT for modelling possible returns, volatility and Sharpe ratios of a classic portfolio consisting of stocks (60%) and bonds (40%) mixed with different levels of exposure to cryptocurrencies ranging from 1% to 50%. Cryptocurrencies are represented by a crypto basket created by Grayscale Investments (Grayscale Digital Large Cap Fund). Time period used: 2019-2022. This paper concludes that adding crypto to a classic portfolio pays off and depending on the risk preferences investors must add a small allocation to crypto in their portfolios. For example, by adding 5%

allocation to a classic 60/40 portfolio returns increase from 43% to 67% and volatility increases from 11.9% to 12.3%. Incremental changes in volatility lead to big changes in returns due to huge upside potential of cryptocurrencies.

However, there is a lot of debate going around whether to use Bitcoin as a general benchmark for crypto market. Market share of Bitcoin is roughly 40% which means that it's the most popular and influential crypto on the market.

Table 1. Market Share. Top 10 Cryptocurrencies, 2022.

Rank	Name	Market Share
1	Bitcoin	39.78%
2	Ethereum	17.26%
3	Tether	7.43%
4	USD Coin	4.98%
5	BNB	4.73%
6	XRP	2.67%
7	Binance USD	2.35%
8	Cardano	1.45%
9	Solana	1.21%
10	Dogecoin	0.86%
#	Other	17.27%

Source: Slickcharts.com, Cryptocurrency Market Data

Cryptocurrencies like BNB or Cardano has only been introduced into the market recently and therefore their long-term growth potential is hard to predict. If adding market share into consideration these cryptos are not good for long-term holding. Bitcoin on the contrary has been dominating the crypto market since its inception in 2008. Ethereum has also been holding its position as the second most popular cryptocurrency. Data for ETH is available since 2017 and therefore Bitcoin is the best crypto for the analysis due to its long history and market share.

It's possible to create a basket of a bunch of cryptocurrencies. However, all the cryptocurrencies are highly correlated with one another, and such a portfolio wouldn't make much sense. And therefore, using Bitcoin alone would be the best solution for investors looking to diversify their stock/bond portfolios with a little bit of crypto.

Table 2. Correlation of returns.

	ADA	BNB	BTC	DOGE	ETH	GSPC	XRP
ADA	1.00						
BNB	0.67	1.00					
BTC	0.73	0.77	1.00				
DOGE	0.57	0.55	0.60	1.00			
ETH	0.76	0.77	0.86	0.60	1.00		
GSPC	0.44	0.46	0.51	0.34	0.52	1.00	
XRP	0.74	0.65	0.69	0.52	0.75	0.43	1.00

Source: Finance.yahoo.com. 2017-2022 daily data.

Correlation of returns is vital when creating a diversified portfolio. The lower the correlation of returns between assets the better. Correlations in a range from 0.3 to 0.6 are considered acceptable.

All the reviewed cryptocurrencies are not correlated with GSPC. BTC and ETH have the worst results, 0.51 and 0.52 respectively. DOGE has the best result of 0.34.

Bitcoin is highly correlated with all the cryptocurrencies mentioned above expect for DOGE (0.55). Making DOGE a potential candidate for diversifying BTC/GSPC portfolio.

CHAPTER 3. METHODOLOGY

The focus of the study is to determine how to effectively add Bitcoin to an investment portfolio of a classic investor and observe changes in volatility and returns.

To create and balance an investment portfolio there must be two components: risk-free asset and Tangent Portfolio (TG) or Risk Portfolio. Risk-free asset is a 1-year US Treasury Bond. The rates are published daily by U.S. Department of Treasury. The last day of data collected is the 23d of September 2022 and the risk-free rate on that day was 4.15% p.a. This day is viewed as the day when an investor is making decisions about allocation of assets in his portfolio.

The paper works mostly with daily returns and therefore it's necessary to calculate the daily risk-free rate that will be used hereafter. To do that the following formula will be used:

$$Rf\ (daily) = (1 + Rf)^{\left(\frac{1}{252}\right)} - 1$$

252 is the number of trading days in a year. Rf is the risk-free rate of 4.15%. Rf (daily) that will be applied in this paper is 0.01614% daily.

Classic investment portfolio consists of 60% stocks (risk-assets) and 40% bonds (risk-free assets). The goal is dilute the risk portfolio with crypto and explore the consequences of such actions. It's also important to change percentage allocation to the risk-free asset and explore how returns and volatility are going to change. Sharpe ratio, which represents a relationship of returns on an investment with its risk, is an important metrics for comparing the portfolios mentioned previously.

It's necessary to determine correlation of returns between assets beforehand. If assets are highly negatively or positively correlated, then they are not a good fit for creating a diversified portfolio.

Correlation of returns can be measured in Excel by using Variance Covariance Matrix to create Correlation Table.

According to Modern Portfolio Theory by Markowitz, an optimal risk portfolio should be based on a maximum Sharpe ratio. There are 2 assets in the risk portfolio in question: BTC and GSPC. By using Solver in Excel one can find an optimal relationship between the 2 assets to get the highest Sharpe ratio.

Sharpe ratio = (Expected Return – Risk Free Rate) / Volatility

Expected Return is calculated as an average of asset returns over a certain period.

Risk Free Rate is determined by outside factors like US Treasury bills.

Volatility is calculated as standard deviation of returns.

Modern Portfolio Theory says that after determining a risk portfolio that provides the highest Sharpe Ratio an investor should choose the level of risk and investor is comfortable with by changing allocation to risk-free asset (US Treasury bills in our case).

However, when working with Bitcoin we have consider not only market risk but a different type of risk as well. A risk that cannot be measured but must be considered. Bitcoin has been around only for a decade and there is a lot of unknown around it. It's unclear exactly who created it and why. Satoshi Nakamoto is believed to

be the founder. However, nobody knows who he really is and if this name is real. There's a lot of debate as to whether it's indeed decentralized and anonymous. Some people say it's controlled by some governments. A lot of people believe that Bitcoin is just a pyramid scheme created to deceive investors worldwide. Or it's bubble that is going to burst any minute.

Bitcoin is not backed by anything, and this fact makes a lot of famous investors look the other way. One of them is Charlie Munger, vice president of Berkshire Hathaway, says this about crypto: "I think anybody that sells this stuff is either delusional or evil. I won't touch the crypto," Munger said in an interview with the Australian Financial Review, adding that he's "not interested in undermining the national currencies of the world." He later added that he would never touch crypto.

Unlike the stock market where a price of a stock is determined by the company's future cash flow on one side and the market on the other side. Therefore, stock prices aren't expected to drop to 0$ or skyrocket by 1000% in one day. There's always going to be people who will buy undervalue stocks and sell overvalued ones. The market keeps itself in the equilibrium.

It doesn't work the same way with crypto. The price of a crypto will go up for as long as there are people who are willing to pay a higher price for the same asset than the previous buyer. If there are nobody ready to pay more the market crashes to a point when somebody is going to be buying.

Dutch Tulip Bulb Market Bubble occurred from 1634 to 1637 in the Netherlands. It's the most famous example of a market bubble in the history. At peak some of the tulips were traded at a range from $50,000 to $150,000 in today's money. The best tulips could be worth up to $1,000,000 in today's money. And then in 1637 this bubble burst and the same tulips were not worth almost anything.

A lot of investors fear that the same can happen with Bitcoin and the crypto market. And therefore, are not keen on allocating a big portion of their investment portfolio to cryptocurrencies.

For those reasons, risk level of a portfolio depends on allocation to Bitcoin as well. Even if Modern Portfolio Theory implies that a high allocation to Bitcoin is good idea – not all investors are going to be comfortable with. Numbers may not be the only indicator for them. That's why it's important to consider different allocation to Bitcoin in a risk-portfolio.

3.2. Pairs Trading

Cointegration of assets can be used in Pairs Trading strategy. It's utilized a price relationship between two similar assets (stocks or crypto currencies) to benefit from situations when it's diverging from the historical benchmark. If assets are highly correlated, then the two cointegrated asset will converge to the same price relationships repeatedly. This strategy is market-neutral which means it can be a great tool for diversification.

One of the assets is taken as independent variable and another as a dependent one. It doesn't matter which asset to view as an independent one because the result will always be the same if assets are fully cointegrated.

If the dependent variable is overvalued based on a projected value, then the dependent asset/variable should be shorted (short selling position should be open) and long position should be open for the independent variable. Dependent being (Asset A), independent being (Asset B). In other words, an investor borrows (Asset A), which is overvalued, then sells it for cash, buys the other asset (Asset B) with this cash and waits for a price relationship to be restored. When it happens, he/she sells (Asset B) and buys (Asset A) to give it back to a person/institution it was borrowed from in the first place. At the moment of retuning (Asset A), its price should be lower than before and the

difference between prices is the profit an investor has made. A vice versa strategy is used when (Asset A) is undervalued.

Rebalancing of a portfolio can be done every day. However, it's quite costly due to commissions that must be paid to a broker or a trading platform. For simplicity daily rebalancing with no fee is applied in this paper.

To prove that cointegration exist one must make a Dickey Fuller Unit Root Test. Critical values are represented in (Table 3).

Table 3. Critical Value for Dickey Fuller test

t critical (10%)	-1.616
t critical (5%)	-1.941
t critical (1%)	-2.567

Source: Wikipedia.

CHAPTER 4. DATA

4.1. Bitcoin and S&P 500

The research is based on daily data gathered from 2014 to 2022. Finance.yahoo.com is a website with information about different financial assets and their daily prices. The assets explored in the paper: Bitcoin (BTC), S&P 500 (GSPC).

Daily prices were converted to daily returns to then create a corelation matrix of returns to see if assets are correlated. The returns were later used to calculate metrices necessary for the analysis.

Table 4. Metrices. GSPC, BTC and other cryptos.

	ADA	**BNB**	**BTC**	**DOGE**	**ETH**	**GSPC**	**XRP**
Expected returns	0.58%	0.66%	0.19%	0.84%	0.31%	0.039%	0.37%
n	1245	1245	1245	1245	1245	1245	1245
stddev	9.8%	7.7%	4.8%	13.7%	6.2%	1.4%	8.2%
variance	1.0%	0.6%	0.2%	1.9%	0.4%	0.0%	0.7%
Sharpe ratio	0.057	0.084	0.037	0.060	0.047	0.017	0.043

Source: Finance.yahoo.com. 2017-2022 daily data.

Table 5. Metrices. GSPC, BTC.

	BTC	**GSPC**
Expected returns	0.299%	0.037%
n	2017	2017
stddev	4.59%	1.16%
variance	0.21%	0.01%
Sharpe ratio	0.062	0.018

Source: Finance.yahoo.com. 2014-2022 daily data.

Expected Returns = Average returns over a period

N = Number of observations

Stddev = Standard deviation of returns / Volatility of an asset

Variance = Variance of Returns

Sharpe Ratio = (Expected Returns – Risk-Free Rate) / Stddev

From the following data it's clear that Bitcoin is much more volatile than GSPC. 4.59% for BTC against 1.16% for GSPC. This in turn means that BTC is riskier than GSPC. However, expected return on BTC is also higher than GSPC. 0.299% for BTC against 0.037% for GSPC. Figure 1. shows growth of Bitcoin from 2014 to 2022. Figure 2. shows growth of GSPC from 2014 to 2022. It's clearly seen that both have experience a bull run during that period. To identify which assets provides better returns for the risk take one must consider Sharpe Ratio. It's much higher for Bitcoin

than GSPC. 0.062 against 0.018. However, investing everything in Bitcoin is not a good idea. Modern Portfolio Theory explains why.

Figure 2. S&P 500 prices USD, 2014-2022.

Source: Finance.yahoo.com. 2014-2022 daily data.

4.2. Pairs Trading

Bitcoin and Ethereum are the best coins for pairs trading because their returns are highly correlated. Dickey Fuller test shows that t-stat is -2.534. The same test with Bitcoin and GSPC returns -0.271. Critical value for 10% is -1.616, which means BTC and GSPC are not cointegrated and BTC and ETH are cointegrated.

CHAPTER 5. RESULTS

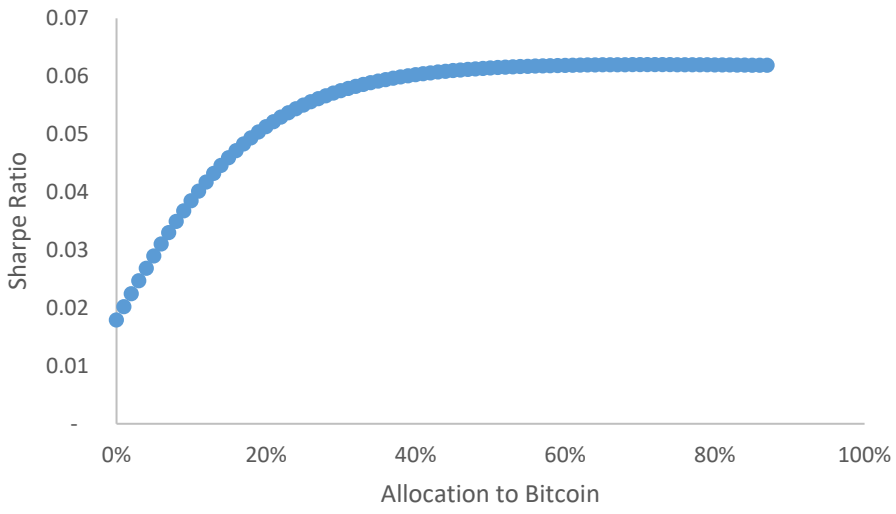
Maximum Sharpe ratio calculated by Solver tool in Excel is 0.061976. Allocation to BTC is 70.43% in this risk portfolio. Results can be seen in Table 5. When adding Bitcoin Sharpe ratio starts increasing rapidly and then after 70.45% slowly declines.

Table 6. Maximum Sharpe Ratio for BTC&GSPC portfolio.

BTC	GSPC
70.43%	29.57%
Er	0.22%
stddev	3.31%
Sharpe ratio	0.061976

Source: Author's calculations.

Figure 3. Sharpe Ratio depending on allocation to Bitcoin.



Source: Author's calculations.

Table 7. Portfolio Variations. Part 1.

BTC	GSPC	Er	Stddev	Sharpe
0%	100%	0.04%	1.16%	0.017896
4%	96%	0.05%	1.17%	0.026831
9%	91%	0.06%	1.21%	0.036729
24%	76%	0.10%	1.54%	0.054352
70%	30%	0.22%	3.30%	0.061975
0%	100%	0.04%	1.16%	0.017896
4%	96%	0.05%	1.17%	0.026831
9%	91%	0.06%	1.21%	0.036729

24%	76%	0.10%	1.54%	0.054352
70%	30%	0.22%	3.30%	0.061975
0%	100%	0.04%	1.16%	0.017896
4%	96%	0.05%	1.17%	0.026831
9%	91%	0.06%	1.21%	0.036729
24%	76%	0.10%	1.54%	0.054352
70%	30%	0.22%	3.30%	0.061975

Source: Author's calculations.

Table 8. Portfolio Variations. Part 2.

Risk Free Allocation	BTC in Portfolio	GCPS in Portfolio	Er	Stddev	Sharpe	Annual Er	Annual Stddev
60%	0.00%	40.00%	0.024%	0.47%	0.0179	6.4%	7%
60%	1.60%	38.40%	0.029%	0.47%	0.0268	7.5%	7%
60%	3.60%	36.40%	0.034%	0.48%	0.0367	8.9%	8%
60%	9.60%	30.40%	0.050%	0.62%	0.0544	13.3%	10%
60%	28.00%	12.00%	0.098%	1.32%	0.0620	27.9%	21%

40%	0.00%	60.00%	0.029 %	0.70 %	0.017 9	7.5%	11%
40%	2.40%	57.60%	0.035 %	0.70 %	0.026 8	9.2%	11%
40%	5.40%	54.60%	0.043 %	0.73 %	0.036 7	11.4%	12%
40%	14.40%	45.60%	0.066 %	0.92 %	0.054 4	18.2%	15%
40%	42.00%	18.00%	0.139 %	1.98 %	0.062 0	41.8%	31%
20%	0.00%	80.00%	0.033 %	0.93 %	0.017 9	8.6%	15%
20%	3.20%	76.80%	0.041 %	0.93 %	0.026 8	10.9%	15%
20%	7.20%	72.80%	0.052 %	0.97 %	0.036 7	13.9%	15%
20%	19.20%	60.80%	0.083 %	1.23 %	0.054 4	23.3%	20%
20%	56.00%	24.00%	0.180 %	2.64 %	0.062 0	57.1%	42%

Source: Author's calculations.

Tables 7 and 8 show what portfolio performance can be expected based on the risk level chosen by an investor. Allocations of 4%, 9%, 24% and 70% are chosen because they represent changes of Sharpe ratio by some significant percentage that investors can operate in their analysis. By allocating 4% of the risk portfolio to Bitcoin,

Sharpe ratio increases by 50%. By allocating 9% to BTC, Sharpe ratio is increasing by 105%. Table 7 shows the results.

Table 9. Sharpe ratio increase depending on Bitcoin.

BTC	Sharpe Ratio incerease
4%	50%
9%	105%
24%	204%
70%	246%

Source: Author's calculations.

The biggest increase is from allocating 70% to BTC. It's the maximum Sharpe ratio that can be observed. By changing allocation to BTC from 24% to 70%, Sharpe ratio increases from 0.0544 to 0.062. This is 14% increases. And 42% difference with the previous level in terms of Sharpe ratio increase from 0%. For most of the investors a change in allocation to BTC from 24% to 70% is a big change. And not all are comfortable with it due to uncertainties around the crypto market.

For that kind of investors, it's best to consider smaller allocation to BTC and therefore balance the risk exposure not only with changing the percentage of risk-free asset but also changing allocation to Bitcoin. Table 6. is most suitable for that purpose. It shows how expected returns and volatility change if the changing risk-free asset allocation for the same level of BTC allocation in the risk portfolio.

In the middle of the table there is 40% allocation to risk-free asset. There are the possible variations of a classic 60/40 (stock/bond) portfolio. Most of the investors would consider options for diversification in that area. By allocating 9% to BTC,

portfolio daily volatility increases from 0.7% to 0.73%. This is 4.3% increase in volatility. If annualized, then from 11% to 12%. Expected return should increase from 0.029% to 0.043%. This is 48% increase in profitability of the portfolio with only a 4% increase in volatility.

5.2. Pairs Trading

For simplicity a starting portfolio of 100 USD was considered. Overall return is 290% (31,3% yearly) over 5-year period (Figure 4).

Figure 4. Pairs Trading result. Bitcoin and Ethereum.

Source: Author's calculations.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

Based on the risk preference each investor must carefully consider different types of risk. Market and existential risk alongside with other risks which are not mentioned in this paper. Depending on the risk preference an investor can choose the portfolio which is most suitable for him/her. The options outlined in Table 6. depict 3 groups which internally vary depending on BTC allocation.

If an investor is considering existential risk of crypto market as a serious threat, he/she should consider lower allocation to BTC and then adjust allocation to risk-free asset. If an investor doesn't consider existential risk of crypto market as an important factor, then he/she should choose 70% allocation to BTC to maximize Sharpe ratio and then choose allocation to risk-free asset.

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