UNIVERSITY OF GOTHENBURG

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DOES BITCOIN MAKE SWEDES SHARP(E)?

An empirical study of the effect on risk-adjusted return when including Bitcoin in the average Swedish investor's portfolio

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Abstract

Globalization causes domestic markets to become increasingly correlated, making it harder for investors to find instruments for diversification. Bitcoin is a cryptocurrency that has shown spectacular returns and drawn great attention during the past two years. This thesis investigates the effect on the risk-adjusted return when including Bitcoin in the average Swedish investors' portfolio, and evaluates potential hedge and safe haven capabilities. We apply the Mean-Variance Optimization framework in adjunction to Monte Carlo simulations on bootstrapped daily returns to find the optimal Bitcoin allocation and its effect on risk-adjusted return. Correlation matrices are used to identify safe haven and hedging capabilities. Our results support the findings of previous research, that including Bitcoin in an average investors' portfolio offers additional return to the same level of risk. Furthermore, Bitcoin show weak hedge and safe haven capabilities against many assets included in the average Swedish investors' portfolio. Hence, the average Swedish investor is better off by including Bitcoin in the portfolio.

Keywords: *Bitcoin, Cryptocurrency, Portfolio Optimization, Hedge, Safe Haven, Diversification, Sharpe Ratio*

Table of Content

1. Background

This chapter aims to convey the underlying reasons as to why we chose to investigate Bitcoin as a diversifying asset. We introduce the concept of diversification and its effect on decreasing risk. Furthermore, presenting the definition, advantages and disadvantages of Bitcoin.

1.1 Diversification on the global market

Continuous innovation causes the world to grow more digital and interconnected every day. Globalization open for increased diversification opportunities through investing in assets across countries and industries that were inaccessible before. Therefore, the process of globalization is usually praised for creating opportunities to diversify investment portfolios (Pauzner 2004).

However, Fernandes (2003) states that financial integration leads to increased correlation across countries. A higher degree of integration of a country's economy with the world economy implies more exposure to international economic shocks, and higher correlation of the national business cycle activity with the worlds business cycle (Backus et al. 1992). The strive for diversification thereby decreases the variance of portfolio returns, but also increases the probability of economic crisis (Pauzner 2004).

Moldovan (2011) found that stocks appeared to be highly correlated during the financial crisis of 2008, placing further emphasize on diversification. In the search of assets that do not follow this pattern and instead reduce risk in times of financial distress, the phenomenon of save haven assets has emerged.

1.2 Assets that decrease systematic risk

1.2.1 Diversifier asset

A diversifier is an asset that has a weak positive correlation with another asset on average (Bouri et al. 2017).

1.2.2 Hedging assets

A weak hedge is uncorrelated with another asset on average, while a strong hedge is negatively correlated with another asset on average (Baur & McDermontt 2010). Hillier (2006) found that gold, platinum and silver all possess hedging capabilities.

1.2.3 Safe haven assets

A weak safe haven is uncorrelated with another asset in extreme market conditions, while a strong safe haven is negatively correlated with another asset in extreme market conditions (Baur & McDermontt 2010). The important distinction here is that safe havens are uncorrelated in times of distress only, and not necessarily on average.

A safe haven asset is typically perceived as performing reasonably well in difficult market situations: it should have a low exposure to traditional risk factors and not be sensitive to market volatility and liquidity squeezes. A safe haven currency benefits from negative exposure to risky assets and appreciates when market risk and illiquidity increase (Söderlind 2009). Gold is the most traditional safe haven asset, both in periods of crisis as well as those of increased uncertainty (Baur & McDermott 2010). Söderlind (2009) showed that the Swiss Franc, the Japanese Yen and the Euro also behave as safe haven assets in distressed times.

1.3 Bitcoin

1.3.1 Description

Bitcoin was launched in 2008 as the world's first decentralized digital currency. Developed by Satoshi Nakamoto, a pseudonym for the person or group that until this day remains anonymous. The crypto peer-to-peer currency is based on blockchain technology. The technology ensures that changes cannot be made to the chain of transactions (Gartner 2018).

Bitcoin enables transactions without the use of a financial institution as an intermediary. Neither can the currency be controlled by any governmental institution. The creation of new Bitcoins is done by so called miners who are rewarded new Bitcoins when confirming a transaction. However, there is a set limit at 21 million Bitcoins, after that miners' incentives will be only the transaction fee.

The main advantages of Bitcoin to fiat currencies are decentralization, pseudoanonymity, transparency, accessibility and the reduction of exchange and transaction cost. Decentralization refers to the fact that Bitcoin is not regulated by a central bank, as fiat currencies are. In times of economic instability, central banks will thereby not be able to affect Bitcoin through monetary policy acts, implying stability to the currency holder. Second, Bitcoin users are pseudoanonymous through the use of public and private keys not linked to their real-world identity. Transactions can be traced to a Bitcoin address but not to a person. Furthermore, the Bitcoin blockchain ledgers are publicly available resulting in greater security of ownership. Last, the elimination of an intermediary institution causes the transaction cost to significantly drop (Investopedia 2018).

The digital currency however does not only possess advantages, there are multiple debated disadvantages to Bitcoin possibly hurting its future success. One major disadvantage regards Bitcoins history of being the go to currency for illegal transactions including tax evasion, terrorism and trading drugs and weapons (Badea & Rogojanu 2014). Furthermore, anonymity of ownership pose an opportunity for hackers to perform cyberattacks. Moore & Christin (2013) found that 18 out of 40 Bitcoin exchanges have been temporarily closed down due to cyberattacks. A currency is defined as anything that is generally accepted as payment for goods or services or in the repayment of debt (Eakins & Mishkin 2011). The value of any currency is equal to the value that users place in it. Value and trust are thereby highly linked, which is why Bitcoins history on the black market and being subject to cyberattacks could limit it from becoming successful as a currency. These factors have led many governments to ban, or discuss regulations of cryptocurrencies as means for payments and investments (Nelson 2018).

1.3.2 Classification

Although Bitcoin is introduced as a digital currency, there have been discussions regarding whether it should be classified as a currency or an investment asset. Yermack (2013) argues that even though Bitcoin has several characteristics usually associated with currencies, it does not fully function like one. Yermack (2013) suggests that the high volatility of Bitcoin, amongst other reasons, make it similar to a speculative investment resembling the Internet stocks in the late 1990s. Further supporting the non-currency classification is the relatively low level of adoption for accepting Bitcoin as a payment method.

2. Problem statement

In this chapter we elaborate on the unanswered questions regarding Bitcoin's effect on a Swedish investor's portfolio's risk adjusted return. We concretize two research questions that the thesis will aim to answer.

2.1 Problem discussion

The characteristic of decentralization has provoked discussions regarding whether Bitcoin has hedging or safe haven capabilities. As governments and central banks cannot affect its value since it is not tied to any single economy, the value becomes less sensitive to a single markets distress. Furthermore, the fixed limit of Bitcoins at 21 million, although the demand deposit could be higher, provides stability in the supply further supporting the question of hedging capabilities. Popper (2015) called Bitcoin digital gold, due to the similar characteristics of the two assets.

Previous research has been made on whether Bitcoin can be used to increase risk adjusted return. Dyhrberg (2015) argued that Bitcoin has hedging capabilities against the Financial Times Stock Exchange Index of the 100 largest stocks in terms of market capitalization on the London Stock Exchange. Klabbers (2017) found that Bitcoin possess diversifying properties on the global market, however, no hedge or safe haven properties were confirmed. The same results were also found by Eisl et al. (2015). Ahnhem & Lindberg (2017) performed research on the Swedish market and found that Bitcoin should be included when optimizing a risk adjusted performance portfolio.

2.2 Purpose

It has been confirmed that the average Swedish investor should include Bitcoin in their portfolio (Ahnhem & Lindberg 2017). However, these results are based on Bitcoin returns before the 2017 hype and following price fall of Q1 2018. We believe that the increased volatility might affect the inclusion and allocation of Bitcoin in an optimized Swedish investor's portfolio.

Furthermore, the world grows more interconnected and financial markets more correlated. Bitcoin's potential hedging and safe haven capabilities have been widely discussed on a global scale, and its diversifying properties have been confirmed (Klabbers 2017). The Swedish

investor however, remains uncertain regarding whether Bitcoin possesses benefits to their portfolio when the Swedish market is under distress.

We aim to fill this research gap by testing Bitcoin's potential inclusion, allocation and diversifying properties to the Swedish investor's portfolio. Ultimately providing suggestions regarding how the Swedish investor should utilize Bitcoin to reap potential benefits.

2.3 Research questions

This thesis aims to answer two questions:

1. Does Bitcoin possess hedging and safe haven capabilities to a portfolio of Swedish assets?
2. Will adding Bitcoin to a Swedish investor's portfolio increase risk adjusted expected return in excess to traditional hedging assets?

3. Theoretical framework

This chapter introduces the concept constituting the foundation of our thesis. We present the theoretical reasoning behind our method chosen for portfolio optimization.

3.1 Optimizing a Portfolio

"There is a rule which implies both that the investor should diversify and that he should maximize expected return" (Markowitz 1952). An investor should aim to maximize the expected return, while keeping risk as low as possible. This is achieved by constructing a portfolio of assets with low or negative correlations, where the joint behaviour and correlations of assets is more important than the return or risk of an individual asset. The average investor is assumed to be risk-averse, meaning that the investor prefers a portfolio of lesser risk compared to one with higher risk, given that the expected returns are the same. When investing, a major risk is that the asset will not perform as well as expected, therefore resulting in a lower than expected return. By diversifying and including several different assets in a portfolio, the total risk will be lower since the individual risks and movements in different assets will cancel each other out.

Risk can be divided into systematic and unsystematic risk. Systematic risk, also known as market risk or non-diversifiable risk, is derived from macroeconomic factors such as inflation,

interest rates, business cycles and exchange rates (Bodie et al. 2014). Unsystematic risk, also known as firm-specific risk or diversifiable risk, is derived from the conditions of the specific company. This includes microeconomic factors such as the business model, research and development and changes in staff (Bodie et al. 2014).

An investor can eliminate the unsystematic risk in a portfolio by increasing the amount of assets and then hopefully only face the systematic risk.

For a portfolio containing two assets, Z and Y, yielding the expected returns π_z and π_y and variances ${\sigma_z}^2$ and ${\sigma_y}^2$, the following equations calculates the expected return and variance of the portfolio. Given that the weights for each asset is denoted by w_z and w_y and their correlation is ρ_{zy}.

(1)
$$E(r_p) = w_z \cdot \pi_z + w_y \cdot \pi_y$$

(2)
$$var(r_p) = {w_z}^2 \cdot {\sigma_z}^2 + {w_y}^2 \cdot {\sigma_y}^2 + 2 \cdot w_z w_y \cdot \rho_{zy} \cdot \sigma_z \sigma_y$$

When the correlation between two assets is equal to one, there is perfect positive correlation. When the correlation is equal to minus one, there is a perfect negative correlation. Lower correlation between assets indicate a higher ratio between risk and return when jointly invested in.

For all levels of return, there is a portfolio allocation that minimizes risk. For all levels of risk, there is a portfolio allocation that offers the greatest return. This is called the mean-variance criteria. The combination of return and risk, as in equation 1 and 2, can be plotted in a graph. All different combinations of asset Z and Y will result in the efficient frontier (Berk & DeMarzo 2014).

It is possible to use any number of N assets in the portfolio. The weights of each asset are denoted w_i, where i can take any number from 1, 2, 3, ..., N. There will also be n expected returns π_i, n variances ${\sigma_i}^2$, and n(n-1)/2 correlations ρ_{ij}. This demands minor modifications to the formulas 1 and 2, for the possibility of adding more assets.

(3)

$$E(r_p) = \sum_{i=1}^{n} w_i \cdot \pi_i$$

(4)

$$var(r_p) = \sum_{i=1}^{n} {w_i}^2 \cdot {\sigma_i}^2 + \sum_{i=1}^{n} \sum_{\substack{j=1 \\ i \neq 1}}^{n} w_i w_j \cdot \rho_{ij} \cdot \sigma_i \sigma_j$$

To find the optimal portfolio, knowing the efficient frontier is not enough. The efficient frontier only shows the maximum expected return dependent on the amount of risk one is prone to take. The next step is therefore to find out what the optimal portfolio allocation will be, namely the market portfolio.

To identify the market portfolio the transformation line is used, which consist of all combinations of two assets which an investor can invest in. The two assets are the risk-free rate and a certain stock portfolio on the efficient frontier. The investor could also lend at the risk-free rate and invest even more in the portfolio. By subtracting the risk-free rate from the risk-premium of the portfolio and divide the sum by the standard deviation, we obtain the linear transformation line. By adding the transformation line to the already constructed return/risk matrix including the efficient frontier, the market portfolio is identified where the transformation line is tangent to the efficient frontier. When this happens the transformation line is called the capital market line (CML). All risk-averse investors should invest in the market portfolio independent of other stock preferences (Berk & DeMarzo 2014). Risk preference should only affect the allocation of funds to the market portfolio. By following the steps of determining the efficient frontier and capital market line, a market portfolio with known weights in each individual asset is identified. Thereby, what optimizing the portfolio involves, is weighting assets depending on their return, risk and covariance with the other assets, so that the portfolio return is maximized and the portfolio risk is minimized.

From a correlation matrix of daily returns, we can be determine whether Bitcoin or other assets have hedging or safe haven properties. If the correlation between two assets is negative (non-existent), then the asset can be shown to have strong (weak) hedging capabilities. The same

goes for safe haven properties but the time frame is limited to periods of distress. If there is a small positive correlation between assets, they are classified to be diversifiers.

4. Method

This chapter describes the process of data collection, the method applied, and its relevance to answer our research questions. We also discuss the robustness checks introduced to test the sensitivity of our results.

4.1 Data Collection

We have sourced daily closing prices for the time period from July 20th of 2010 until March 22nd of 2018 from Bloomberg. We also built our portfolio in alignment to Gehrig (1993) findings on domestic bias, implying that Swedish investors will invest primarily in Swedish assets due to incomplete information.

Stocks	SIX30 Return Index mirroring the total return of the 30 most liquid stocks of Nasdaq Stockholm Large Cap including dividends (Avanza a 2018). OMXSPI is the Stockholm all-share index, weighting the value of all shares traded on the Stockholm exchange (Avanza b 2018).
Bonds	OMRXBOND which is a bond index related to nominal treasury bonds with benchmark status and mortgage bonds represented by benchmark bonds or equivalent issues by Stadshypotek AB. We use the short term bond of 1-3 years and the long term bond of 5+ years (Nasdaq 2018).
Real estate	HOX, a price index of the traded private real estate house and apartment markets in major metropolitan areas in Sweden (Nasdaq 2010).
Commodities	S&P GSCI is an index including the most liquid commodity futures (S&P-Dow-Jones 2018).
Gold	XAU CMPN Currency is the current exchange rate of Gold to USD including currency converter (Bloomberg 2018).
USD	The exchange rate US Dollar/Swedish Krona.
JPY	The exchange rate Japanese Yen/Swedish Krona.
CHF	The exchange rate Swiss Franc/Swedish Krona.
Risk free rate	GSGB10YR Index is a Swedish government bond 10 year note index.

In addition to the traditional assets of a Swedish investor, we have chosen to add the widely accepted hedging assets of gold, US Dollar, Japanese Yen and Swiss Franc. By optimizing a portfolio including these assets, we aim to investigate whether Bitcoin presents any additional diversifying benefits. Dyhrberg (2015) found that Bitcoin has hedging capabilities against the USD and Gold, which are classical hedging assets. Also Yen and Franc have been found to show safe haven capabilities by Söderlind (2009) and are therefore added to our portfolio.

4.2 Application of Method

We apply the Mean-Variance Optimization framework (MVO), in adjunction with bootstrapped Monte Carlo Simulations (MCS), to extend the statistical significance of the results. A similar method to the one used by Klabbers (2017) when optimizing a Bitcoin portfolio from a global investors perspective. While other frameworks are efficient in testing the hedge and safe haven capabilities of assets, they do not present the optimal portfolio weights, risk levels and returns. Using MVO, we yield a result that provides guidelines in terms of Bitcoin allocation for the average Swedish investor. MVO also has the benefit of offering unique ways to tweak the optimization through policy constraints for the portfolio.

We set initial constrains based on assumptions of the average Swedish investor's preferences. These are:

- *Allowing no short-selling* $w_i \geq 0$
  The weights of all assets must be equal to or exceed 0.
- *A budget constraint of* $\sum w_i = 1$
  The sum of all weights must be equal to 1.

The historical daily closing prices (p_t) are transformed into daily returns (r_d) by the following formula:

(5)

$$r_d = \ln\left(p_t / p_{t-1}\right)$$

Thereafter average yearly returns (r_a) are calculated assuming 251 trading days per year, applying the following formula:

(6)

$$r_a = 100 \cdot ((1 + r_{\bar{d}})^{251} - 1)$$

A covariance matrix is constructed based on all assets returns. The covariance matrix is used along with the assets average yearly returns to construct an efficient frontier. To investigate whether Bitcoin increases the expected risk adjusted return and offers diversification benefits to a portfolio we construct the optimal portfolio excluding Bitcoin, denoted Base Portfolio, and compare it to the optimal portfolio including Bitcoin, noted Bitcoin Portfolio. We identify the two optimal portfolios by maximizing the Sharpe ratio.

We have chosen to adapt the method applied by Klabbers (2017) to account for the fact that Bitcoin returns have not shown a normal distribution over the time period of interest. Bootstrapping is therefore applied when simulating data for the MCS. We draw random samples of daily sets of returns, with replacement, to generate 100 new datasets with an equal amount of daily returns as our initial dataset. From the generated data we calculate the average returns and covariance matrices, and then optimize to find 100 market portfolios. A scatterplot of all simulated market portfolios is created and added to the graph with the efficient frontiers and market portfolios based on the historical dataset.

We calculate the average Sharpe ratio, return, risk and Bitcoin allocation for the 100 simulations. These averages are then compared to the optimal market portfolio based on the historical dataset as a test of sensitivity. Large differences between the simulated average and the historical based numbers indicate high sensitivity of our results.

To test the significance of Bitcoin's effect on risk adjusted return, confidence intervals with a 10% confidence bounce are constructed from the differences between the 100 simulated Sharpe ratios of the portfolios. The five largest and smallest Sharpe ratio differences are removed, thus resulting in the remaining 90 ratios portraying the confidence interval. Positive Sharpe differences indicate that the Bitcoin and Base portfolios are significantly different in terms of Sharpe ratio. We can then conclude that introducing Bitcoin to the average Swedish investor's portfolio will significantly improve the portfolio's Sharpe ratio.

A correlation matrix is constructed from the assets daily returns. Assets with negative correlation are classified to have strong hedging capabilities, and those with no correlation to have weak hedging capabilities.

To identify whether Bitcoin possesses safe haven capabilities the 10% worst trading days in terms of return for each asset of the portfolio except Bitcoin is selected. Furthermore, the 25% best trading days in terms of return for Bitcoin is identified. Our method is based on the assumption that the 10% worst trading days of an asset is likely to represent market instability and uncertainty. Since the majority of trading days over the period has shown positive returns for Bitcoin, we cannot use positive or above average performance as an indication of save haven capabilities. Instead we look for Bitcoins 25% best trading days, as an indication of uncustomary well performance. These days are denoted with the dummy variable 1, while all other days receive the denotation 0. We calculate Bitcoin's correlation with other assets based on the dummy variables. Bitcoin is classified as a strong safe haven asset to those assets it has a negative correlation to, and a weak safe haven to those with zero correlation.

To avoid a biased result caused by the extreme price increase of Bitcoin during 2017, we perform the same method of analysis for the data set excluding daily returns from the 23rd of March 2017 until the 22nd of March 2018. Hereafter we refer to this time period as Pre-hype.

4.3 Method Evaluation

MVO is based on the assumption that the investor is only interested in the mean and variance of all included assets. This is a limitation as the returns of Bitcoin has been shown to have a non-normal distribution by Eisl et al. (2015), and is not predictable only based on the mean and variance. We apply bootstrapping when simulating data to include Bitcoin's abnormally high volatility in our results, and predict potential returns based on a random collection of actual historical outcomes.

Estimation risk can be a major issue with Bitcoin being an extremely volatile asset, since small changes in return or risk have major impact on Bitcoins allocation in the optimal portfolio. Performing the MCS will test the sensitivity of our results based on historical data by simulating 100 optimal portfolio allocations.

4.4 Robustness Checks

4.4.1 Portfolio Optimization Introducing Constraints

We perform the method of analysis four additional times with newly introduced policy constraints as robustness checks to test whether the final results are constant for investors with other investment preferences.

The first test is performed without the lower budget constraint on investors, that the sum of all weights is not limited to equal 1. This test aims to mirror the risk aversion of investors who given a risk-free rate may choose to not invest their full budget into the optimal portfolio in order to decrease its risk to the cost of reduced return (Sharpe 1964).

$$0 < \sum w_i < 1$$

For the second test, the constraint of no short-selling is removed and weights do not have to be equal to or exceed 0. Short-selling could impose higher risk and is most likely not an activity the average Swedish investor will engage in. Nonetheless it is a powerful tool to increase the portfolio Sharpe ratio by hedging, justifying a test to see how the results change for investors engaging in short-selling.

$$-1 < w_i < 1$$

The third test will take note of what Conover et al. (2007) states, that equity fund managers usually are limited to invest no more than 25% of total portfolio budget in one single asset. This implies that some Swedish investors may adopt this investment philosophy and thereby place an upper allocation boundary on each asset.

$$w_i \leq 0{,}25$$

Our fourth test models an equally weighted portfolio, consequently there is no need for an optimization process since all assets will be invested in with equal weights. DeMiguel et al. (2007) find that a portfolio with equally weighted assets performs similar to portfolios optimized with different techniques. We choose to test the philosophy as it is an easy approach for the average investor to apply.

$$w_i = {}^{1}/_{n}$$

4.4.2 Safe Haven Capabilities

As a robustness check for the safe haven properties of Bitcoin we apply the method used by Klabbers (2017). 2016 is identified as a year of great uncertainty and market instability on the financial markets due to major events such as Brexit and the U.S. Elections. Assets performing well during this time period are therefore defined as possessing safe haven capabilities. A correlation matrix is constructed for all assets for the full year of 2016. Assets showing negative correlation are classified as strong safe havens, and those with no correlation are classified as weak safe havens.

5. Results

In this chapter we present the results from applying the original method described in chapter four on our full and pre-hype time periods. We introduce portfolio characteristics and asset correlations that are analysed from the standpoint of our research question.

5.1 Summarizing Statistics

Table 1 presents the average annual returns and standard deviations as a measure of volatility. Data is separated between the full time period, and the Pre-hype period as defined earlier. For both time periods, Bitcoin show large return and standard deviation in comparison to the other portfolio assets. Bitcoins average annual return for the full period is 369,69%, compared to the second highest, OMXSPI at 5,9%. It also shows a greater volatility of 114,75%, whereas OMXSPI has a volatility of 22,84%. Bitcoin therefore performs roughly 62,5 times better than OMXSPI in terms of return, but is only 5 times more volatile. For the Pre-hype time period, Bitcoin has an average annual return of 327,01% in comparison to OMXSPI's return of 5,79%. The assets' volatilities are 117,54% and 23,98% respectively. Thereby, Bitcoin has 56,5 times higher return but is only 4,9 times more volatile.

Table 1: Average annualized return and standard deviation for the eleven assets included in the average Swedish investor's portfolio for the full time period and Pre-hype.

In %	*Return*	*Std.Dev.*	*Return*	*Std.Dev.*
	Full period	Full period	Pre-hype	Pre-hype
Bitcoin	369,69	114,75	327,01	117,54
OMXSPI	5,90	22,84	5,79	23,98
SIX 30	3,66	23,82	3,69	25,02
Bond 1-3	0,43	10,62	-0,53	10,98
Bond 5-	3,11	10,73	2,21	11,12
Housing	4,56	11,87	4,37	11,88
Commodities	-1,50	19,13	-4,33	19,79
Gold	1,57	16,31	0,84	17,06
USD	1,53	11,36	2,77	11,71
JPY	-1,08	13,49	-1,10	13,98
CHF	2,97	12,68	3,75	13,29

5.2 Testing for hedge and safe haven properties

A correlations matrix for the full time period is presented in table 2, which is used to identify the assets to which Bitcoin possess hedging capabilities. Bitcoin is negatively correlated to Bond 1-3, Bond 5-, Housing, Gold, USD and JPY and is therefore by our definition a hedge against these assets. OMXSPI, SIX 30, Commodities and CHF all show low positive correlations to Bitcoin, suggesting that Bitcoin function as a diversifier towards these assets.

We also see that the three currencies included as widely accepted hedging assets show low negative correlations to housing and Bitcoin and large negative correlations to every other asset excluding themselves and gold. This falls in line with previous research of Söderlind (2009), suggesting that these currencies function well as hedges.

Bitcoin's correlations are also presented for the Pre-hype period, in order to detect whether the extreme price fluctuations during 2017 and 2018 has an impact on the results. Pre-hype correlations are negative and showing hedge capabilities for Bitcoin to Bond 5-, Housing, Gold, USD and JPY. OMXSPI, SIX 30, Bond 1-3, Commodities and CHF are all weakly positive correlated to Bitcoin, therefore diversifying properties are present. The only asset that changes definition when looking at the Pre-hype period is Bond 1-3 going from a hedge to a diversifier.

The safe haven correlations of Bitcoin as defined earlier are included in table 2. OMXSPI, SIX 30, Housing and Commodities all show negative correlations to Bitcoin, presenting a safe haven opportunity. Bond 1-3, Bond 5-, Gold, USD, JPY and CHF show low correlations to Bitcoin, indicating diversifying properties also during times of distress.

Table 2: The correlation matrix for all eleven assets for the full time period, in adjunction to Bitcoins Pre-hype correlations to the other assets, and Bitcoins correlations to the other assets based on the safe haven dummy variables.

Full period	*Bitcoin*	*OMXSPI*	*SIX 30*	*Bond 1-3*	*Bond 5-*	*Housing*	*Comm.*	*Gold*	*USD*	*JPY*	*CHF*
Bitcoin	1	0.032	0.032	-0.001	-0.007	-0.01	0.021	-0.006	-0.014	-0.014	0.037
OMXSPI		1	0.995	0.649	0.456	0.064	0.424	0.077	-0.575	-0.577	-0.323
SIX 30			1	0.632	0.439	0.062	0.422	0.068	-0.561	-0.571	-0.314
Bond 1-3				1	0.901	0.076	0.300	0.257	-0.876	-0.620	-0.407
Bond 5-					1	0.071	0.214	0.310	-0.760	-0.448	-0.335
Housing						1	0.017	-0.031	-0.048	-0.042	-0.014
Comm.							1	0.231	-0.291	-0.288	-0.170
Gold								1	-0.261	0.022	0.074
USD									1	0.695	0.449
JPY										1	0.496
CHF											1
Pre-hype	1	0.032	0.032	0.005	-0.004	-0.006	0.023	-0.002	-0.021	-0.015	0.04
Safe haven	1	-0.014	-0.013	0.02	0.02	-0.015	-0.031	0.026	0.045	0.013	0.033

5.3 Full Time Period Portfolio Optimization

Graph 1 displays the efficient frontiers of the Base and Bitcoin portfolios when optimizing for the full time period. As is visually clear, the frontier of the portfolio including Bitcoin climbs higher and at a faster rate in comparison to the Base portfolio. Thereby portraying substantially larger returns at the same level of risk. This indicates that Bitcoin is a potent diversifier and that the average Swedish investor is better off by including Bitcoin in their portfolio.

Graph 1: Illustrates the efficient frontiers of the full time Bitcoin and Base portfolios based on historical values, along with the optimal Bitcoin and Base portfolio. 100 Monte Carlo simulated optimal portfolios each are also visualized.

Outliers with above 200% annual portfolio return and/or above 40% annual standard deviation lie outside the axes' boundaries for the full time period, this constitutes 11 MCS optimal Bitcoin portfolios.

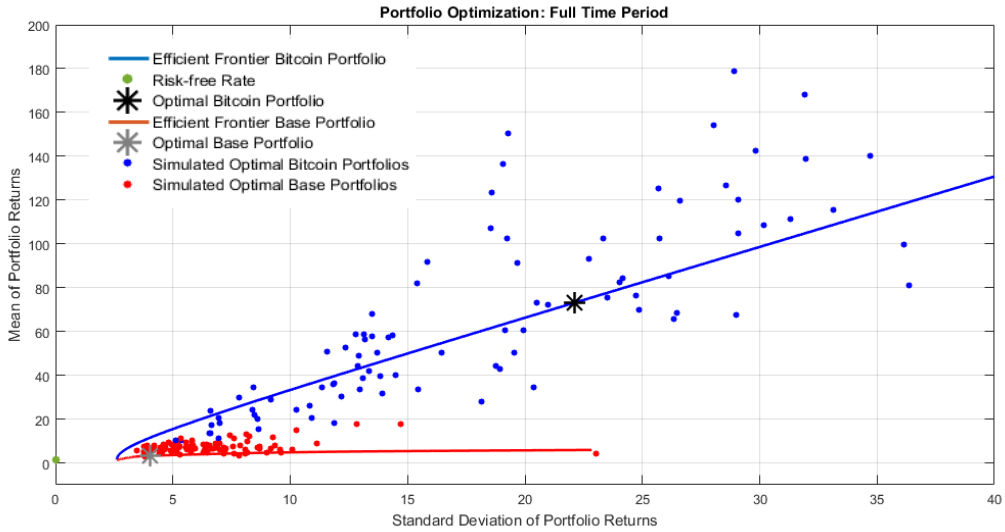

Table 3: The optimal portfolio asset allocations for the Bitcoin and Base portfolio, based on the full time period historical data. The resulting Sharpe ratio, annual return and risk is displayed respectively.

Weights (%)	*Bitcoin Portfolio*	*Base Portfolio*
Bitcoin	19,129	
OMXSPI	4,412	11,581
Six 30	0,000	0,000
Bond 1-3	0,000	0,000
Bond 5-	29,896	28,677
Housing	15,789	18,503
Comm.	0,000	0,000
Gold	0,348	0,000
USD	30,426	29,290
JPY	0,000	0,000
CHF	0,000	11,950
Sharpe	3,307	0,802
Return	73,099	3,221
Risk	22,107	4,015

Bitcoin has a weight of 19,13% in the optimal portfolio, the return of the portfolio is calculated to 73,10% and the volatility to 22,11%. Resulting in a Sharpe ratio of 3,31. For the optimized Base portfolio the return is 3,22% with a volatility of 4,02% and a Sharpe ratio of 0,80. By including Bitcoin in the portfolio, the investor gains roughly 23 times the Base return at only 5,5 times the risk.

When performing 100 Monte Carlo Simulations, the average Bitcoin weight shown in table 4 is 18,20%, with all simulations investing in Bitcoin. Including Bitcoin increases the average optimal portfolio return from 7,02% to 87,02%, and the risk from 6,42% to 21,64%. Resulting in a greater Sharpe ratio of 3,64 in comparison to 0,92.

Table 4: The average Sharpe ratio, return, risk and Bitcoin weight for the 100 MCS optimal Bitcoin and Base portfolios based on the full time period data.

	Sharpe	***Return***	***Risk***	***Bitcoin Weight***
Simulated Optimal Bitcoin Portfolios	3,639	87,016	21,640	18,197
Simulated Optimal Base Portfolios	0,917	7,021	6,417	

5.4 Pre-hype Time Period Portfolio Optimization

Graph 2 visualizes the efficient frontiers of the Base and Bitcoin portfolios when optimizing for the Pre-hype period. Also in this case, including Bitcoin in the portfolio leads to a higher return for the same risk-level. Once again, indicating that Bitcoin is a potent diversifier and strengthening that the average Swedish investor is better off by including Bitcoin in their portfolio.

Graph 2: Illustrates the Pre-hype efficient frontiers for the Bitcoin and Base portfolios based on historical values, along with the optimal Bitcoin and Base portfolio. 100 Monte Carlo simulated optimal portfolios each are also visualized.

Outliers with above 200% annual portfolio return and/or above 40% annual standard deviation lie outside the axes' boundaries for the Pre-hype time period, this constitutes 12 MCS optimal bitcoin portfolios.

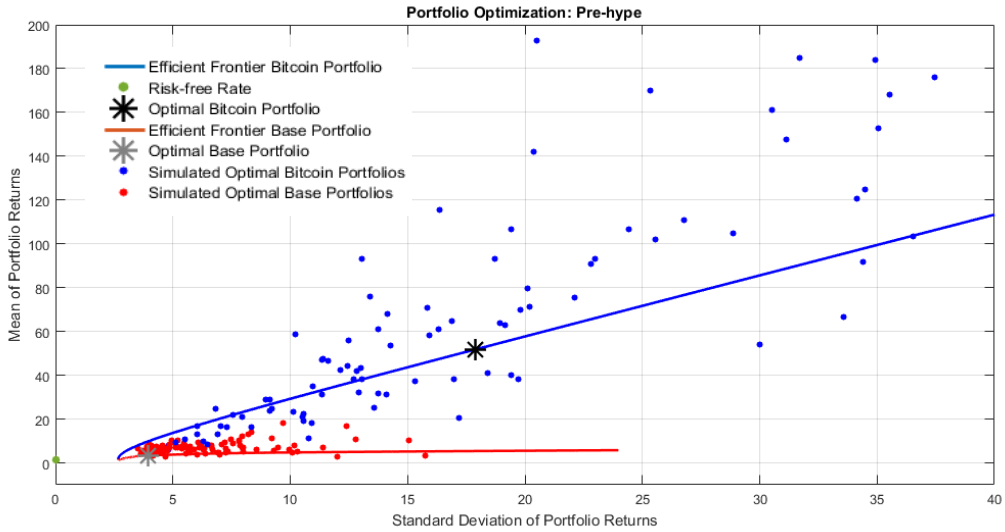

Table 5: The optimal portfolio asset allocations for the Bitcoin and Base portfolio, based on the Pre-hype historical data. The resulting Sharpe ratio, annual return and risk is displayed respectively.

Weights (%)	*Bitcoin Portfolio*	*Base Portfolio*
Bitcoin	15,045	
OMXSPI	7,185	12,788
Six 30	0,000	0,000
Bond 1-3	0,000	0,000
Bond 5-	26,814	24,618
Housing	13,167	15,593
Comm.	0,000	0,000
Gold	0,000	0,000
USD	37,788	36,257
JPY	0,000	0,000
CHF	0,000	10,744
Sharpe	2,895	0,853
Return	51,830	3,373
Risk	17,901	3,956

Bitcoin has a weight of 15,05% in the optimal portfolio, the return of the portfolio is calculated to 51,83% and the volatility to 17,90%. Resulting in a Sharpe ratio of 2,90. For the optimized Base portfolio the return is 3,37% with a volatility of 3,96% and a Sharpe ratio of 0,85. By including Bitcoin in the portfolio, the investor gains roughly 15 times the Base return at only 4,5 times the risk.

When performing 100 Monte Carlo Simulations, the average Bitcoin weight presented in table 6 is 17,02% with all simulations taking a position in Bitcoin. Including Bitcoin increases the average optimal portfolio return from 6,97% to 88,33%, and the risk from 6,38% to 20,62%. Resulting in a greater Sharpe ratio of 3,68 in comparison to 0,92.

Table 6: The average Sharpe ratio, return, risk and Bitcoin weight for the 100 MCS optimal Bitcoin and Base portfolios based on the Pre-hype period data.

	Sharpe	***Return***	***Risk***	***Bitcoin Weight***
Simulated Optimal Bitcoin Portfolios	3,681	88,329	20,619	17,024
Simulated Optimal Base Portfolios	0,918	6,972	6,381	

6. Robustness checks

In this chapter we present the results from applying the robustness checks described in chapter four on our full time period. We introduce portfolio characteristics and asset correlations that are analysed from the stand point of our research question.

6.1 Portfolio Optimization Introducing Constraints

6.1.1 No Lower Budget Constraint Portfolio Optimization

Graph 3 displays the efficient frontiers of the Base and Bitcoin portfolios when optimizing for the full time period, and removing the constraint of full budget investment. The optimal portfolios have lower risk and return when removing the budget constraint in comparison to the original full time period optimal portfolios. This is a result of not being fully invested in the optimal portfolio and instead investing part of the budget in the risk-free rate.

Graph 3: Illustrates the efficient frontiers of the full time Bitcoin and Base portfolios based on historical values, along with the optimal Bitcoin and Base portfolio, when the constraint of a lower budget is removed. 100 Monte Carlo simulated optimal portfolios each are also visualized.

Outliers with above 200% annual portfolio return and/or above 40% annual standard deviation lie outside the axes' boundaries, this constitutes 3 MCS optimal Bitcoin portfolios.

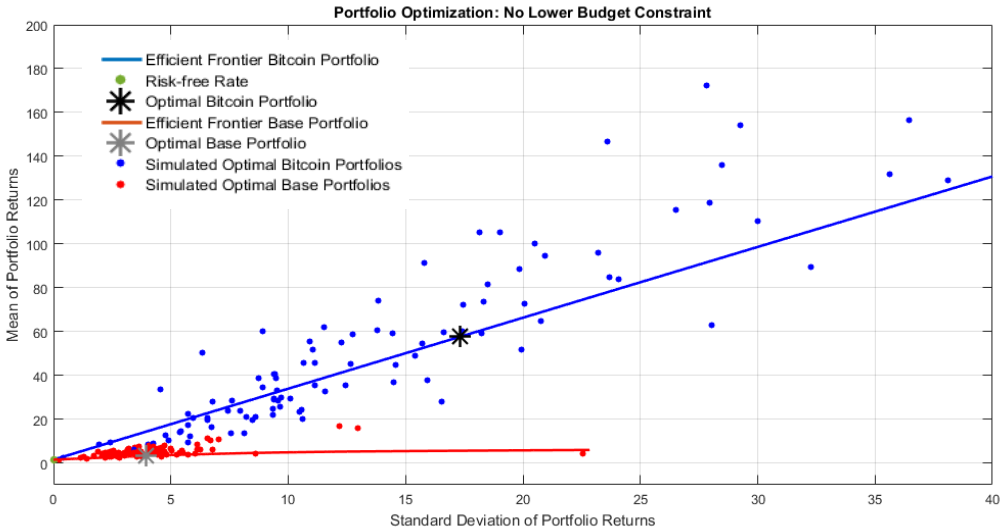

Table 7: The optimal portfolio asset allocations for the Bitcoin and Base portfolio, based on the full time period historical data with no lower budget constraint. The resulting Sharpe ratio, annual return and risk is displayed respectively.

Weights (%)	*Bitcoin Portfolio*	*Base Portfolio*
Bitcoin	14,978	
OMXSPI	3,454	11,351
Six 30	0,000	0,000
Bond 1-3	0,000	0,000
Bond 5-	23,408	28,107
Housing	12,363	18,135
Comm.	0,000	0,000
Gold	0,272	0,000
USD	23,824	28,707
JPY	0,000	0,000
CHF	0,000	11,712
Total	78,300	98,011
Sharpe	3,325	0,810
Return	57,556	3,186
Risk	17,310	3,936

Bitcoin has a weight of 14,98% in the optimal portfolio, the return of the portfolio is calculated to 57,56% and the volatility to 17,31%. Resulting in a Sharpe ratio of 3,33. The allocation of funds to the optimal Bitcoin portfolio is 78,30% while the remaining 21,70% are invested in the risk-free rate. For the optimized Base portfolio the return is 3,19% with a volatility of 3,94% and a Sharpe ratio of 0,81. By including Bitcoin in the portfolio, the investor gains roughly 18 times the Base return at only 4,4 times the risk. The allocation of funds to the optimal Base portfolio is 98,01% while the remaining 1,99% are invested in the risk-free rate.

When performing 100 Monte Carlo Simulations, the average Bitcoin weight is 12,29%, as can be seen in table 8, with all simulations investing in Bitcoin. Including Bitcoin increases the average optimal portfolio return from 5,05% to 60,08%, and the risk from 4,06% to 14,66%. Resulting in a greater Sharpe ratio of 3,64 in comparison to 0,92.

Table 8: The average Sharpe ratio, return, risk and Bitcoin weight for the 100 MCS optimal Bitcoin and Base portfolios based on the full time period with no lower budget constraint.

	Sharpe	***Return***	***Risk***	***Bitcoin Weight***
Simulated Optimal Bitcoin Portfolios	3,639	60,079	14,657	12,291
Simulated Optimal Base Portfolios	0,917	5,045	4,057	

6.1.2 Short-Selling Allowed Portfolio Optimization

Graph 4 displays the efficient frontiers of the Base and Bitcoin portfolios when optimizing for the full time period, and removing the constraint of no short-selling. Short-selling offers an additional instrument to hedge the portfolio, resulting in higher Sharpe ratios by reducing risk for similar levels of returns in comparison to the full time period optimal portfolios.

Graph 4: Illustrates the efficient frontiers of the full time Bitcoin and Base portfolios based on historical values, along with the optimal Bitcoin and Base portfolio, when short-selling is allowed. 100 Monte Carlo simulated optimal portfolios each are also visualized.

Outliers with above 200% annual portfolio return and/or above 40% annual standard deviation lie outside the axes' boundaries, this constitutes 5 MCS optimal Bitcoin portfolios.

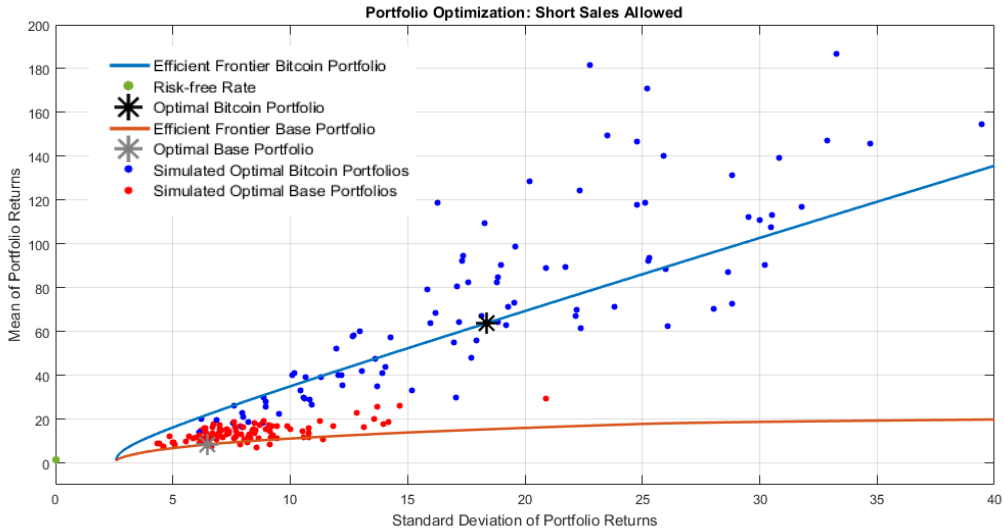

Table 9: The optimal portfolio asset allocations for the Bitcoin and Base portfolio, based on the full time period historical data with short-selling allowed. The resulting Sharpe ratio, annual return and risk is displayed respectively.

Weights (%)	*Bitcoin Portfolio*	*Base Portfolio*
Bitcoin	15,203	
OMXSPI	100,000	100,000
Six 30	-84,834	-80,094
Bond 1-3	-68,999	-79,395
Bond 5-	89,861	100,000
Housing	18,010	19,154
Comm.	-6,571	-5,419
Gold	6,129	5,251
USD	50,038	52,168
JPY	-25,111	-28,808
CHF	6,275	17,142
Sharpe	3,393	1,072
Return	63,737	8,392
Risk	18,352	6,451

Bitcoin has a weight of 15,20% in the optimal portfolio, the return of the portfolio is calculated to 63,74% and the volatility to 18,35%. Resulting in a Sharpe ratio of 3,39. For the optimized Base portfolio the return is 8,39% with a volatility of 6,45% and a Sharpe ratio of 1,07. By including Bitcoin in the portfolio, the investor gains roughly eight times the Base return at only 2,8 times the risk. Shorting assets is a hedging technique slightly reducing the advantages of including Bitcoin as a hedging asset to the portfolio. Including Bitcoin still increases the portfolios risk adjusted return, but the effect is smaller in comparison to Bitcoins advantages to the original portfolio.

When performing 100 Monte Carlo Simulations, the average Bitcoin weight shown in table 10 is 15,42%, with all simulations taking a long position in Bitcoin. Including Bitcoin increases the average optimal portfolio return from 13,65% to 83,78%, and the risk from 8,13% to 19,46%. Resulting in a greater Sharpe ratio of 3,89 in comparison to 1,53.

Table 10: The average Sharpe ratio, return, risk and Bitcoin weight for the 100 MCS optimal Bitcoin and Base portfolios based on the full time period with short-selling allowed

	Sharpe	***Return***	***Risk***	***Bitcoin Weight***
Simulated Optimal Bitcoin Portfolios	3,894	83,781	19,458	15,416
Simulated Optimal Base Portfolios	1,533	13,647	8,129	

6.1.3 Upper Allocation Boundary 25% Portfolio Optimization

Graph 5 displays the efficient frontiers of the Base and Bitcoin portfolios when optimizing for the full time period, and introducing an upper allocation boundary of 25% per asset. Imposing the restriction of 25%, we see that the risk increases for the optimal Bitcoin portfolio, suggesting that the original full time period portfolio uses larger weights in assets with a greater return to risk ratio.

Graph 5: Illustrates the efficient frontiers of the full time Bitcoin and Base portfolios based on historical values, along with the optimal Bitcoin and Base portfolio, when an upper constraint of 25% per asset is introduced. 100 Monte Carlo simulated optimal portfolios each are also visualized.

Outliers with above 200% annual portfolio return and/or above 40% annual standard deviation lie outside the axes' boundaries, this constitutes 3 MCS optimal Bitcoin portfolios.

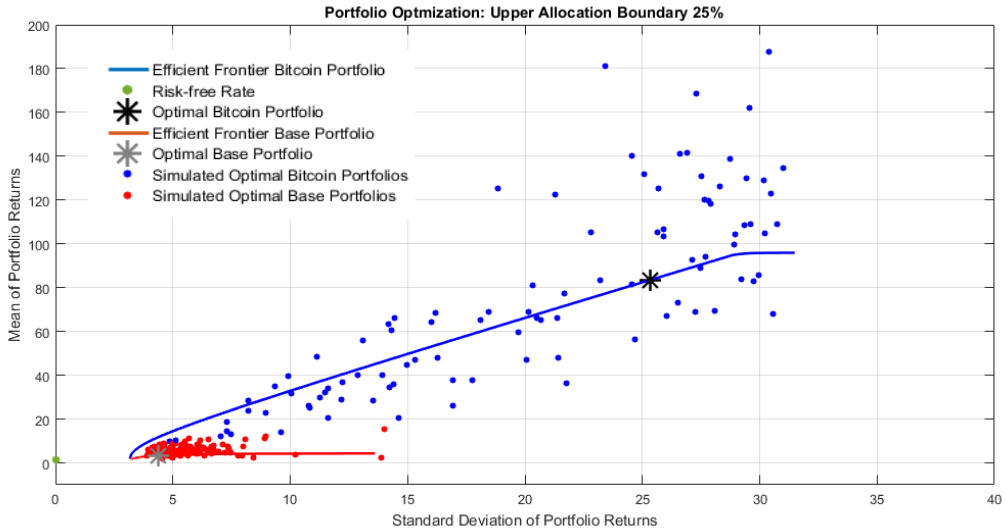

Table 11: The optimal portfolio asset allocations for the Bitcoin and Base portfolio, based on the full time period historical data when a upper constraint of 25% per asset is introduced. The resulting Sharpe ratio, annual return and risk is displayed respectively.

Weights (%)	*Bitcoin Portfolio*	*Base Portfolio*
Bitcoin	21,933	
OMXSPI	4,874	12,798
Six 30	0,000	0,000
Bond 1-3	0,000	0,000
Bond 5-	25,000	25,000
Housing	20,185	21,799
Comm.	0,000	0,000
Gold	1,445	0,000
USD	25,000	25,000
JPY	0,000	0,000
CHF	1,563	15,402
Sharpe	3,296	0,768
Return	83,520	3,366
Risk	25,336	4,386

Bitcoin has a weight of 21,93% in the optimal portfolio, the return of the portfolio is calculated to 83,52% and the volatility to 25,34%. Resulting in a Sharpe ratio of 3,30. For the optimized Base portfolio the return is 3,37% with a volatility of 4,39% and a Sharpe ratio of 0,77. By including Bitcoin in the portfolio, the investor gains roughly 25 times the Base return at only 5,8 times the risk.

When performing 100 Monte Carlo simulation, the average Bitcoin weight presented in table 12 is 17,16% with all investing in Bitcoin. Including Bitcoin increases the average optimal portfolio return from 0,80% to 81,27%, and the risk from 5,36% to 20,36%. Resulting in a greater Sharpe ratio of 3,61 in comparison to 0,80. When comparing the MCS average portfolio risk to the one based on historical values we see that it is greatly reduced, probably due to the average investment in Bitcoin being reduced by 23%.

Table 12: The average Sharpe ratio, return, risk and Bitcoin weight for the 100 MCS optimal Bitcoin and Base portfolios based on the full time period when a upper constraint of 25% per asset is introduced.

	Sharpe	***Return***	***Risk***	***Bitcoin Weight***
Simulated Optimal Bitcoin Portfolios	3,610	81,272	20,360	17,159
Simulated Optimal Base Portfolios	0,801	0,801	5,890	

6.1.4 Equal Weights Portfolio Optimization

Graph 6 displays the optimal Bitcoin and Base portfolios of 100 Monte Carlo Simulations when investing equal weights into each asset. The Bitcoin portfolios have greater spread of optimal portfolio return as the standard deviation is greater, in comparison to the Base portfolio.

Graph 6: Illustrates the efficient frontiers of the full time Bitcoin and Base portfolios based on historical values, along with the optimal Bitcoin and Base portfolio, when all assets are equally weighted. 100 Monte Carlo simulated optimal portfolios each are also visualized.

There are no outliers with above 200% annual portfolio return and/or above 40% annual standard deviation.

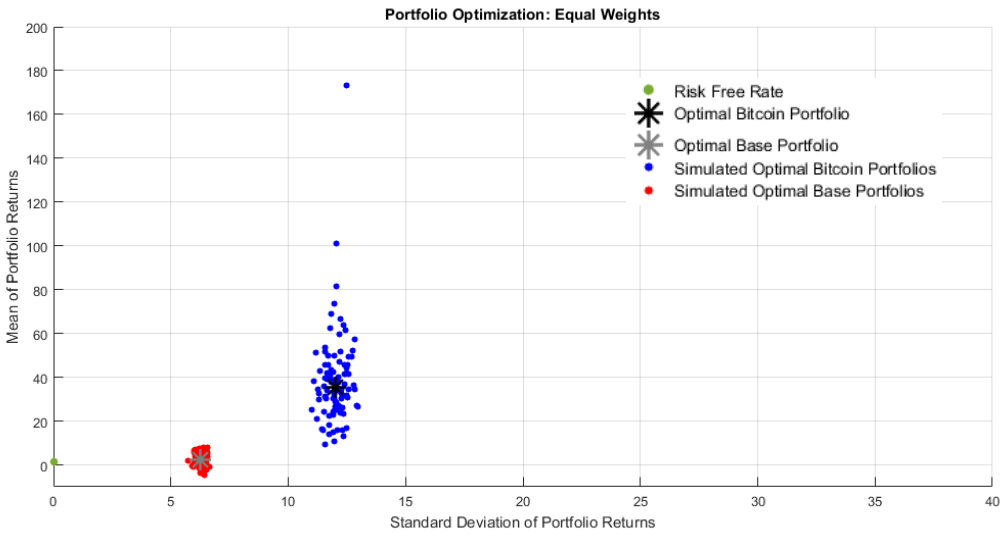

Table 13: The optimal portfolio asset allocations for the Bitcoin and Base portfolio, based on the full time period historical data when all asset are equally weighted. The resulting Sharpe ratio, annual return and risk is displayed respectively.

Weights (%)	***Bitcoin Portfolio***	***Base Portfolio***
All assets	9,091	10,00
Sharpe	2,956	0,338
Return	35,532	2,120
Risk	12,019	6,256

Bitcoin has a weight of 9,09% as all other assets, the return of the portfolio is calculated to 35,53% and the volatility to 12,02%. Resulting in a Sharpe ratio of 2,96. For the equally weighted Base portfolio the return is 2,12% with a volatility of 6,26% and a Sharpe ratio of 0,34. By including Bitcoin in the portfolio, the investor gains roughly 17 times the Base return at only 1,9 times the risk.

When performing 100 Monte Carlo Simulations, the average Bitcoin weight presented in table 14 is 9,09%. Including Bitcoin increases the average optimal portfolio return from 2,14% to 38,21%, and the risk from 6,25% to 12,02%. Resulting in a greater Sharpe ratio of 3,05 in comparison to 0,11.

Table 14: The average Sharpe ratio, return, risk and Bitcoin weight for the 100 MCS optimal Bitcoin and Base portfolios based on the full time period when all asset are equally weighted.

	Sharpe	*Return*	*Risk*	*Bitcoin Weight*
Simulated Optimal Bitcoin Portfolios	3,051	38,211	12,019	9,091
Simulated Optimal Base Portfolios	0,108	2,142	6,247	

6.2 Safe Haven Capabilities

The robustness check was performed on daily returns from 2016, based on the assumption that 2016 was a volatile year on the financial markets. Bitcoin shows negative correlations to OMXSPI, SIX 30, USD and CHF, suggesting that Bitcoin is a strong safe haven to these assets. Bitcoin is positively correlated to all other assets and should thereby not be used as a hedge during distressed times towards these assets.

Table 15: The correlation matrix for all eleven assets for 2016, defined as a year of instability.

	Bitcoin	*OMXSPI*	*SIX 30*	*Bond 1-3*	*Bond 5-*	*Housing*	*Comm.*	*Gold*	*USD*	*JPY*	*CHF*
Bitcoin	1	-0,077	-0,076	0,016	0,073	0,035	0,002	0,108	-0,037	0,06	-0,061
OMXSPI		1	0,992	0,577	0,376	0,019	0,449	-0,258	-0,544	-0,651	-0,516
SIX 30			1	0,538	0,331	0,02	0,448	-0,28	-0,508	-0,637	-0,49
Bond 1-3				1	0,898	-0,013	0,206	0,165	-0,895	-0,518	-0,507
Bond 5-					1	0,007	0,097	0,311	-0,764	-0,305	-0,359
Housing						1	0,078	-0,022	-0,04	0,01	-0,107
Comm.							1	-0,05	-0,224	-0,323	-0,328
Gold								1	-0,182	0,378	0,124
USD									1	0,563	0,617
JPY										1	0,597
CHF											1

6.3. Significance of results

Constructing confidence intervals of the optimal Bitcoin and Base portfolio's Sharpe ratio difference is done to test whether including Bitcoin has a significant positive effect on the risk adjusted return to a Swedish investor's portfolio. All tests show positive intervals indicating that Bitcoin indeed has a positive effect independent of policy constrains.

Table 16: The confidence intervals of all tests with a 10% bounce for the optimal Bitcoin and Base portfolio's Sharpe ratio differences

Sharpe Ratio Difference Interval	*Lower limit*	*Upper limit*
Full time	0,63	5,35
Pre-Hype	0,39	6,81
No lower budget constraint	0,63	5,35
Short-selling	0,45	4,93
Max 25%	0,71	5,38
Equal weights	1,13	5,2

7. Conclusion

In this chapter we discuss the answers to our research questions and draw conclusions from the data analysis done in chapters 5 and 6. We also suggest areas for future research that could strengthen the recommendations to a Swedish investor, or explore the implications to other geography- or crypto investors.

As globalization has increased, so has market correlation, putting new emphasis on finding good portfolio diversifiers to prevent greater exposure to global market shocks. Furthermore, digitalization of the banking industry has provoked increased interest in finding the future of payment methods. This thesis covers the characteristics of diversifiers, hedges and safe haven assets aiming to conclude whether the average Swedish investor is better off by including Bitcoin in their portfolio. Former research has confirmed Bitcoins diversifying capabilities on the global market, and its positive effect on a Swedish portfolios risk adjusted performance. In accordance to portfolio theory, an investor will in many cases be better off by including an asset with negative or no correlation with existing assets. Inclusion will enhance the market portfolios risk adjusted return.

7.1 Research Questions

The aim of this thesis is to answer two questions, the first being whether Bitcoin possesses hedging and safe haven capabilities to a portfolio of Swedish assets.

We answer question one in two parts, starting off with hedging capabilities. We found that Bitcoin shows hedging capabilities to the researched Swedish portfolio. With negative correlation of Bitcoin to Bond 1-3, Bond 5-, Housing, Gold and JPY suggesting that it is a strong hedge to these assets. The results are aligned for both the full time period and the Pre-hype time period.

The second part of the first question regards whether Bitcoin has safe haven capabilities, which we tested through two methods. Both methods show that Bitcoin can be used as a safe haven to OMXSPI and SIX 30. Furthermore, the first method shows safe haven properties for Bitcoin against Housing and Commodities, while the second method suggests these against USD and CHF.

Our second research question regards whether adding Bitcoin to a Swedish investor's portfolio increases expected risk adjusted return in excess to traditional hedging assets. We found that when optimizing risk adjusted return of a portfolio, Bitcoin was included as a complement to the traditional hedging assets of gold, USD, JPY and CHF. This finding was consistent in all robustness tests, where Bitcoin allocation ranged from 15% to 22% as shown in table 17. Including Bitcoin to the portfolio increased the Sharpe ratio in all tests, mirroring the risk adjusted return. In the more statistically significant MCS optimal portfolios Bitcoin is also included in all tests, with an average allocation span from 12% to 18%. All MCS tests show a great increase of the portfolio's Sharpe ratio when including Bitcoin. Strengthening the conclusion that Bitcoin is a potent diversifier to a Swedish investors portfolio.

Table 17: Summarizes the Sharpe values and Bitcoin allocations of the Bitcoin and Base portfolio in all tests and simulations.

	Bitcoin Sharpe	*Bitcoin Allocation*	*Sim. Bitcoin Sharpe*	*Sim. Bitcoin Allocation*	*Base Sharpe*	*Sim. Base Sharpe*
Full Time Period	3,31	19%	3,64	18%	0,80	0,92
Pre-hype	2,90	15%	3,68	17%	0,85	0,92
No Lower Budget Constraint	3,33	22%	3,64	12%	0,81	0,92
Short Sales Allowed	3,47	15%	3,89	15%	1,30	1,53
Upper Allocation Boundary	3,30	22%	3,61	17%	0,77	0,80
Equal Weights	2,96	9%	3,05	9%	0,34	0,11

Our findings strongly suggest that the average Swedish investor should include Bitcoin in their portfolio. However, there are many uncertainties and risks regarding the underlying value of Bitcoin and its credibility as stated in the introduction. The history of heavy interest from the black market and cyberattacks hurts Bitcoins trust and reputation. Today many governments are banning, or discussing regulations of or against cryptocurrencies as a means for payments and investments (Nelson 2018). We therefore leave it to the individual investor to determine whether the potential gains outweigh the potential risks.

7.2 Recommendations for Future Research

Our results are limited to the time period of July 20th 2010 until March 22nd 2018. It would therefore be interesting to see how the current price decline in Bitcoin alters the results of Bitcoin's effect on risk adjusted return to the Swedish investor. Also, should the price of Bitcoin stabilize as adoption increases this would change the results of the study. To further strengthen the conclusion that the average Swedish investor would be better off by including Bitcoin, one could test the inclusion of Bitcoin when optimizing another performance ratio such as Treynor or Sortino. Optimizing portfolios when assuming a different set of assets to the average Swedish investor could also strengthen the results relevance on the Swedish market.

Our study concludes that Bitcoin is a potent diversifier, and shows signs to possess hedge and safe haven capabilities against an average Swedish investor's portfolio. It would be interesting to see if the same results can be found on other financial markets, and whether other cryptocurrencies show the same benefits to a Swedish investors portfolio.

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