Can Bitcoin be used as a hedge against the Swedish market?

Does Bitcoin have hedging capabilities against the OMXS30, or is it just a diversifier in a portfolio?

Camilla Law
Marja Vahlqvist
Abstract

Bitcoin has gained more recognition than ever before, and the interest in cryptocurrencies seems to grow exponentially. Without any central government regulating Bitcoin, a global user group has adopted this new technology, which is designed to be used as a currency for trading without banks. Empirical studies focus on revealing the true characteristic of cryptocurrencies. Are they a currency, an asset or something else?

This paper explores the potential of Bitcoin as a financial asset when used for hedging and portfolio diversification. A regression analysis will be performed to analyse if Bitcoin can be used as a hedge against OMXS30. This analysis yields insignificant values, which leads to a complication in the conclusion. The result imply that Bitcoin is an inadequate hedge, but may possess diversification properties. Studying Bitcoin in relation to OMXS30, Dow Jones, Nikkei 225, Gold and Oil results in correlation values close to zero. By using the mean-variance optimization method, two portfolios are created, one including and one excluding Bitcoin. We show that by including Bitcoin in the portfolio the risk can be decreased on a given return rate. Considering the low and insignificant correlation values with other assets and the better risk-return ratio when Bitcoin is included in a portfolio, we conclude that Bitcoin can be a suitable diversification tool.

Keywords: Cryptocurrency, Bitcoin, Hedge, Diversifier
Abstract 1

1. Introduction 4
   1.1 Background 5
      1.1.1 Bitcoin 5
      1.1.2 Limitations of Bitcoin as a financial asset 7
   1.2 Problem discussion 7

2. Literature Review 9
   2.1 Previous Research 9
      2.1.1 Hedging 9
      2.1.2 Portfolio theory 10
      2.1.3 Bitcoin as a currency 10
      2.1.4 Bitcoin as an asset 11
   2.1.5 Conclusion of Previous Research 13
   2.2 Theoretical Framework 14
      2.2.1 Econometric model 14
      2.2.3 Interpretation of empirical data 16

3. Research Design 17
   3.1 The Linear Regression Models 18
      3.1.1 The Linear Regression Models 18
      3.1.3 Significance test 20
      3.1.4 Problems with hypothesis testing (type I and type II error) 20
      3.1.5 Limitations of The Linear Regression Model 21
      3.2 Data 22
      3.3 Research Question 2 23
      3.3.1 Correlation Table 23
      3.3.2 Significance test 24
      3.2.3 The Mean Variance Optimization 24
3.2.4 Limitations of the Mean Variance Optimization-method

3.3 Data

4. **Empirical presentation**

   4.1 Descriptive statistics
   4.2 Statistical findings
   4.2.1 Test for heteroscedasticity
   4.2.2 Autocorrelation
   4.3 Bitcoin as a diversifier
   4.3.1 Descriptive Statistics
   4.3.2 Statistical Findings

5. **Discussion and Critical Reflection**

6. **Conclusion**

7. **Limitations of Research**

References

Appendices
1. Introduction

In this chapter a background for Bitcoin will be introduced, followed by a problem discussion about this cryptocurrency.

The concept of a cryptocurrency has created different opinions on whether it should be perceived as a real currency or something even more valuable. There have been diverse views on Bitcoin, one of the most well-known cryptocurrencies. The interest in Bitcoin has increased exponentially over the past year, and Bitcoin was traded at a higher price than ever before in December 2017.

Bitcoin was initially created as a decentralized currency with its own way of generating and transferring money. However, recent studies have had a contradictory perception of its positioning in the field of finance. While some authorities (Internal Revenue Service and Financial Crimes Enforcement Network) acknowledge Bitcoin as a currency with restraints, other researchers state that Bitcoin fails to fulfil the requirements of a currency (Yermack, 2013). Furthermore, Yermack suggests that it is more aligned with being a speculative asset because of its high excessive volatility. Another approach by Bouri, Molnár, Azzi, Roubaud and Hagfors (2017) investigates the safe haven and hedging properties of Bitcoin, where their study shows varying results for different time horizons. Although there are disagreements in this area of study we can agree that further research is required in order to obtain an improved perception on Bitcoin.

In this paper, we will pose two research questions, firstly, an examination will be done regarding if Bitcoin can be used as a hedge against the Swedish market index. In this case the Swedish market index will be defined as the OMXS30. This is a subject that has been studied in another market with positive results (Dyhrberg, 2016A; 2016B). However, this market is bigger and may have a different impact on Bitcoin. To determine if Bitcoin can be used as a hedge, we will use a linear regression model with dummy variables. These dummy variables will be dependent on the negative return of the Swedish market at time t.

Secondly, for a more comprehensive analysis of Bitcoin, an examination of its diversification capabilities will be conducted. The second research question will be as followed: Can Bitcoin
be used as a diversification tool in a diversified portfolio? This question will be answered by analysing a correlation matrix and by creating two diversified portfolios using the mean-variance optimization method. One portfolio will include Bitcoin as an asset and the other one will exclude it. Further on, an analysis will be made of whether the portfolio including Bitcoin yields a lower risk or not.

The result of our study concludes that we cannot identify Bitcoin as a good hedge since the obtained coefficients were neither negative nor were they significant. Although this result was obtained, the correlation matrix from the second research question presented a contradictory result. The correlation between the return of Bitcoin and the return of OMXS30 was insignificantly different from zero. This may indicate that hedging properties with Bitcoin against the OMXS30 exist. Furthermore, the portfolio which included Bitcoin yielded a slightly lower risk in comparison to the other one.

This paper will be structured as follows. Chapter 1.1 presents a background for Bitcoin, followed by a problem discussion. Chapter 2 covers the literature framework of previous studies regarding Bitcoin and general theories to build a solid foundation for the reader and to position our study. In chapter 3 the methodology and hypotheses for the two research questions will be presented. Chapter 4 gives an empirical presentation of the results. In chapter 5 we present a discussion of our findings, followed by a conclusion in chapter 6. This study will end with Chapter 7 which covers the limitations of this study.

The aim of the study is to analyse a smaller, yet internationally penetrated market and its co-movements with Bitcoin. This will contribute to future research in examining the impact of Bitcoin on different markets.

1.1 Background

1.1.1 Bitcoin
The decentralized “peer-to-peer electronic cash system” was created by the alias Satoshi Nakamoto in 2008 to offer an alternative currency for a global user group. Bitcoin is a system proposed to be an alternative real monetary and payment system (Weber, 2014). A unique selling point of Bitcoin is its independence of any government or central bank which is
attractive to those who lack trust in their governments and financial institutions (Nakamoto, 2008).

The technology behind Bitcoin is “Blockchain” which allows this currency to be anonymously but securely traded without any third-party intermediates (Nakamoto, 2008). The maximum amount of Bitcoin is set to be 21 million, which are made available to the public through mining (Weber, 2014). Mining is a process where computers solve mathematical problems to create new Bitcoins (Yermack, 2013). Digital wallets are available to users where the Bitcoins are stored. These expose investors to risk, as wallets are not necessarily sufficiently protected, and investors may lose all of their Bitcoins to a hacker (Brière et al., 2015).

Bitcoin started to gain attention in late 2013 when the first governmental agency started to investigate Bitcoin (The U.S Senate Committee on Homeland Security and Governmental Affairs, 2013). Some of the hottest topics since then have been taxing of Bitcoin, security breaches in the digital marketplaces and money laundering (Brière et al., 2015). The financial crashes on the financial markets have contributed to the popularity of Bitcoin through a legitimacy crisis towards the financial institutions (Weber, 2014).

Graph 1 shows the Bitcoin price development in USD in 2017.
During the last year, the world's most known cryptocurrency, Bitcoin, has shown an incredible price curve. Graph 1 demonstrates the Bitcoin price in 2017, when the price increased tenfold which has been the steepest slope so far (coindesk, 2018). During the 10 years of Bitcoin's existence, approximately 80% of Bitcoins have been mined and the currency has become widely recognized name through global media visibility (Blockchain, 2018).

1.1.2 Limitations of Bitcoin as a financial asset

When it comes to regulation of Bitcoin, most countries do not consider the usage of Bitcoin illegal but have adopted other regulations for its use instead. In the Swedish context, the use of Bitcoin is legal. However, the Swedish tax agency collects taxes from the use of Bitcoin (Skatteverket, 2017). Hence, regulations do not limit the use of Bitcoin as a financial asset in the Swedish environment.

Another limitation to use Bitcoin as a financial asset is its volatility. As Bitcoin is a fairly new technology many researchers have stated that the data of Bitcoin prices can be affected by its young age (Yermack, 2013). Hence, the volatility is assumed to be unusually high compared to other assets and currencies, which makes it difficult to work with. For trading, the volatility poses significant risks for the reseller, slowing down the Bitcoin adaptation in a bigger scale. This might become easier in the future as Bitcoin futures contracts are coming to the market (CME Group, 2017). For asset purposes the high volatility poses a legitimacy issue as many still believe that Bitcoin is a bubble (Garcia, 2014; Fry and Cheach, 2016). This speculation regarding Bitcoin’s price development and what may influence it, makes it an unpredictable and a risky investment. Hence, this characteristic can limit the use of Bitcoin as a financial asset, as some investors may be looking for more stable and familiar investments tools.

1.2 Problem discussion

Risk is something that concerns every investor, and is therefore a recurring subject of study. Market risk is something every asset is exposed to through a change in one or more market variables (Haughey and Bychuk 2011:18). In this study we will be looking at the market risk of Sweden, which we assume to be reflected in the market index OMXS30. This index includes the 30 most traded public companies in Sweden, which we assume to follow the general market situation.
Hedging as a term can be used in many ways from insurance to futures contracts in trading. In the context of risk and portfolio management, a hedge takes a counteractive market position to reduce portfolio and asset risks (Haughey and Bychuk 2011:47). There are different strategies and financial assets available to decrease these risks (Haughey and Bychuk 2011:48). We will be focusing on a simple strategy of allocating assets to Bitcoin to protect against potential losses in the OMXS30.

To hedge against a security or a market, an investor should focus on the co-movements of securities to construct a portfolio with less risk but with the same expected return (Elton and Gruber, 1997). This will be the foundation for this study as we aim to find a negative correlation between Bitcoin and the Swedish market index. This negative correlation would allow a Swedish investor to hedge the market risk by allocating assets to Bitcoin. The research question is inspired by a study conducted by Dyhrberg (2016B), who found that Bitcoin provides an opportunity for investors to hedge some of the London equity market risk away.

To further extend the study and to gain a better understanding of Bitcoin, correlations between different assets and Bitcoin will be studied. The portfolio return and risk will be analysed in two different cases, portfolio including and excluding Bitcoin. This will provide an overview of whether Bitcoin can be used for diversification purposes in diversified portfolios. Similar studies have been conducted with positive results by Eisl et al. (2015) and Briére et al. (2015) where Bitcoin proved to have very low correlation with other assets and portfolios including Bitcoin had an improved risk-return ratio.
2. Literature Review

This chapter will cover theories which builds a better foundation for understanding this intended study and previous studies related to it. The theoretical framework for the methodology used will follow.

Bitcoin has been speculated to be a virtual gold (Dyhrberg, 2016B) as well as possibly one of the biggest financial bubbles (Garcia, 2014; Fry and Cheach, 2016). A great amount of attention in the empirical research of Bitcoin has been directed at its price formation and whether it is a currency or an asset. Below we present the previous research conducted regarding Bitcoin as a currency and as an asset. We will also present studies related to hedging and portfolio theory.

2.1 Previous Research

2.1.1 Hedging

Managing risk is relevant to all investors and companies. Market risk is something all investments are exposed to when one or more market variables such as interest rate, equity price, commodity prices or exchange rates change significantly (Haughey and Bychuk 2011:18). Hence, managing risks is a relevant area of study.

Hedging plays a big part in risk management for investors when building investment portfolios. The purpose of hedging is to protect the investor from severe asset losses by using different hedging strategies (Haughey and Bychuk 2011:193). For instance, an investor who speculates a market crash and wishes to hedge against the bond and equity market should consider investing in commodities like gold and other metals (Garcia-Feijoo, 2012). Hedging can also be used to cover investors from currency loss in international trading and additionally even to generate better results for international investments (Schmittmann, 2010).

Seeing Bitcoin as a commodity (Dyhrberg, 2016A; 2016B; Bouri, Jalkh, Molnár and Roubaud, 2017) gives us a suitable setting to hedge against the equity market (Garcia-Feijoo, 2012; Bouri, Gupta, Tiwari and Roubaud, 2017).
2.1.2 Portfolio theory
Since 1952 the Portfolio theory has had a great impact on investment decision making regarding different types of risks. This theory was created by Markowitz (1952), who argued that to maximize the risk and return ratio investors should analyse the total variance of the portfolio by analysing the covariance between the individual investments. To minimize or eliminate risks investors should diversify their portfolios with different types of assets (Markowitz, 1952). A study from Booth and Fama (1992) concludes how diversification clearly increases the performance through greater incremental returns and diminished risks. Diversification is a key element to Markowitz’s portfolio theory and multiple studies support this theory (Goetzmann and Kumar, 2008; Geert and Campbell, 1995).

Several studies have concluded that diversification becomes even more important during the most volatile time periods. One study captures a significantly increased correlation in international equity return in a bear market (Campbell, 2002). In addition, there are also arguments which advocate that allocating investments to different markets is beneficial even if said markets are highly integrated (Geert and Campbell, 1995).

According to Markowitz (1952) the selection of different asset weights in a portfolio is done by finding the efficient frontier on a risk-return spectrum. The author suggests that the portfolio with the highest expected return and lowest risk is considered to be the optimal portfolio for a rational investor. The optimal portfolio can be found by testing the portfolio with different asset weights, and by computing different expected return and risk values (Markowitz, 1952).

2.1.3 Bitcoin as a currency
Previous research regarding Bitcoin as currency is relatively limited considering that it was made to be a cryptocurrency. Bitcoins can be used for the exchange of goods globally, but it fails in fulfilling the other requirements to be considered a currency (Yermack, 2013). Yermack points out that despite of its trading possibilities, the unit of account and store of value are high in volatility and the abstract pricing and security issues are too severe to classify Bitcoin as a real currency. The author suggest that Bitcoin behaves more like a speculative investment, which is a similar conclusion the studies below have come to as well. An analysis
of the user behaviour of the Bitcoin may reveal the real intentions with Bitcoin, suggesting that users see Bitcoin as an asset rather than a currency (Glaser, 2014). Furthermore, a study about the negative bubbles and shocks in cryptocurrency markets by Fry and Cheach (2016) concludes that Bitcoin has a significant speculative factor, reaching the same conclusion as Yermack (2013) and Glaser (2014).

2.1.4 Bitcoin as an asset

This standpoint of classifying Bitcoin as a speculative asset inspires to analyse Bitcoin in relation to other currencies, indices, bonds, oil and gold. This area of study seeks to conclude if Bitcoin is a hedging tool, safe haven or only useful for diversification. The general findings are diverse, some have established hedging capabilities (Dyhrberg, 2016A; 2016B; Bouri, Jalkh, Molnár and Roubaud, 2017) and some occasional safe haven properties (Bouri, Azzi and Dyhrberg, 2017; Bouri, Jalkh, Molnár, Roubaud, 2017) while other authors agree only on Bitcoin as a diversification tool (Bouri, Molnár, Azzi, Roubaud and Hagfors, 2017). Many researchers have found some properties of most or all of these three financial asset types, although the real applications of Bitcoin as a financial asset is questionable due to the high volatility and liquidity of Bitcoin (Bouri, Molnár, Azzi, Roubaud and Hagfors, 2017). However, Yermack (2013) makes a stronger statement by suggesting that the high volatility and zero correlation with other currencies and gold, make it useless for hedging and risk management.

For a better understanding of the nature of Bitcoin comparisons are often made to gold. According to Dyhrberg (2016A) this is due to the similarities of the two; they are scarce and costly to extract, free from governments and they have no nationality, both are also mined, and gold used to be a medium of exchange in the same way Bitcoin is used today. Gold is also negatively correlated with USD and for that reason used as a store of value (Dyhrberg, 2016A). Dyhrberg considered the features of Bitcoin in relation to USD, gold and other financial assets to define the economic elements that Bitcoin reacts to. The results showed similarities to both gold and the USD, positioning Bitcoin to somewhere between the two (Dyhrberg, 2016A). Since Bitcoin has these similarities to gold, Dyhrberg suggests that hedging capabilities exist for Bitcoin.
Dyhrberg (2016B) further researches the distinction between the USD, gold and Bitcoin in another study by hedging against the London stock market and the USD with Bitcoin. The results show that Bitcoin can be used to hedge against the FTSE Index and short-term against the USD (Dyhrberg, 2016B). The author suggests that the capabilities of Bitcoin to eliminate or minimize specific market risks indicate placing it in the same asset class with gold (Dyhrberg, 2016B).

Dyhrberg’s (2016A; 2016B) definition of a hedge is difficult to comprehend in the studies of the hedging capabilities of Bitcoin. In the first study the author explains the hedging capability with a non-asymmetric reaction to good and bad news, and the insignificant leverage effect (Dyhrberg, 2016A, 91). The author states that these two combined would allow risk averse investors to hedge some of the market risk under uncertainty. This approach to hedging appears subjective and lacks clarity in how good of a hedge Bitcoin is with these features. In the second study Dyhrberg (2016B) does not discuss or present the hedging definition at all but rather refers to other studies. Hence, it is difficult to understand how the author has approached hedging and identified important characteristics of Bitcoin when it comes to hedging.

Placing Bitcoin alongside with gold may suggests defining it as a commodity with safe haven properties. A study from Bouri, Jalkh, Molnár and Roubaud (2017) analysed if Bitcoin can be used as both a hedge and safe haven for several major financial securities. Their conclusion indicates that Bitcoin function as an effective diversifier in most of the cases rather than a hedge or safe haven. However, a more specific study regarding the hedging capabilities of Bitcoin as opposed to the energy commodity indices revealed significant hedge and safe haven properties (Bouri, Jalkh, Molnár and Roubaud, 2017). In addition, an analysis of the 2013 market crash revealed that Bitcoin has a safe haven property and benefits the investor in risk reduction (Bouri, Azzi and Dyhrberg, 2017).

A global perspective of Bitcoins hedging properties was introduced by Bouri, Gupta, Tiwari and Roubaud (2017) in a study about the possibilities of using Bitcoin to hedge against the global uncertainty. Looking at the global uncertainty levels and how Bitcoin returns behaves,
the study concluded that Bitcoin can be useful as a hedge against global equity market in a short-term (Bouri, Gupta, Tiwari and Roubaud, 2017).

Studies have been done to examine the impact of Bitcoin in an optimal portfolio and researchers have concluded that Bitcoin improves the performance of an investment portfolio (Chen and Vivek, 2014). One study from Brière et al. (2015) looked into the effect of using Bitcoin in portfolio diversification by analysing the correlations between different assets and Bitcoin. The author found a clear benefit in investing a small proportion of Bitcoin in a well-diversified portfolio. The high risk of Bitcoin is compensated by low correlations with other assets and improves the risk-return trade-off (Brière et al., 2015).

Another study by Eisl et al. (2015) analysed how including Bitcoin would change the asset allocation in a well-diversified portfolio, and whether it would improve the risk-return profile. They conclude that including Bitcoin in efficient portfolios with a mean weight ranging from 1.65% to 7.69% outweighs the additional risks faced by the investor. The results indicate that Bitcoin should be included in optimal portfolios (Eisl et al., 2015).

Since Bitcoin is decentralized without any central institution it has been speculated how the Bitcoin price is formulated. Instead of price formation that is based on economics, Bitcoin price may follow the Google search hits as Ladislav (2013) analysed it. According to the study there is a clear causality between Bitcoin price and the Google and Wikipedia searches. Ladislav (2013) also concludes that this might make Bitcoin prone to a bubble behaviour.

2.1.5 Conclusion of Previous Research

In conclusion, previous studies have different perceptions regarding the positioning of Bitcoin in the field of finance. Researches seem to agree that Bitcoin fails to fulfil the requirements of a currency (Yermack, 2013) and state that it is more aligned with the properties of a financial asset (Yermack, 2013; Dyhrberg, 2016A; 2016B). The question of how Bitcoin return correlates with different exchange rates, monetary policies and equity markets has not yet been comprehensively answered. Previous studies about the hedging capabilities of Bitcoin give contradictory results to this question since studies show differing results (Bouri, Molnár, Azzi, Roubaud and Hagfors, 2017; Bouri, Jalkh, Molnár and Roubaud, 2017). This suggests that cryptocurrencies need to be studied more and placed in a category of their own.
Furthermore, the importance of risk managing is presented above and supported by Markowitz (1952) Portfolio Theory. According to Markowitz diversifying the portfolio is one of the key aspects in minimizing the variance and maximizing the return. In this area of study Bitcoin has had a successful result as it seems to be possible to diversify some risk away by holding Bitcoin in an optimal portfolio (Briére et al., 2015; Chen and Vivek, 2014; Eisl et al., 2015). Since these studies do not provide an unified perception of Bitcoins properties and how it reacts in a Swedish market, it is of high interest to broaden our knowledge even further.

2.2 Theoretical Framework

2.2.1 Econometric model

In line with a previous study (Baur and Lucey, 2010) a basic version of a regression model is created to examine whether an asset can act as a diversifier, safe haven or hedge. The purpose of using this model is to examine a possible negative correlation between the independent and dependent variables. A negative correlation indicates a hedging capability. If a zero correlation exists it may indicate a diversification property since the assets are uncorrelated to each other. This theory will be adopted in our methodology.

A subsample analysis is examined in the research by Baur and Lucey (2010), to determine whether the result for the whole sample is also valid in smaller samples. These samples are divided into three different periods; two bull markets and one bear market. This research forms the theoretical foundation for applying dummy variables in our model, to capture the effects of positive and negative returns.

As Bouri, Jalkh, Molnár and Roubaud (2017) noted, Bitcoin is traded every day whereas indices are only active during trading days. Therefore, those additional non-trading days when Bitcoin is traded will be excluded.

The intention of our study is to examine the hedging capabilities of Bitcoin, thus there is an interest in obtaining data where there are multiple movements in price in both directions, as seen in figure 1 (coindesk, 2018; yahoo finance; 2017). Therefore, an observation from the year 2013 to 2017 will be studied.
Figure 1 showing the price in SEK of OMXS30 and Bitcoin during 2013-11-04 to 2017-02-02.

2.2.2 Theory and Concept

To examine the effect of Bitcoin as a diversifier in an optimal portfolio, several approaches have been conducted (Brière et al., 2015; Chen and Vivek, 2014; Eisl et al., 2015). In this study, we will follow a modified method conducted by Chen and Vivek (2014). This modified method will minimize the total portfolio variance for different fixed return with the constraint that short-selling will not be included in this study. The portfolio is fully invested, and each asset obtains a weight between 0 and 1 and the total weight of the assets will together be 1. The supporting argument for this strategy is the result of an unbiased effect of adding additional assets in the portfolio. However, the risk of this strategy is that a large weight may be obtained on the asset that yields the lowest risk on a fixed return. This would further on possibly not reflect reality since it would not be a well-diversified portfolio if the majority of the weight were put on one single asset.
The previous studies mentioned in the earlier paragraph have created two portfolios to observe Bitcoins effect on the portfolio return. This study will be conducted in a similar way by creating two portfolios, one including Bitcoin as an asset and the other one excluding it. These portfolios will have the same base of assets and adding Bitcoin will consequently affect the risk in either a positive or negative way. Furthermore, two efficient frontiers will be created to observe the overall impact Bitcoin has.

2.2.3 Interpretation of empirical data

One of the most common methods of deciding whether a result is significant or not is by performing a hypothesis test. A rejection of the null hypothesis $H_0$ will be practiced in the intended study when computing the regression model, which is also performed by Baur and Lucey (2010). The same procedure will be conducted when we are testing the significance of the correlations in the correlation table. This is done in similarity with previous studies where we test whether the correlation is significantly different from zero or not (Eisl et al., 2015).

To make the analysis of the data more accurate, a hedging capability is defined in a similar way as Baur and Lucey (2010) defines it; negatively correlated with another asset or portfolio on average. Since we use the same methodology to compute the results from the data, this will assist us in the interpretation.

The definition of Bitcoin acting as a potential diversification tool will be in accordance with the theory by Markowitz (1952). He defines a diversifier as an asset that is less than perfectly correlated to other assets in the same portfolio. Since this theory is used in several studies (Briére et al., 2015; Chen and Vivek, 2014; Eisl et al., 2015) examining diversification opportunities for an asset, it is reasonable to execute this study accordingly.
3. Research Design

In this chapter, we will introduce the research methods and tools used to answer our research questions. The first research question will be introduced first and thereafter followed by the second research question. A critical reflection will be conducted for each of the research questions.

The study aims to examine the hedging and diversification capabilities of Bitcoin. In previous studies contradictory statements about the positioning of Bitcoin in the field of finance has been made. Hence, this study will contribute to the knowledge of how Bitcoin behaves in a small but well integrated market compared to the rest of the world. The study aims to capture a comprehensive view of Bitcoin by studying both potential hedging and diversification properties.

3.1 Research Question 1

The approach of this study is based on a deductive analysis. The theory is that Bitcoin can be used as a hedge against the Swedish market. Furthermore, the data will be collected of the price of Bitcoin and the OMXS30 index.

There is insufficient research on the hedging capabilities of Bitcoin against the Swedish market, hence supporting this study's purpose of further examining that area and contributing to the knowledge of Bitcoin as an investment tool in a Swedish market.

To explore the hedging possibilities of Bitcoin against the index OMXS30, a quantitative study will be carried out by using a linear regression model. The chosen index OMXS30 is a capitalization-weighted index of the 30 most actively traded stocks on the Stockholm Stock Exchange (The NASDAQ Group, 2017). This will be an appropriate index to use since previous studies have been conducted using similar indices, but for other markets (Bouri, Molnár, Azzi, Roubaud and Hagfors, 2017; Dyhrberg, 2016A; 2016B).

Several studies (Dyhrberg, 2016A; 2016B; Baur and Lucey, 2010) have used the GARCH model to examine the field of using Bitcoin as a hedging tool, however, a recent replication of that study, stated that this model cannot provide an answer to their research question (Baur,
Dimpfl and Kuck, 2017). Even though the latter study concluded that the model could not give an answer to the research question, it may be due to other errors in the study than the model itself.

To answer the research question with a different approach, separated from the previous studies, a linear regression model with dummy variables will be presented. The dummy variable will be dependent on high negative returns of OMXS30, defined by an interval. This interval is the mean_{OMXS30} ± 1 standard deviation_{OMXS30}. A value r_{OMXS30} at time t that falls below this interval will be considered a high negative return. Continuously, the dummy variable will obtain the value of 1 when the negative return is high, otherwise 0.

3.1.1 The Linear Regression Models

In this study, two regression models will be presented to determine if we can hedge using Bitcoin. The first model will be constructed to observe the correlation between the assets. The second model will be an extension of the first one to observe if the relationship between the assets changes when the negative return is high.

The data obtained will be used to estimate the linear regression models, with the assumptions that the model used is given by:

\[ Y_t = \alpha + \beta X_t + \epsilon_t \]

Where variable Y is the return of the Bitcoin price, α is a constant, β is a regression coefficient, the independent variable X is the return of the OMXS30 index and ε is a disturbance term.

The first model is given by:

\[ r_{t, \text{Bitcoin}} = \alpha + \beta_1 r_{t, \text{OMXS30}} + \epsilon_t \quad (1) \]

For the second model we use dummy variable to capture the high negative returns of Bitcoin and its relationship to OMXS30. Dummy variables are convenient when categorical variables are present and when the variables have no relationship to each other. This binary variable
takes the value of 1, otherwise 0 depending on what is decided. This creates an estimated model that is divided into two different groups, further on creating a possibility to observe the data and apply a model that can include several conditions.

The second model is given by:

\[ r_{t, \text{Bitcoin}} = \alpha_1 + \beta_1 r_{t, \text{OMXS30}} + D \beta_2 r_{t, \text{OMXS30}} + D \alpha_2 + \varepsilon_t \]  

(2)

*Where D=dummy variable.*

When D=1, indicating a higher negative return the model will have the following form:

\[ r_{t, \text{Bitcoin}} = \alpha_1 + \beta_1 r_{t, \text{OMXS30}} + 1 \times \beta_2 r_{t, \text{OMXS30}} + 1 \times \alpha_2 + \varepsilon_t \]

When D=0, indicating a non-high negative return, the model will have the following form:

\[ r_{t, \text{Bitcoin}} = \alpha_1 + \beta_1 r_{t, \text{OMXS30}} + \varepsilon_t \]

These models seek to explain the relationship between the return of Bitcoin and OMXS30. The potential negative correlation between \( r_{\text{OMXS30}} \) and \( r_{\text{Bitcoin}} \) will define the hedging capabilities of Bitcoin, as stated by Baur and Lucey (2010). The use the of a linear regression model is a different approach compared to previous studies that have applied the GARCH model instead (Dyhrberg 2016A; 2016B; Baur and Lucey, 2010).

**Ordinary Least Square**

For the regression models, the OLS is a method is used. The method estimates the linear regression models by minimizing the distance between the estimated linear regression and the actual data points. The total sum of squared residuals describes how well the fitted model explains the given data. The R\(^2\)-value will obtain a value between 0 and 1. A value of 1 means that the model explains 100% of the data and a value of 0 means that 0% of the model explains the data.
3.1.2 Calculations of the return

\[ r_{\text{Bitcoin}} = \frac{P_t}{P_{t-1}} \]
\[ r_{\text{OMXS30}} = \frac{P_t + D}{P_t} \]

The variable \( P_t \) is the price for time \( t \) and variable \( P_{t-1} \) is the price for time \( t-1 \), in our case, the previous stock market day. The variable \( D \) is the paid dividends.

3.1.3 Significance test

A hypothesis test is conducted by defining a null hypothesis and an alternative hypothesis. A p-value will be conducted on the significance level of 1%, 5% and 10%. The significance levels of \( \alpha=0.01, 0.05 \) or 0.10 indicate a 1%, 5% or 10% unlikeness of observing a test statistic that extreme.

The hypothesis test conducted in the study tests the significance of \( \beta_2 \). We reject the null hypothesis \( H_0 \) of \( \beta_2 = 0 \) if the p-value < than the chosen significance level and we do not reject the null hypothesis otherwise.

\[ H_0: \beta_2 = 0 \]
\[ H_1: \beta_2 \geq 0 \]

If we can reject \( H_0 \), \( \beta_2 \) results in being significant. This means that the parameter should be included in the model, indicating that correlation between the \( r_{\text{Bitcoin}} \) and \( r_{\text{OMXS30}} \) is lower when the market is not doing well. This will further on indicate a hedging opportunity for Bitcoin against the Swedish market.

If we cannot reject \( H_0 \) it may indicate that \( \beta_2 \) is in fact equal or close to zero. This may show that Bitcoin holds other properties which are separate from the properties of a hedging tool.

3.1.4 Problems with hypothesis testing (type I and type II error)

The issue of executing a hypothesis test may be the encounter of error, more specifically type I and type II error. The first error concerns the issue of falsely rejecting a null hypothesis which results in a false positive. Type I error can be minimized by choosing a proper
significance level $\alpha$ and taking the risk of rejecting a true null hypothesis into account when drawing conclusions. However, decreasing $\alpha$ and keeping everything else the same, may increase the probability of a type II error. Which is when one is not rejecting the null hypothesis when it is false, resulting in a false positive (Banerjee et al., 2009).

Further studies have questioned the use of hypothesis testing and its validity since there are a few misconceptions regarding it. A smaller $p$-value gives for instance, the misunderstanding that the relationship is stronger. Another criticism stated by Kirk (1996) is that this test does not actually provide the researcher with the answer he/she is looking for. This is explained by the fact that we want to know if $H_0$ is rejectable or non-rejectable, given a set of data. But, what this test shows is that if $H_0$ is true, then the probability of obtaining an at least as extreme data is given by the $p$-value (Gliner, Leech, & Morgan, 2002).

3.1.5 Limitations of The Linear Regression Model

**Heteroscedasticity**

The existence of dependent noise, also known as heteroscedasticity, may affect the reliability of some data points. The importance of examining this is based on the risk of building an inefficient regression model that could affect the estimated parameters negatively. This problem can occur when the noise is dependent on other properties in the actual data, making the variance in the error term non-constant. Since the given values of these data points are still valuable we do not want to ignore them, but instead give them a less weighted value in the estimation of the coefficients.

To measure how the errors increase when the independent variable increases, and thereby test the existence of heteroscedasticity, a Breusch-Pagan test can be set up accordingly:

Hypothesis:

- $H_0$: The model is homoscedastic
- $H_1$: The model is heteroscedastic

Test statistics: $n * R^2 \sim \chi^2$
Where n is the sample size and $R^2$ of the regression model. Furthermore, the H0 should be rejected if the p-value resulted from the chi-squared test is less than the significance level, normally 0.05.

**Autocorrelation**

The problem of autocorrelation occurs when the error terms are not independent from each other, meaning that $y(x_{t+1})$ is not independent from $y(x_t)$. In other means, an autocorrelation in the error terms is present if the correlation between the error term is not equal to zero. This is quantified by defining the autocorrelation between -1 and 1, which indicates a strong negative and positive association respectively.

The problem that can arise from autocorrelation in the error terms is that the OLS test statistics and the standard error is not valid. Hence the importance of detecting whether there is an autocorrelation present. This can be achieved by performing a Durbin-Watson test that tests the following:

Hypothesis:

- H0: no first order autocorrelation exists
- H1: first order autocorrelation exists

**3.2 Data**

The data gathered in this study will extend from the period 2013-11-02 to 2017-02-02, where the prices are obtained when the market closes for OMXS30. Since Bitcoin is traded daily at all hours, the daily price is defined as midnight 00:00 UTC.

The time period was chosen due to the fact that it consists of both a positive and negative trend. The total amount of observations for Bitcoin will be 811 which accounts for all the weekdays, subtracting the Swedish weekends since the OMXS30 is closed during these days. The data for the historical prices of Bitcoin and OMXS30 is obtained from [www.coindesk.com](http://www.coindesk.com) and [www.finance.yahoo.com](http://www.finance.yahoo.com) respectively. Since the Bitcoin price is
3.3 Research Question 2

The second research question investigates Bitcoin as a potential diversification tool in a diversified portfolio. A deductive analysis will be conducted from six different assets returns to identify the co-movements to Bitcoin. Furthermore, different portfolios will be analysed to identify Bitcoins diversification properties that many other previous studies have found (Eisl et al., 2015; Brière et al., 2015; Bouri, Molnár, Azzi, Roubaud and Hagfors, 2017).

A quantitative analysis of the correlations of Bitcoin and other assets gives us an understanding of how Bitcoin relates to other investments. Looking further into the minimum variance portfolio computation provides us with an insight as to whether Bitcoin should be included in a portfolio, and how the risk-return ratio changes. Many of the other assets that are analysed have been included in other studies as well (Brière et al., 2015; Eisl et al., 2015). OMXS30 is a new asset that this study introduces to the diversified portfolio.

To answer the second research question with a positive response, we are looking for correlations between other assets and Bitcoin that are close to zero. Additionally, Bitcoin should be included in the minimum variance portfolio with other assets. Finally, by including Bitcoin in the portfolio one should be able to lower the risk on given return rates, as opposed to excluding Bitcoin.

3.3.1 Correlation Table

A table of correlations will demonstrate how each asset correlates with other assets in a portfolio. The selected assets are OMXS30, Dow Jones, Nikkei 225, gold, oil and Bitcoin.

The outcome of Bitcoin having relatively lower correlations, or more specifically zero correlation, with other assets is of interest. This would indicate that Bitcoin is a good diversifier since it would not get affected by other assets in the same portfolio. An uncorrelated asset minimizes the risk of the portfolio as uncertainty in other assets will not be transferred to the uncorrelated asset. Hence, a depreciation in the value of other assets is more unlikely to spread forward to this asset.
3.3.2 Significance test

To test if the correlations are significantly different from zero, a significance test is performed. The hypotheses will be the following:

\[ H_0: \text{corr} = 0 \]
\[ H_1: \text{corr} \neq 0 \]

A test is rejected if the p-value < chosen significance level, this indicates that the correlation is significantly different from zero. A non-rejection implies that the correlation is insignificantly different from zero, which is in favour of a good diversifier. A significance test is performed for all asset combinations.

3.2.3 The Mean Variance Optimization

To estimate the minimum variance portfolio and the efficient frontier, a mean-variance optimization (MVO) method will be used. The efficient frontier is defined by several portfolios that are collections of the same assets in different weights. These portfolios will find the best risk-return ratios with the MVO-method. The portfolio with the lowest risk value is the minimum variance portfolio. To find the variance for each asset the following formula is used:

\[ \delta^2 = \sqrt{\frac{\sum_{i=1}^{N} (x_i - \bar{x})^2}{n-1}} \]

where \( x \) is the return of an asset at time \( t \).

For the variance of the portfolio we use the formula:

\[ \delta^2(r_p) = \sum_{i=1}^{n} w_i^2 \times \delta^2(r_i) + \sum_{i=1}^{n} \sum_{j=i+1}^{n} 2 \times w_i \times w_j \times \text{cov}(r_i, r_j) \]

where \( w \) is the weight of an asset \( i \) in the portfolio \( p \), and \( r \) is a return of an asset \( i \).
The expected portfolio return is defined as the sum of the weighted expected returns for each asset:

\[ E(r_p) = E(r_1) \times w_1 + E(r_2) \times w_2 + E(r_3) \times w_3 + E(r_4) \times w_4 + E(r_5) \times w_5 + E(r_6) \times w_6 \]

where \( w_1 + w_2 + w_3 + w_4 + w_5 + w_6 = 1 \)

Following the Portfolio Theory by Markowitz, two efficient frontiers will be created. To find the efficient frontiers we estimate two different portfolios with eight different fixed returns for each portfolio. To find the optimal weights for each asset the portfolio variance is minimized on fixed returns. This will answer the question of whether adding Bitcoin to the portfolio yields a lower risk.

3.2.4 Limitations of the Mean Variance Optimization-method

Due to the abnormal nature of Bitcoin returns, the distribution may show large values for kurtosis and skewness as Eisl et al. (2015) describes it. They do not suggest the classic mean-variance approach for this reason. Alternatively, they suggest that Conditional Value-at-Risk framework can have better properties when asset returns are not normally distributed. As most of the portfolio assets present more traditional investment alternatives with more stable returns, it may not be necessary to choose a framework that can support returns that are not normally distributed.

3.3 Data

The data source of OMXS30 and Bitcoin are the same as in the first research question. Nikkei 225 and Dow Jones are obtained from [www.finance.yahoo.com](http://www.finance.yahoo.com). The crude oil prices are from [www.research.stlouisfed.org](http://www.research.stlouisfed.org) and gold prices are from [www.gold.org](http://www.gold.org). For the second research question the data is analysed daily, ranging from 2013-11-02 until 2017-02-02. For Bitcoin the same price will be used as in research question 1, being the daily price at 00:00 UTC. The obtained prices for Nikkei 225, Dow Jones, OMXS30, oil and gold are the daily closing prices in the respective markets. The assets that are outside the Swedish market are adapted to the Swedish trading days. This means that on days when an asset has a non-trading day and the Swedish calendar has a trading day, there is an additional return that equals the price on the
previous day. Also, on days when an asset is trading but the Swedish market is not, the asset return values are excluded. This is done to get more accurate results on a daily level.
4. Empirical presentation

*In this chapter, we will present the results from the first research questions, followed by a presentation of the second research question.*

4.1 Descriptive statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Variance</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>rBitcoin</td>
<td>0.003129</td>
<td>0.051978269</td>
<td>0.00270174</td>
<td>2.549376214</td>
<td>34.15823258</td>
</tr>
<tr>
<td>rOMXS30</td>
<td>0.000303</td>
<td>0.011490734</td>
<td>0.000132037</td>
<td>-0.510878053</td>
<td>4.370225815</td>
</tr>
</tbody>
</table>

*Table 1 shows the descriptive statistics of the daily trading returns on Bitcoin and OMXS30.*

Table 1 provides an insight to the characteristics of the data sample. The values are obtained from Bitcoin and OMXS30 returns over the sample time. Bitcoin has a higher mean and standard deviation value than OMXS30, which can indicate higher risk and return. Both mean values are close to zero.

Bitcoin has a positive value for skewness, indicating frequent small negative outcomes and less likely extreme negative outcomes. Since the skewness is higher than +1 this indicates a highly skewed distribution. Negative value in skewness indicates that frequent small positive outcomes and extremely negative outcomes are rather likely.

Kurtosis values for Bitcoin and OMXS30 provide an understanding of the distribution of the observations around the mean. In a normal distribution kurtosis is equal to three, which means that both of our data samples are leptokurtic. This describes a kurtosis above three and expresses a distribution with fatter tails and more chances of extreme outcomes. For Bitcoin this is significantly larger than for OMXS30 or normal distribution. In other words, historical values are clustered around the mean and large fluctuation are more likely within the fat tails.
4.2 Statistical findings

<table>
<thead>
<tr>
<th></th>
<th>Model (1)</th>
<th>P-value (1)</th>
<th>Model (2)</th>
<th>P-value (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\alpha_1$</td>
<td>0.00232</td>
<td>0.19189</td>
<td>0.00114</td>
<td>0.56426</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>-0.10621</td>
<td>0.50040</td>
<td>0.05929</td>
<td>0.78697</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td></td>
<td>0.13358</td>
<td>0.81386</td>
<td></td>
</tr>
<tr>
<td>$\alpha_2$</td>
<td></td>
<td>0.01268</td>
<td>0.27782</td>
<td></td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.00056</td>
<td></td>
<td>0.00326</td>
<td></td>
</tr>
</tbody>
</table>

Table 2 shows the coefficients of the models and their p-value respectively, followed by the $R^2$-value.

Table 2 provides us with the results from the regression output for the models. Model (1) presents a negative $\beta_2$-value which indicates that the return of Bitcoin and OMXS30 is negative. The parameter for model changes its sign when the dummy variables are added which indicates that the relationship between these assets changes when large movements in the return is present. But, none of the coefficients are significant since they are well above a significance level of 10%. The $R^2$-value is slightly higher for model (2) than for model (1) which indicates that the contribution of dummy variables improves the model. However, the $R^2$-value is not satisfactory since it is well below the value of 1. This indicates that the model is not a good fit for the observed data, thus creating an analysis that may lack accuracy.

Observing $\beta_2$ in model (2) concludes that we cannot reject the null hypothesis of $\beta_2=0$ at the significance level 0.1, since 0.81387>0.1. Additionally, this indicates that $\beta_2$ might be zero, i.e. it might not provide an extra value for the model.
4.2.1 Test for heteroscedasticity

Table 3 shows the result of the Breusch-Pagan-test for heteroscedasticity for model (2).

* significantly different from zero in 5% significance level
** significantly different from zero in 1% significance level

Heteroscedasticity is tested for model (2) by using the Breusch-Pagan-test. From table 3 we can interpret a non-rejection of the null hypothesis, stating that the data used to estimate the model is homoscedastic. This does not limit the use of the model in this study. Furthermore, it indicates that modification of the model is not necessary since the noise is independently distributed.

4.2.2 Autocorrelation

Graph 2 describes the autocorrelation function for the residuals of model (2).
Observing graph 2 gives us the indication that until the third lag (k=3) there is evidence of autocorrelation since they fall below respectively above the critical value of -0.07 and 0.07. In other words, we reject the null hypothesis of no autocorrelation up until the third lag. This argues for the existence of a moderate correlation in the residuals of the model. Since the lags are within the critical values from k=4 up until k=10 we cannot reject the null hypothesis, implying a lack of evidence of autocorrelation in the residuals for the latter lags.

Since autocorrelation in the residuals is present it limits the use of our linear regression model in this study. We can no longer assume that the linear regression model is able to provide us with valid information of Bitcoins hedging opportunities.

4.3 Bitcoin as a diversifier

4.3.1 Descriptive Statistics

<table>
<thead>
<tr>
<th>Assets</th>
<th>OMXS30</th>
<th>Dow Jones</th>
<th>Nikkei 225</th>
<th>Oil</th>
<th>Gold</th>
<th>Bitcoin</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMXS30</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dow Jones</td>
<td>0.01066</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nikkei 225</td>
<td>-0.03290</td>
<td>0.17135*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil</td>
<td>0.07416**</td>
<td>0.33861*</td>
<td>0.15216*</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td>0.05680</td>
<td>-0.14318*</td>
<td>-0.14391*</td>
<td>0.00860</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Bitcoin</td>
<td>-0.02328</td>
<td>0.00442</td>
<td>0.03597</td>
<td>0.03004</td>
<td>0.03201</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 4 shows a correlation matrix that presents the correlation between the assets studied.

* significantly different from zero in 5% significance level

** significantly different from zero in 1% significance level
Table 4 presents correlations between the assets included in the portfolio. It can be observed that Bitcoin has the lowest correlations among all assets. From the significance test we conclude that Bitcoin correlation values are insignificantly different from zero. Additionally, Bitcoin and OMXS30 have a negative correlation, though very close to zero. OMXS30 has low correlations with other assets as well, and correlates negatively to the market index of Japan, Nikkei 225. The strongest positive correlation in the portfolio is between Dow Jones and Oil. The strongest negative correlation is between gold and Dow Jones, and gold and Nikkei 225, which are significantly different from zero. This strong negative correlation can indicate hedging and safe haven properties which are studied further by other researchers (Lucey and Baur, 2010).

One should keep in mind that these values can be temporary. Correlations are known to be unstable and can change dramatically under extreme market conditions (Goetzmann et al., 2005; Brière et al., 2015). Other studies have also presented results where Bitcoin has low correlations with the other assets. In a study by Brière et al. (2015) only two assets exhibited a significant correlation with Bitcoin, gold (14%) and inflation-linked bonds (14%).
4.3.2 Statistical Findings

<table>
<thead>
<tr>
<th>Return</th>
<th>SD Including Bitcoin</th>
<th>SD excluding Bitcoin</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01%</td>
<td>0.011580</td>
<td>0.011580</td>
</tr>
<tr>
<td>0.02%</td>
<td>0.009314</td>
<td>0.009314</td>
</tr>
<tr>
<td>0.03%</td>
<td>0.007998</td>
<td>0.007998</td>
</tr>
<tr>
<td>0.04%</td>
<td>0.007033</td>
<td>0.007035</td>
</tr>
<tr>
<td>0.05%</td>
<td>0.006497</td>
<td>0.006499</td>
</tr>
<tr>
<td>0.06%</td>
<td>0.006446</td>
<td>0.006620</td>
</tr>
<tr>
<td>0.07%</td>
<td>0.007019</td>
<td>0.007673</td>
</tr>
<tr>
<td>0.08%</td>
<td>0.008103</td>
<td>0.014716</td>
</tr>
</tbody>
</table>

*Table 5 presents the returns and standard deviation valued for the two portfolios that are demonstrated in figure 2.*

Table 5 presents the result of the MVO analysis of eight portfolios each. These portfolios create an efficient frontier line, that can be seen in figure 2. From the efficient frontiers it can be observed that the portfolios including Bitcoin yields a lower risk than the portfolios excluding Bitcoin. The minimum variance portfolio can be found between 0.05% and 0.06% return (figure 2), and from there including Bitcoin in the portfolio decreases the standard deviation on each return level.
Figure 2 depicts the efficient frontier lines of the two portfolios. The minimum variance portfolio is the one furthest to the left of the graph. The portfolio return is presented as a percentage and the risk is defined as the standard deviation of the portfolio.

In appendix 1 and 2 the weights for the portfolios can be found. It can be observed that having a return under 0.05% is not suggested with a portfolio where Bitcoin has a weight. This could be explained by the high returns of Bitcoin that contribute to a higher portfolio return, even with a minimal weight in a portfolio. Hence, looking at return values that are above 0.05% is more valuable in this study. Additionally, having a higher return than 0.08% is not found for a portfolio that excludes Bitcoin and by including Bitcoin in the portfolio investor can reach a higher return value.

The obtained results are aligned with previous studies regarding the portfolio return with and without Bitcoin (Eisl et al., 2015; Brière, 2015). From the results in this study we can observe that Bitcoin contributes more to the return of the portfolio than to the risk. This has also been observed by Eisl (2015) and Brière (2015).
5. Discussion and Critical Reflection

In this section, we discuss and perform a critical reflection on the study.

To determine if Bitcoin can be used for hedging against OMXS30 we have conducted a test of significance to the parameter $\beta_2$. The parameter defines how the relationship of Bitcoin and OMXS30 is affected when the return of OMXS30 is negative. The analysis gives a parameter value that is slightly above zero but insignificant. Since the result is insignificant we cannot suggest that the theory of using Bitcoin as a hedge is supported in this context. In a previous study (Dyhrberg, 2016B) there are differing results, therefore our result was unexpected.

To test the error term in the model, heteroscedasticity and autocorrelation tests are conducted. There is no evidence of heteroscedasticity and the autocorrelation is significant until the third lag. This suggest a limitation on our linear regression model. There might be an opportunity to gain an improved $R^2$-value by lagging the variable. However, we do not perform this since we observe this as a limitation to our study only. This may furthermore cause an invalid test statistic and standard error which should be acknowledged. The linear regression analysis gives us a high p-value and low R-squared value, indicating a poor choice of model to fit the data. Therefore, our results propose the use of a more suitable model to analyse the return of Bitcoin. One used by many other researchers is the GARCH model which captures high volatility that is also a characteristic of Bitcoin.

Observing the skewness and kurtosis values for both OMXS30 and Bitcoin, we can observe varying characteristics. This implies distributions that are slightly different from each other, leading to potential difficulties in modelling the two data sets.

As the estimated parameter values for the OMXS30 are slightly above zero, it may indicate that Bitcoin can be used as a diversification tool instead. The linear regression analysis has not provided a comprehensive answer to the first research question. The results indicate that Bitcoin cannot be used as a hedge against the OMXS30, however the results are not accurate enough for a clear conclusion.
Since the results of our first research question gave us coefficients that were close to zero, that may indicate potential diversification capabilities for Bitcoin. This supports the execution of the second research question, which provides positive results for considering Bitcoin as a diversification tool. As presented in figure 2 Bitcoin decreases the standard deviation for different portfolios on fixed returns. These results imply that investor may be able to diversify some risk by holding Bitcoin in a portfolio. This is aligned with the Portfolio Theory by Markowitz (1952), as increased diversification decreases the risk.

The relatively low weight of Bitcoin in the portfolio may be explained by the other assets in the portfolio. Since three of the assets are indices they contribute to great diversity in the portfolio. Hence the portfolio is already well diversified, and it may not be surprising that Bitcoin obtains a lower weight in comparison. It can be noted that the given return levels are rather low. This may limit the Bitcoin weight as well, since including even a small portion of Bitcoin in a portfolio can contribute to the return significantly.

Something worth noticing in table 4 is that Bitcoin has the lowest correlation to other assets and a negative correlation to OMXS30. The low correlation with other assets indicates that Bitcoin should be a good diversifier and the negative correlation with the OMXS30 index should indicate potential hedging opportunities. This is contradictory to our results obtained from the first research question since the obtained $\beta_1$ from model (2) is positive, as seen in table 2. However, this result may further support the speculation that the linear regression model is a poor choice for this study.

The results of considering Bitcoin as a diversification tool are compelling. Considering Bitcoin as a good diversifier would not be a completely new discovery as other studies have also found similar results (Brière et al., 2015; Eisl et al., 2014). In these studies, a good diversification tool is presented as an asset that is uncorrelated with many other assets, which are similar to our findings.

The real-life application of using Bitcoin as an investment tool are questionable since previous studies are contradictory. This may be explained by the young age of Bitcoin, which may contribute to its unstableness. This can be observed in the high volatility in the Bitcoin price.
Continuously, the observation window for the data is narrow since the market has not experienced any major crisis. This fails to provide us with data to analyse how Bitcoin reacts in extreme market conditions.
6. Conclusion

Bitcoin is the most well-known cryptocurrency with an exceptional price development. The empirical studies regarding cryptocurrencies tend to consider Bitcoin as more of an asset than a currency. Hence it is a lucrative research subject for hedging and portfolio diversification. This study analyses Bitcoin from a Swedish investors perspective, contributing a knowledge of how Bitcoin relates to a small yet internationally well-integrated market.

In conclusion, the research question: *if Bitcoin can be used as a hedge against the Swedish market index?* cannot be accurately answered since we did not obtain significant coefficients. Furthermore, our approach of using the linear regression model resulted in a poor fit for the data observed. The obtained value of the insignificant coefficient $\beta_2$ hints that Bitcoin cannot be used for hedging. The divergent result in comparison to previous studies conducted by Baur and Lucey (2010) and Dyhrberg (2016A; 2016B) can be due to the different choice of model for this study.

Despite obtaining insignificant coefficients, $\beta_2$ had a correlation that was positive and close to zero. This supported an even stronger argument for executing our second research question: *Can Bitcoin be used as a diversification tool in a diversified portfolio?* The results obtained from the correlation matrix (table 4) implied a minimal correlation between Bitcoin and the other assets in the portfolio. This is an adequate result for diversification. Performing the MVO-method for the portfolio provides further support for the research question as the optimized portfolio includes Bitcoin among the assets in the minimum variance portfolio. Furthermore, removing Bitcoin from the portfolio increases the risk on the given return rate. Hence, including Bitcoin in an investment portfolio seems to result in lower risks for different fixed returns.

Low correlation values of Bitcoin and other assets raise further questions on the possibilities of diversification. What might be interesting to research further is how different industries and markets correlate with Bitcoin. In addition, in the case of an extreme market crash it could be interesting to look into Bitcoin as a safe haven on the Swedish market.
Lastly, we want to emphasise the difficulty in defining the true nature of Bitcoin. One of the problems with this is that Bitcoin has not matured yet, which contributes to it being unpredictable.
7. Limitations of Research

_In this section we will state the limitations and the flaws in our study._

One of the limitations in our study is that the linear regression model may not be the best fit for a data set that has a inconsistent volatility. Since autocorrelation for the error terms is present it is argued that one should lag the variable, which was not done as it was considered as a limitation to our study only. This might result in only an approximately valid hypothesis testing. Another concern is the MVO-method may also be compromised when analysing Bitcoins data with high skewness and kurtosis values.

The analysed days range from 2013-11-02 to 2017-02-02 which does not include the remaining months for the year of 2017. These months had a high price development and including these could result in different outcomes of the study. This may therefore limit the application of our findings in the future as Bitcoin is highly unpredictable. Furthermore, our data may also be contaminated by early-stage behaviour compromising the analysis of future performance. The correlation results may also change significantly under uncertainty and crisis.
References


http://dx.doi.org/10.2139/ssrn.2408997


Skatteverket, 2017. Virtuella valutor. [online] Available at: https://www.skatteverket.se/privat/skatter/vardepapper/andratillgangar/virtuellavalutor.4.15532c7b1442f256bae11b60.html [Accessed 22 November 2017]


Appendices

<table>
<thead>
<tr>
<th>Assets</th>
<th>Weight 1</th>
<th>Weight 2</th>
<th>Weight 3</th>
<th>Weight 4</th>
<th>Weight 5</th>
<th>Weight 6</th>
<th>Weight 7</th>
<th>Weight 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMXS30</td>
<td>0.629</td>
<td>0.611</td>
<td>0.532</td>
<td>0.447</td>
<td>0.364</td>
<td>0.271</td>
<td>0.157</td>
<td>0.043</td>
</tr>
<tr>
<td>Dow Jones</td>
<td>0</td>
<td>0</td>
<td>0.082</td>
<td>0.207</td>
<td>0.327</td>
<td>0.417</td>
<td>0.508</td>
<td>0.599</td>
</tr>
<tr>
<td>Nikkei 225</td>
<td>0</td>
<td>0.173</td>
<td>0.214</td>
<td>0.206</td>
<td>0.198</td>
<td>0.177</td>
<td>0.150</td>
<td>0.122</td>
</tr>
<tr>
<td>Oil</td>
<td>0.371</td>
<td>0.215</td>
<td>0.138</td>
<td>0.078</td>
<td>0.020</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gold</td>
<td>0</td>
<td>0</td>
<td>0.035</td>
<td>0.063</td>
<td>0.089</td>
<td>0.111</td>
<td>0.137</td>
<td>0.162</td>
</tr>
<tr>
<td>Bitcoin</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.003</td>
<td>0.024</td>
<td>0.049</td>
<td>0.074</td>
</tr>
</tbody>
</table>

| Portfolio Return | 0.01%    | 0.02%    | 0.03%    | 0.04%    | 0.05%    | 0.06%    | 0.07%    | 0.08%    |
| Portfolio Standard Deviation | 0.0116   | 0.0093   | 0.0080   | 0.0070   | 0.0065   | 0.0064   | 0.0070   | 0.0081   |

Appendix 1 presents the portfolio weights when the MVO-method is applied for fixed returns. The portfolios include Bitcoin.
<table>
<thead>
<tr>
<th>Assets</th>
<th>Weight 1</th>
<th>Weight 2</th>
<th>Weight 3</th>
<th>Weight 4</th>
<th>Weight 5</th>
<th>Weight 6</th>
<th>Weight 7</th>
<th>Weight 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>OMXS30</td>
<td>0.629</td>
<td>0.612</td>
<td>0.532</td>
<td>0.447</td>
<td>0.361</td>
<td>0.214</td>
<td>0.041</td>
<td>0</td>
</tr>
<tr>
<td>Dow Jones</td>
<td>0</td>
<td>0</td>
<td>0.082</td>
<td>0.207</td>
<td>0.332</td>
<td>0.480</td>
<td>0.638</td>
<td>0.383</td>
</tr>
<tr>
<td>Nikkei 225</td>
<td>0</td>
<td>0.172</td>
<td>0.214</td>
<td>0.206</td>
<td>0.198</td>
<td>0.174</td>
<td>0.142</td>
<td>0</td>
</tr>
<tr>
<td>Oil</td>
<td>0.371</td>
<td>0.217</td>
<td>0.138</td>
<td>0.078</td>
<td>0.018</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Gold</td>
<td>0</td>
<td>0</td>
<td>0.035</td>
<td>0.063</td>
<td>0.090</td>
<td>0.132</td>
<td>0.179</td>
<td>0.617</td>
</tr>
</tbody>
</table>

| Portfolio Return | 0.01%  | 0.02%  | 0.03%  | 0.04%  | 0.05%  | 0.06%  | 0.07%  | 0.08%  |
| Portfolio Standard Deviation | 0.0116 | 0.0093 | 0.0080 | 0.0070 | 0.0065 | 0.0066 | 0.0077 | 0.0147 |

Appendix 2 presents the portfolio weights when the MVO-method is applied for fixed returns. The portfolios exclude Bitcoin.