An examination of the hedging properties of gold and bitcoin using volatility

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Abstract:

Gold has been considered a hedge against inflation for a long time, although researchers have found different results in their examinations. Bitcoin, a relatively new phenomenon in the financial market, is also, for some investors, a monetary protection against central banks' actions resulting in inflation. Studying the effects of different economic variables such as volatility, inflation and interest rates on investments is of great value for investors when deciding whether to buy, sell or hold on to an asset. This study examined if gold and bitcoin's conditional volatilities can be useful when determining a hedge against inflation. It did so by investigating the relationship between the asset's conditional volatility, log returns and inflation levels in Sweden and the USA. The S&P 500 and OMXSPI, representing the stock markets in both the USA and Sweden respectively, were both included in the thesis as comparisons with gold and bitcoin, as they are considered alternative investments to each other. We did this such comparison to see if these investment objects exhibit different hedging properties. While this study did not confirm the conditional volatility to be a good indication or strategy for hedging against inflation, it did signal different relationships between the conditional volatilities of gold and bitcoin relative to the two countries' inflation.

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1. Introduction

One significant advancement in finance is the development of recent technical tools that help investors forecast assets' future behaviour. This development allows investors to predict the determinants of an investment's return and the risks coupled to their investments choices to maximise returns. There is a relationship between risk and return coupled to all investments, and investors can adopt strategies to minimise risk.

Future purchasing power and real return on investments, which is the difference between nominal return and inflation (Bodie, Kane & Marcus, 2014), is always a concern for investors because the higher the future inflation, the lesser the real return. This connection makes inflation a risk, and investors can protect their portfolios by offsetting such risk through hedging. Different assets react differently to the effects of inflation, and investigating such relationships is of significant interest. Some assets considered by investors to hedge against a rise in inflation are gold and, in most recent times, bitcoin.

The word "hedge" is used as a synonym for "protection" and is often used in finance when referring to a way of limiting something (Cambridge Dictionary, n.d.). In this thesis, hedging refers to investors trying to limit the losses incurred from systematic risks coupled to investments, such as inflation. Investors can do this by holding alternative investments as a protection against their portfolio decreasing in value. This report will evaluate the hedging properties of gold and bitcoin by looking at their volatility and how it relates to inflation and see if gold and bitcoin express different hedging properties than the stock indices OMXSPI and S&P 500.

Volatility is a widely observed parameter in finance that is fundamental when pricing a financial instrument and considering a risk or studying its behaviour. Technically, volatility measures an asset's returns variation around its mean, i.e., variance. The higher the variance, the higher the uncertainty and, therefore, volatility is considered a risk (Bodie et al., 2014). Investors are interested in studying and predicting an asset's future volatility to use it in different ways. One way can be to make an investment or portfolio with a more even risk level over time by examining the volatility (current and future) and increasing or decreasing the underlying asset's exposure (Strukturinvest Fondkommission, 2020). Afees et al. (2020) argue that forecasting the volatility of gold can be of importance in the quest of hedging

strategies to reduce or offset portfolio risks. Volatility can also be used to examine the market's reaction to a particular factor as it responds to a variety of global economic conditions, such as inflation.

Since the financial crisis in 2008, many central banks around the world have been operating expansive monetary policy to boost economic activity. The ongoing pandemic has and is still having negative consequences on many economies and the global financial market, and its impact has led central banks to stimulate the economy further. Referencing portfolio theory, history, and macro theory, these actions from the central banks could increase inflation rates, which might make investors reallocate their capital and diversify their portfolios. This leads to some critical questions: How do investors react to the consequences of the pandemic and the actions of the central banks, which assets should investors buy, and which should they avoid?

The results of previous research on whether gold is a good hedge against inflation or not differ depending on the methods used or the period analysed. Meanwhile, bitcoin as a hedge is not widely researched due to the short period of data available. The recent development in bitcoin's price, together with the stimulus from the central banks and governments because of the ongoing pandemic, give reasons to research the consequence of these developments on investments. Based on economic theories, the stimulus might lead to a rise in inflation rates. Therefore, it becomes relevant to research the question of using gold and bitcoin as a hedge. Previous research has studied the effects of macroeconomic variables such as inflation on gold and bitcoins volatility; however, based on what we found during our research, the perspective of determining assets hedging properties through their volatility remains unexplored and is the objective of this thesis.

1.2 Aim

This research aims to determine if investors can use gold and bitcoin's volatility when considering these assets as hedge against the effects of inflation on their investments. We also investigate the impact of inflation on the stock markets by including the indices S&P 500 and OMXSPI to see if their returns and volatilities act differently due to inflation changes.

Our study aims to, by studying historical data of the volatility and returns of these assets and inflation, give investors insights that make their hedge more robust, and to explore a strategy that could be included by investors when analysing hedging positions against inflation in their portfolios.

This research intends to answer the following questions:

Q1: Can gold and bitcoins volatility be used to indicate if these assets are a good hedge against the effects of inflation?

Q2: More specifically, how do gold and bitcoins volatilities vary with their logarithmic returns and inflation in Sweden and the USA compared to the S&P 500 and OMXSPI?

1.3 Background

1.3.1 Properties of Gold and Bitcoin as Investments

Generally, investors and scholars have regarded gold as a hedge against inflation over a long time. Gold retains its purchasing power over a very long period, has the characteristics to be classed as international money (Goodman, 1956) and is useful in industrial components and jewellery (Tully & Lucey, 2007). Gold is also an effective portfolio stabiliser since it keeps its liquidity during times of market turbulence (Shahzad et al., 2020). These are some of the properties that make investors and scholars consider gold a good investment and sometimes a hedge against inflation.

Bitcoin is a recent (relative gold) investment alternative and element in the financial markets. Since its introduction in 2008, bitcoin has gained more attention from the media, finance industry, and academics.

Fiat money is government-issued currencies not backed by any commodity. Bitcoin differentiates itself from such currency because of its quality of being created through a mining process of cryptography and is decentralised, i.e., it is not coupled with any central bank nor controlled by any central government. The mining process of bitcoin is the process where it gets released into circulation, which requires solving computationally tricky puzzles (Investopedia, 2021). One of its creation's argument was to

avoid central banks' ability to deflate the currency's value by increasing the money supply (Hunter & Kerr, 2019). These features give bitcoin its uniqueness. At the same time, it fails as a unit of account and store of value because of its volatility, which are two qualities of fiat money. (Cheung, Roca & Su, 2015).

As described above, bitcoin has some unique features, and with its increase in gaining a reputation among Millennials and young investors, it is sometimes referred to as the "digital gold" (Bambrough, 2020, 26 October). The bitcoin user base is increasingly growing, and it has had a tremendous appreciation in recent years, with bitcoin now traded on multiple exchanges.

The popularity of bitcoin leads one to question whether investors have started buying bitcoin to substitute for gold and use bitcoin to hedge against an expected rise in inflation. Forest and real estate are other assets widely used as a hedge against inflation. However, we will not cover these in this report to limit this paper's scope.

1.3.2 2020 and the Covid-19 Pandemic

From 2020 to date, a drastic weakening of the global economy has prevailed, and central banks and governments worldwide have taken extensive actions to stabilise the economy. An example is the Swedish Central Bank which has provided households and corporates with the support needed for a functioning credit system by keeping interest rates low. The central bank asserts that extensive support will be provided for as long as necessary, and that its goal is to send rising inflation signals, so the expected inflation does not stay on low levels for a long time (Central Bank of Sweden, 2020).

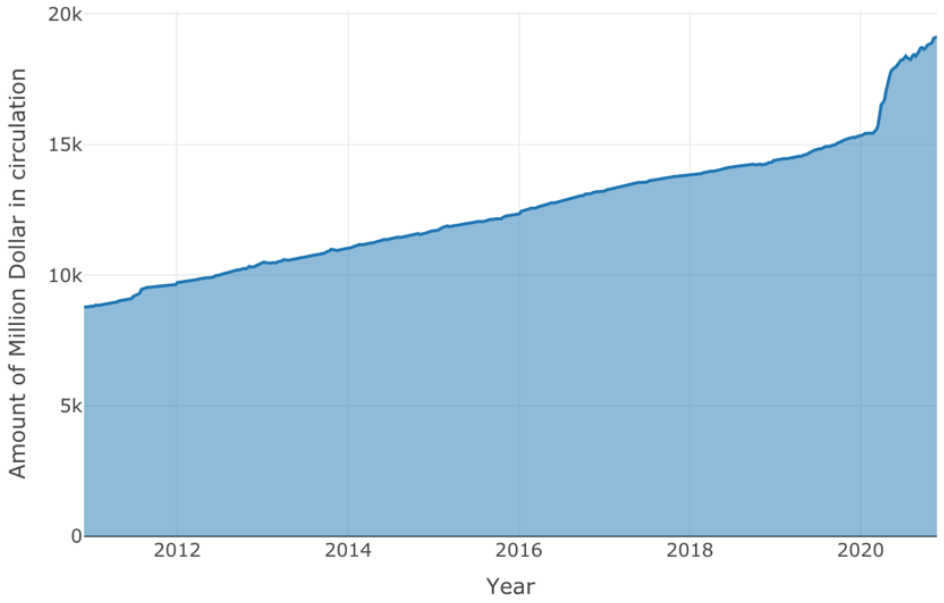
One can see that investors are predicting future scenarios of a rise in inflation rates because of the ongoing stimulus due to the pandemic. With the recent development of the Coronavirus vaccines and some already rolling out, reasons for expecting an overheat of the economy exist. For one, the stimulus is already in the economy and will still be provided to corporations for an extended period. Two, the consumption is back to higher levels sooner than predicted. These expectations can be traced to the increase in demand for alternative assets and be read about in financial newspapers and research sites. Pond (cited in Stanton & Purvis, 2021), head of inflation-linked market strategy at Barclays Capital, said that higher

inflation is motivated due to increased demand as things go back to normal while some supply chains are still disrupted. Another recent article on Yahoo Finance (2021) illustrates that investors fear inflation due to various factors, such as significant stimulus, positive effects from vaccines and supply bottlenecks.

Figure 1 shows one example of the significant stimulus, which shows how the USA's central bank has increased the number of dollars in circulation under 2020 relative to recent years.

Figure 1

Amount of Million Dollars in Circulation



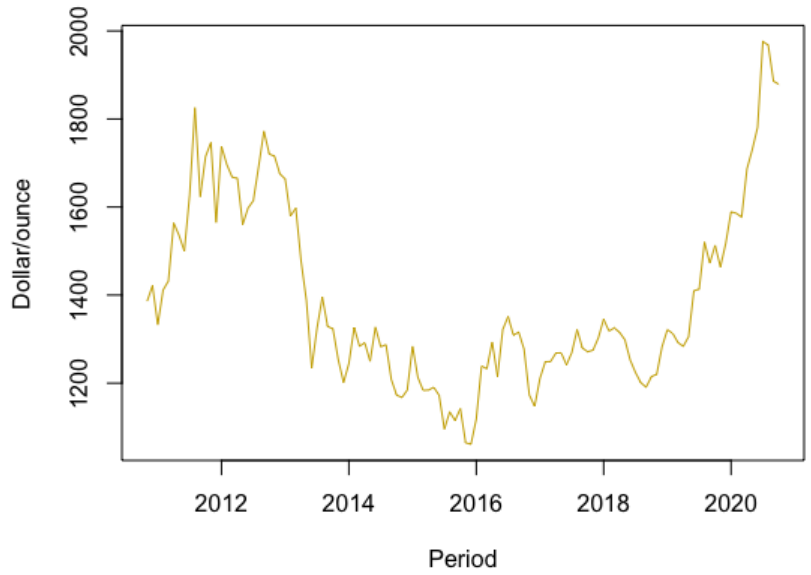
Note. Money stock (M2) in the USA from November 2010 - November 2020. Data for graph construction is collected from the Board of Governors of the Federal Reserve System (U.S.).

However, the Central Bank of Sweden (2020) writes in its monetary policy report that inflation will likely stay under its target of 2 percent for a long time.

One can also see an increase in the demand for gold and bitcoin, which are assets associated with higher inflation, by observing their prices as shown in figure 2 and 3, where these assets have seen a significant rise during 2020, although with minor exceptions.

Figure 2

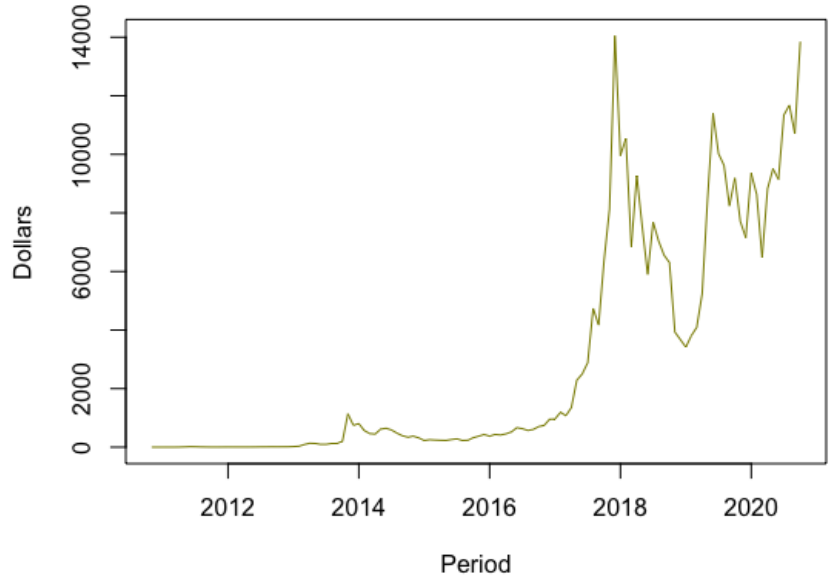
Gold Price



Note. Diagram of the gold price from November 2010-November 2020. Data: Bloomberg.

Figure 3

Bitcoin Price



Note. Diagram of bitcoin price from November 2010-November 2020. Data: Bloomberg.

1.3.3 Inflation, Interest Rates and its Effects on Stock Investments

Inflation is the rate at which the general price level is measured. The central banks influence inflation by both long- and short-term interest rates to either heat up or cool down the economy (Oxenstierna, 2018). According to Bodie et al. (2014), when a central bank increases the money supply, the short-term interest rates decrease, ultimately encouraging consumption and investment demand, resulting in lower unemployment and a rise in inflation. They also state that supply bottlenecks are another factor that triggers inflation.

Interest rates and forecasting it are an essential factor for an investor when making asset allocation decisions. Bodie et al. (2014) outline that when high inflation becomes a fact, the central banks instead make the interest rates rise, which will lead investors to move to bonds as it is the main alternative to stocks, besides cash. In the last decade, the interest rates have been low, and investors and institutions have had a few choices but to invest their capital in the stock market to find return (Grocer, 2019, 11 July). These capital flows have led to a long rise in the stock markets.

Considering the above scenario of rising interest rates, it is relevant to think about what will happen if we see an opposite scenario, i.e., interest rate rising to tone down an overheat of the economy as a result of the stimulus during 2020 and 2021, which might result in inflation if the recovery from the pandemic comes faster than expected. If so, other investment alternatives than stocks will provide more return, and capital will seek these opportunities, leading to a sell-off on the stock markets, and the stock prices might fall. An investor that mainly holds stocks today should therefore be aware of other assets to own or hedge with, especially assets that are not negatively affected by these changes in such market climate.

1.3.4 Theory

1.3.4.1 Efficient Market Hypothesis

Following the Efficient Market Hypothesis (EMH), stock prices and change in stock prices reflect all available information in the market. Though, the debate of whether the market is perfectly efficient or not is widely discussed. Still, intelligent investors try to predict and

forecast future scenarios to discover relevant information that can guide them on which asset to buy or sell (Bodie et al., 2014).

Fama (1970) suggests different levels of how efficient the market is, reaching from weak, semi-strong to strong form. If the market is perfectly efficient, there shouldn't exist the possibilities of attaining future greater returns since all information is reflected in the actual price. These market efficiencies are determined by how fast new information is reflected in an investment's current price.

This market disorder guides investors into taking advantage of their sophisticated models, new methods and relatively strong investment knowledge to use historical data for future forecasts and thereby take advantage of these market inefficacies to gain high future returns.

1.3.4.2 Modern Portfolio Theory

One of the Modern Portfolio Theory's central arguments is that investors and portfolio managers desire high returns on their investments while being averse to risk. All investments bear some risk, and the intercorrelation between assets of the same class makes it impossible to eliminate all risk. However, the Modern Portfolio Theory implies that there should exist an efficient portfolio relative to the risk of the assets in the portfolio, thereby suggesting that investors and portfolio managers should create a well-diversified portfolio of different investments. By doing so, investors and portfolio managers can increase their probability of attaining greater returns while maintaining the same level of risk equivalent to owning just one or very few assets (Markowitz, 1952).

This theory makes diversification fundamental in investors' approach to minimise risk. By owning securities within different sectors or multiple industries that exhibit low intercorrelation, an investor can stabilise a portfolio or gain greater returns since different sectors are affected differently by the same economic factors. Despite this, systematic risks, such as inflation, which is undiversifiable and inherent to the whole market, still exist, and other instruments that can offset or counter the effects of such risks are desirable. Thus, by identifying such risks, reducing or eliminating their effects can increase an investors probability of attaining higher returns. During economic climates characterised by an increase in expected inflation or unpredictable growth, investors should be risk-averse, thus seeking

risk-free investments and diversifying their portfolios with assets that hedge against inflation (Sherman, 1982).

1.3.4.3 The Expectation Hypothesis

The Expectation Hypothesis implies that the future interest rate coincides with the markets consensus expectation of the future short interest rate. This convergence gives a reason to believe that when the market actors predict a rise in the interest rates, the actual rates will eventually follow. The hypothesis suggests that when the future short rate is expected to rise, today's long rate will exceed the current short rate plus a risk premium for them to yield the same return. Thereby, this theory claims that the investments of different maturities are perfect substitutes for each other (Browne & Manasse, 1989). The theory states that one can predict the future expected inflation by comparing the real and nominal forward rates. This, because forward rates are obtained from the bond markets, which are the nominal interest rates, and the difference between the real and the nominal rates is approximately the inflation rate (Bodie et al., 2014).

Knowing this relationship can be important for investors when taking early investment or hedging positions especially when seeing the expectations in the market changes.

1.3.5 Literature review

The works of literatures relevant to this subject can be categorised into two groups, those who study the relationship between inflation and the prices of gold and bitcoin, trying to contribute to the discussion of whether these assets are a hedge against inflation or not, and those who examine the effect of inflation on these assets' volatility.

By different methods and models, such as Capital Allocation Pricing Model, Arbitrage Pricing Theory, General Auto-Regressive Conditional Heteroscedasticity Model, and other statistical techniques, researchers have studied the hedging properties of gold against inflation in different periods and have found different results. Some find that gold has hedging properties (Beckmanna & Czudaj 2013; McCown & Zimmerman 2006; Tkacz 2007), while some did not confirm the existence of such a relationship (Blose 2009; Tully & Lucey 2007).

Beckmanna & Czudaj (2013) argue that gold has partly hedging properties and that gold price movements reflect expected inflation changes. It asserts that this relationship between gold's return and inflation exists in the long-term in extended periods for investors, but not in the short-term when no price adjustments are observed. McCown and Zimmerman (2006) conclude by using Arbitrage Pricing Theory in their report that they also find evidence that gold hedge against inflation. Both studies imply, though, that the time horizon is crucial for finding such a relationship. These studies have collected data from 1970 until 2003 (McCown & Zimmerman, 2006) respective 2011 (Beckmanna & Czudaj, 2013), partly covering an era with a different inflation climate than we have today.

In the last 25 years, inflation has been low and stable, and one study covering only this period is Tkacz (2007), who has collected data from 1994 till 2005. Tkacz (2007) concluded that gold price contains information about the future path of inflation, which was especially significant in countries studied with inflation targets. Since our paper also covers a period where inflation has been low and stable, but post the financial crisis 2008, it is interesting to compare its results with this thesis's. Blose (2009) also examines the relationship between inflation and gold prices but claims that gold price does not get affected due to an unexpected rise in the Consumer Price Index. Lawrence (2003) investigates gold hedging properties with statistical methods and claims that there is no significant link between gold returns and inflation, which is a good characteristic of a hedging instrument. However, Lucey et al. (2019) point out in their article that in recent times, bitcoin's properties have made investors' attention to be shifting from gold in favour of bitcoin as a hedging instrument.

Some research papers have examined the volatility of gold and its role for investors and portfolio managers during times of market uncertainty or situations perceived by investors to play out negatively to their market positions. Tully & Lucey (2007) investigates the macroeconomic influences on the gold market using a method related to the one we use, called AP-GARCH. Although it studies a different time spectrum than us, it could not draw a statistically significant conclusion of inflation's influence on gold return variance. One of its findings was that over time, the volatility of gold return is derived endogenously. Bailey (1988) examines the impact on asset volatility from economic announcements. This study found a relationship between the announced money supply and the volatility of gold and stock index volatility. The volatility in gold rises as a result, while the stock indices' volatility

declines with unexpected money supply growth.

There have been some studies on bitcoin, though much less than on gold, as a hedge against inflation. Still, not many investigate its volatility since it is a relatively new phenomenon with data from 2010. Thus, it is attractive to add more research on the field since we have more data and information to analyse in the area for every year and month that passes. However, prior evidence that exists shows different results. Hunter and Kerr (2019) examine the price determinants of Non-Fiat Anonymous Digital Payment Methods, such as bitcoin, and their relationship with inflation. The study notes that bitcoin is partly a hedge against inflation but 11mphasizes the need for better tools to capture the relationship between that kind of currency (Non-Fiat Anonymous Digital Payment Methods) and fiat money supply. This gap is what we hope our study can fill-in too. Schilling and Uhlig (2019) found that an increase in the money supply needed to achieve inflation targets influences bitcoin price, making it interesting to investigate inflation's impact on bitcoins volatility. One study on bitcoins volatility, written by Lyócsa et al. (2020), studies various price determinants of bitcoin and concludes that bitcoin volatility tends not to be influenced by general macroeconomic news such as inflation announcements.

2. Methodology

We investigate the relationship between gold and bitcoin's volatility, inflation levels, and log returns, by including these variables in a regression model. Before the presentation of the regression model, the data and the data transformation process are presented in the following section.

2.1 Data

OMXSPI is the stock market index that gives an overall picture of all the stocks listed on the exchange in Sweden. The S&P 500 consists of the 500 most traded stocks on the USA stock exchange and provides a good view of the USA's general stock market. Gold is the spot market price of gold measured in US dollars per ounce, while bitcoin is the spot exchange rate, reflecting the price of one bitcoin per US dollar. The Consumer Price Index (CPI) is our measurement for inflation, an average index of domestic consumer prices based on

consumers' actual paid prices continuously updated to match the new fashion and new technology consumed (Statistics Sweden 2020).

2.2 Data Collection Procedures

To fulfil this thesis's purpose, we have collected data from both the Swedish and the U.S. markets. The U.S. economy has a substantial influence on Sweden and the rest of the world, and therefore the inclusion of this essential, financially interesting and overseen nation. We have downloaded the S&P 500, OMXSPI, bitcoin and gold price data from the Bloomberg terminal, Swedish CPI from Sweden Bureau of Statistics and the U.S. CPI from the U.S. Bureau of Labour Statistics. The period is the same for all our dataset and reaches from November 2010 till November 2020. They are all collected monthly, which gives 120 observations for all variables.

2.3 Log Returns

The prices of the observed indices, gold and bitcoin, bear some characteristics of non- stationarity, that is, when data is consistently trending from its mean, and an excellent approach to this is to model their returns and not the price. According to Tsay (2005), log returns, short form of logarithmic return, tend to be more stable over multiple periods than the price change, also known as net returns. Log returns also enable the evaluation between the relationships of two or more variables originating from price series of different values. Brownlees, Engel and Kelly (2011) estimated assets' volatility in their research using the log returns. Therefore, the indices', gold and bitcoin return in this thesis, are calculated using log returns, as illustrated in equation 1.

$$log\ return\ =\ ln_{pt} - ln_{pt-1} \qquad (1)$$

Where:

$ln\ =\ the\ natural\ logarithm$

$pt\ =\ \ price\ at\ time\ t$

$pt-1 = price\ at\ time\ t-1$

2.3.1 Descriptive Statistics

Table 1

Descriptive Statistics for our 120 observations

	Mean	Median	Max	Min	Skewness	Sd
Log return gold	0.003	-0.0008	0.12	-0.12	0.01	0.046
Log return Bitcoin	0.094	0.057	1.70	-0.5	1.62	0.33
Log return S&P	0.009	0.014	0.12	-0.13	-0.55	0.039
Log return OMXSPI	0.006	0.011	0.1	-0.14	-0.65	0.042
CPI Sweden	1.094	1.05	3.4	-0.6	0.275	1.05
CPI USA	1.733	1.7	3.9	-0.2	0.009	0.886

Table 1 shows the descriptive statistics for the assets and the CPIs under study. From the table above, we can see that the log transformed returns of the indices, gold and bitcoin have more comparable values, where the mean and median do not differ as much as they would have done with their original values. Within the collected data, one can see that bitcoin's log return has the highest standard deviation and exhibits positive skewness. This is as expected due to the recent development of bitcoins price, which has seen a drastic increase in value.

The values of the CPI in Sweden and USA are included in the regression in their original form since we are interested in the levels of these variables, however, if a regression analysis is condoned with the standard deviation of the log returns as a measure of volatility, the result can be misleading. This problem will be addressed by the GARCH (1,1) model, whose specifications are presented in the following section.

2.4 GARCH (1,1)

In this paper, we use the General Autoregressive Conditional Heteroscedasticity model (GARCH) introduced by Bollerslev (1986), a model for analysing and forecasting time series volatility. According to Stock and Watson (2012), GARCH is frequently used for its simplicity and ability to capture volatility clustering (periods of high volatility followed by periods of low volatility), which is often one of the characteristics of financial time series data. Our data variables portray such features, as seen in figure 6.1.1, 6.1.2, 6.2.3 and 6.1.4 in Appendix 6.1.

We use standard GARCH (1,1) in this thesis, the most general form of its related GARCH models. It is mostly used to forecast an asset's future volatility as it provides the asset's conditional volatility. The conditional volatility is derived from weighting the asset's average long-run volatility, lagged squared errors of returns and lagged standard deviation affected by new market information. This is done by assigning coefficients as weights to these variables (see equation 2).

GARCH (1,1):

$$\sigma^2 = \pi + \alpha\,\sigma_{t-1} + \beta\varepsilon_{t-1}^2 \qquad (2)$$

Where:

$\sigma^2 = Conditional\ volatility$

$\pi = Weighted\ long-run\ average\ volatility$

$\sigma = Standard\ deviation\ of\ log\ returns\ from\ equation\ (1)$

$t = time\ period$

$\varepsilon^2 = squared\ errors\ from\ the\ ARMA\ process.$

$\pi, \alpha, \beta = weights$

$With\ the\ constraints:\ \pi + \alpha + \beta = 1\ \ where\quad \pi > 0,\quad \alpha \geq 0,\quad \beta \geq 0,$

There is a built-in process in the GARCH model that takes the log returns from equation *(1)* and provides its error terms which is one of the inputs in the GARCH equation, that is ε (see equation above). This built-in process is called ARMA and takes a linear approach to the log

returns in order to get these residuals.

In other words, the volatility from standard GARCH (1,1) is a refined volatility containing the future volatility outlook, making it more suitable for this analysis. We apply the GARCH (1,1) model to the 120 observations of each asset. Then, we do a regression of the volatilities gained from GARCH to analyse the impact of the inflation on each asset's conditional volatility.

2.5 Model Choice

After we obtain the conditional volatility from the GARCH (1,1) model, we include it in our regression model as the dependent variable to detect any relationship between conditional volatility, inflation and log returns.

2.5.1. Regression Model

We chose to construct the regression model as presented in equation *(3)*, where inflation is our variable of interest while we control for log returns. The variable log return is derived from equation *(1)* and the variable conditional volatility from equation *(2)*

$$Conditional\ Volatility = \beta_0 + \beta_1\, CPI + \beta_2\, log\ return + \varepsilon \qquad (3)$$

Where:

$Conditional\ volatility = volatility\ from\ GARCH\ (1,1)\ in\ equation\ 2.$

$\varepsilon = Error\ term/unobserved\ component$

$\beta = coefficient\ of\ variables$

A graphical examination of the relationship between price levels and volatility was performed, to also get a better understanding of the short-term relationship and the reaction of price levels during high volatility, than what the regression model could reveal, the result is presented in Appendix 6.2.

2.6 Limitations

Since bitcoin has only existed for approximately ten years, we chose the period from 2010 until today for our complete analysis. After the financial crisis, the inflation rate has been scanty and almost stagnant, while there has been a relatively sturdy rate of change in the other parameters. This makes it hard to capture a whole cycle and different inflation levels within these ten years. It would be interesting to expand some parts of our research; doing so might reveal relevant and more robust results. However, bitcoin's inclusion does not allow our research to capture all the assets' extended history, limiting the time frame of our study.

3. Results

3.1 *Results and analysis*

3.1.1 Regression

Below is the presentation of the regression model's result applying equation 3, which estimates the effects of monthly inflation and the assets' respective monthly returns on the conditional volatility of bitcoin and gold. The main discovery, among other findings, from the regression model is the effect of inflation on the volatility of bitcoin. The results are presented in table 2 below.

Table 2

Regression Table

	Conditional Volatility Gold		Conditional Volatility Bitcoin		Conditional Volatility OMXSPI	Conditional Volatility S&P 500
	(1)	(2)	(3)	(4)	(5)	(6)
CPI Sweden	-0.004		0.029***		0.001	
CPI USA		0.002*		0.006***		-0.002
Log return OMXSPI					0.026	
Log return S&P 500						0.057
Log return Gold	0.000	-0.006				
Log return Bitcoin			0.005	0.001		
Intercept	0.004***	0.043***	0.277***	0.207***	0.039***	0.042***
R-Square	0.007	0.032	0.04	0.12	0.009	0.046

*Note. P-values: *** < 0.01, ** < 0.05, * < 0.1 Observations: 120*

The table above shows our regression estimates, containing six models of the relationship between conditional volatility and the other variables of interest. Regression 1 models the effect of gold's log returns and inflation in Sweden on gold's volatility. Regression 2 models the relationship of inflation in the USA and gold's log returns on its volatility. In model 3 and 4, we examine the effect of inflation in Sweden and the USA and bitcoins log returns on bitcoin's conditional volatility. Models 5 and 6 address the relationship between the volatility of the stock market and the stock market's log returns and inflation in the respective country.

In regression 1, the coefficients of inflation in Sweden and gold's log return are not statistically significant. In contrast, in regression 2, the USA inflation coefficient is positive and statistically significant, implying that, in general terms, when the inflation rate rises in the USA, gold becomes more volatile. Controlling for the log returns of gold does not indicate the direction of price during a volatile period. Gold's conditional volatility shows different relationships with inflation in the considered countries, a negative relationship with inflation in Sweden, though not significant, while the opposite is the case in the USA.

Positive statistically significant coefficients yield in regression 3 and 4, where the effect of inflation in both the USA and Sweden on bitcoins volatility are presented. This result suggests that bitcoin becomes more volatile during a rise in the examined countries' inflation rates. In contrast, the coefficient of bitcoin's log return is not significant, which gives a slightly different result compared to gold but still does not provide a statistically significant price direction during the examined period.

Regression 5 and 6 show no statistically significant coefficients.

The coefficients of the assets' log returns did not yield any statistically significant relationship with the assets' volatility, leading us to consider a periodic relationship analysis between the price levels and the assets' conditional volatility in the next section.

3.1.2 Graphical Interpretation of Assets Price Levels and Volatility.

The following sub-section presents a complementary analysis to the above regression results. The figures from this analysis are placed in appendix 6.2. From the figures, one can see the existence of short-term patterns between the conditional volatility and the price levels of our considered assets. With this analysis we want to see if the price levels act in a certain way or direction during high volatility, despite the mechanical connection in the variables, considering they originate from the same data variable. Inflation has been low and stagnant during the analysed period, and its effect has been captured in the regression analysis above. Therefore, we present this graphical presentation including only the conditional volatility and price levels. However, looking at the figures in appendix 6.2, it is hard to justify specific periodic patterns, thus, making a consequential conclusion difficult. Figure 6.2.2 shows that

the relationship between bitcoin's price and conditional volatility during the chosen timeframe is hard to interpret because bitcoin has been extraordinarily volatile and was at low price levels in its early years. Despite this, looking at the last five years (figure 6.2.5), the spikes of volatility follow significant price levels both up and down. Studying figures 6.2.3 and 6.2.4 shows that the indices' volatility spikes match the dips in prices. This pattern is extra clear when looking at the crisis of 2020. It can also be seen that at low volatility times, we observe a positive trend in price levels of both OMXSPI and S&P 500.

4. Discussion and Conclusion

4.1 Discussion

This paper aimed to see if the examination of conditional volatility can help to determine which asset to use as a hedge against the effect of inflation on expected return. Based on market theories, when inflation rates suddenly increase, investors should consider the new inflation level and efficiently reallocate capital to assets they traditionally consider a hedge against inflation. These actions can contribute to the higher volatility, which comes as a result of the inflow or outflow of capital in the asset. Hence, when the CPI rises in the USA and the same happens in gold volatility, it indicates a lot of market activity. When the inflow is more than the outflow, the price increases, and the opposite result is a price decrease; thus, examining this volatility is of great interest for investors.

The positive relationship between the inflation in the USA and gold conditional volatility indicates that an increase in inflation rates results in higher volatility, which could make gold a less attractive asset to investors since volatility is a measure of risk. Therefore, analysing price reactions during this period of high volatility could reveal to investors if there exist some benefits of a hedge against inflation using gold. Thus, our result was complemented with the price level analysis.

In the graphical analysis of assets' price movements and conditional volatility (appendix 6.2), the gold price has been both on up and downtrends during high volatility measures. This indicates that, even though investors could use gold conditional volatility to decide when to rally to gold as a hedge, the relationship between the price and the volatility does not give a

clear view of what direction the price will go in the following period, and so determining the profitability of the hedge is inconclusive.

Our result differs from the conclusion that Tully and Lucey (2007) reached, who did not find a relationship between macroeconomic effects, such as inflation, on the volatility of gold. The difference in the examination periods could explain this divergence. A different economic climate such as higher inflation, higher interest rates and lower unemployment existed during their study since it was conducted before the financial crisis in 2008 and this study was made after the crisis.

Bitcoin has in recent times seen an enormous increase in price and relatively low volatility in comparison to the early years of our analysis; this makes the price to volatility relationship hard to analyse and conclude something consequential. Analysing bitcoin also comes with a caution; it is a very speculative, unregulated and controversial asset, which explains its high volatility and unpredictability. These characteristics coincide with the presented results. Our results show a significant positive impact of a rise in inflation rate on bitcoin's volatility despite low inflation levels. This relationship partly confirms the arguments for the creation of bitcoin and the efficient markets of today where a signal of a rise in inflation reflects attention of investors to the asset, which might prove the acceptance of it being a conventional hedging asset against inflation. Nonetheless, its hedging capacity is not confirmed in the price level analysis, leaving our examination without proof that bitcoin's conditional volatility could determine its hedging profitability.

The outcome of our analysis differs from Lyócsa et al. (2020) findings in their paper, where no reaction on the volatility due to inflation announcements was detected. Their analysis involves multiple macroeconomic variables, and this thesis does not, a scenario which could have impacted the difference in the two analyses.

No relevance is detected when examining the effect of a rise in inflation on the volatility of OMXSPI and S&P 500. Although the volatility increases simultaneously as the stock prices fall, it is hard to look at one parameter to predict the other, as seen in figures 6.2.3 and 6.2.4 (appendix 6.2). Despite this and the uptrend in indices price, the volatility cannot tell us when to hedge against inflation with stock indices and whether there is profitability in the hedge due to increased price levels. As a result, neither the volatilities of OMXSPI nor the S&P 500

can help investors determine a profitable hedge.

Besides bitcoin and partly gold, we could not see a statistically significant impact of inflation on the other assets' volatility. These results contrast with Bailey's (1988) study, which could prove different effects of money supply growth on its considered assets' volatilities, where the volatility in gold rises, while the stock indices' volatility falls due to unexpected money supply growth. Recent developments such as the internet, economic factors such as the existence of new financial instruments, and globalisation could have contributed to the contrasting results.

4.2 Conclusion

Our study has analysed the conditional volatility of assets with different characteristics to explore the usefulness of their conditional volatility in pinning-down their hedging properties. To the best of our knowledge, we are the first to consider the use of conditional volatility to investigate the hedging properties of gold and bitcoin against the effect of inflation on expected return.

The foundation of this thesis and its analysis are based on the theoretical assumptions and relationships presented in the background, such as the Modern Portfolio Theory, where a distinction between asset classes could show different or even opposite reactions. Therefore, we included the indices to lead investors to better decision making when deciding what asset to hold when inflation increases. However, our examination of volatility as a method did not portray such guidance.

Considering our method of measurement and time-period, we conclude that our examined assets' volatility is not a reliable tool to determine the hedging properties of an investment such as gold, bitcoin and the considered stock indices. Nevertheless, our analysis still suggests that gold conditional volatility could only be useful to investors in the USA when determining a hedge against an expected increase in inflation. Additionally, bitcoin's conditional volatility could help investors in Sweden and the USA under the same circumstances. The weakness of their relationships and the lack of a clear price direction indicate that they cannot be used alone but can be included as a complement in a toolbox with other sophisticated hedging tools when considering these assets as a hedge against inflation's

effect on a well-diversified portfolio.

4.3 Recommendations for Further Research

It would be interesting to see the full consequence of the ongoing pandemic and see how inflation reacts to the stimulus when the pandemic is over. The outcome of this pandemic will vary depending on the vaccine's effectiveness that has just come into circulation within some economies. The next coming 4 to 5 years after the pandemic will be an interesting experimental time to examine gold and bitcoin's full effect as hedge against inflation.

5. References

Afees, A.S., Rangan, G., Elie, B., & Qiang, J. (2020) "The role of global economic conditions in forecasting gold market volatility: Evidence from a GARCH-MIDAS approach" Research in International Business and Finance, Vol 54
https://doi.org/10.1016/j.ribaf.2020.101308

Bailey, W. (1988) "Money Supply Announcements and the Ex. Ante Volatility of Asset Prices" Journal of Money, Credit and Banking, Vol. 20, No. 4, pp. 611-620 (10 pages)
https://doi-org.ezproxy.ub.gu.se/10.2307/1992287

Bambrough, B. (2020, October 26). Why America's Biggest Bank Is Suddenly Very Bullish on Bitcoin. Forbes. Collected 2020 November 28, from https://www.forbes.com/sites/billybambrough/2020/10/26/why-americas-biggest-bank-is-suddenly-very-bullish-on-bitcoin/?sh=14ac1f4476f6

Beckmanna, J., & Czudaj, R. (2013) "Gold as an inflation hedge in a time-varying coefficient framework". The North American journal of economics and finance, (24): 208-222.
https://doi.org/10.1016/j.najef.2012.10.00

Blose, E. L. (2010) "Gold prices, cost of carry, and expected inflation".
Journal of Economics and Business Volume 62, Issue 1, Pp 35-47
https://doi.org/10.1016/j.jeconbus.2009.07.001

Board of Governors of the Federal Reserve System (U.S.), M2 Money Stock [M2], retrieved from FRED, Federal Reserve Bank of St. Louis.
https://fred.stlouisfed.org/series/M2, December 13, 2020.

Bodie, Z., Kane, A., & Marcus A.J. (2014) Investments Global edition. 10th ed. Berkshire: McGraw-Hill Education.

Bollerslev, T. (1986) "Generalised autoregressive conditional heteroscedasticity". Journal of Econometrics (31): Issue 3, Pages 307-327 https://doi.org/10.1016/0304-4076(86)90063-1

Browne, F., & Manasse, P. (1989) "The Information Content of the Term Structure of Interest Rates: Theory and Practice", OECD Publishing

https://doi-org.ezproxy.ub.gu.se/10.1787/748671027822

Brownlees, C., Engle, R., & Kelly, B. (2012) "A practical guide to volatility forecasting through calm and storm", The Journal of Risk, vol. 14, no. 2, pp. 3-22. Doi: 10.21314/JOR.2012.237

Cambridge Dictionary (n.d.) HEDGE | meaning in the Cambridge English Dictionary. Collected 2021-02-15, from https://dictionary.cambridge.org/dictionary/english/hedge

Central Bank of Sweden (November 2020) "Monetary policy report". Central Bank of Sweden: Stockholm. https://www.riksbank.se/sv/penningpolitik/penningpolitisk-rapport/2020/penningpolitisk-rapport-november-2020/ p.13

Cheung, A., Roca, E., & Su, J.J. (2015). Crypto-currency bubbles: an application of the Phillips-Shi-Yu (2013) methodology on Mt. Gox bitcoin prices. Applied Economics, 47(23), 2348–2358. https://doi-org.ezproxy.ub.gu.se/10.1080/00036846.2015.1005827

Fama, E. F. (1970) "Efficient capital markets: A review of theory and empirical work". The journal of Finance 25(2), 383-417

Goodman, B. (1956) "The Price of Gold and International Liquidity"
The Journal of Finance Vol. 11, No. 1, pp. 15-28 (14 pages)
https://doi-org.ezproxy.ub.gu.se/10.2307/2976526

Grocer, S. (2019, July 11) Why Stocks Are Hitting Records as Economic Fears Rise: "There Is No Alternative". The New York Times. Collected: 2020-11-29,
https://www.nytimes.com/2019/07/11/business/stock-market-record.html

Hunter, G.W., & Kerr, C. (2019) "Virtual Money Illusion and the Fundamental Value of Non-Fiat Anonymous Digital Payment Methods." Int Adv Econ Res 25, 151–164.
https://doi-org.ezproxy.ub.gu.se/10.1007/s11294-019-09737-4

Investopedia (2021) Guide to bitcoin. Collected 2021-01-26, from
https://www.investopedia.com/terms/b/bitcoin.asp

Lawrence, C. (2003) "Why is Gold Different from Other Assets? An Empirical Investigation" World Gold Council, London (2003)
http://www.spdrgoldshares.com/media/GLD/file/colin_lawrence_report.pdf

Lucey, B., Shahzada, S.J.H., Bouri, E., Roubaudc, D., & Kristoufek, L. (2019) "Is Bitcoin a better safe-haven investment than gold and commodities?". International review of financial analysis, (69): 322-330.
https://doi.org/10.1016/j.irfa.2019.01.002

Lyócsa, S., Molnár, P., Plíhal, T., & Širaňová, M. (2020). "Impact of macroeconomic news, regulation and hacking exchange markets on the volatility of bitcoin". Journal of economic dynamics & control (119).
https://doi.org/10.1016/j.jedc.2020.103980

Markowitz, H. (1952). Portfolio selection. The Journal of Finance, 7(1), 77–91.

McCown, J. R. & Zimmerman, John R., Is Gold a Zero-Beta Asset? Analysis of the Investment Potential of Precious Metals (July 24, 2006).
http://dx.doi.org/10.2139/ssrn.920496

Oxenstierna, Gabriel. (2018) Placeringsrådgivning; Kunskap för Swedsec Licensiering. s.75 Lund: Studentlitteratur AB.

Schilling, L., & Uhlig, H. (2019) "Some simple bitcoin economics" Journal of Monetary Economics,106, 16–26.
https://doi.org/10.1016/j.jmoneco.2019.07.002

Shahzad, S.J.H., Bouri, E., Roubaudc, D., & Kristoufek, L. (2020) "Safe haven, hedge and diversification for G7 stock markets: Gold versus bitcoin". Economic Modelling, 87, 212-224.
https://doi.org/10.1016/j.econmod.2019.07.023

Sherman, E. J. (1982) "Gold: A conservative, prudent diversifier". The Journal of Portfolio Management, 8 (3): 21-27.
https://doi.org/10.3905/jpm.1982.408850

Stanton, E. & Purvis, B. (2021-01-04) Treasuries Inflation Gauge Exceeds 2% for First Time Since 2018. Bloomberg.
https://www.bloomberg.com/news/articles/2021-01-04/treasuries-inflation-gauge-on-cusp-of-2-first-time-since-2018

Statistics Sweden (2020) New data sources in the CPI. Statistics Sweden: Stockholm.

https://www.scb.se/contentassets/618be4362e9a4f6a857b4d361bb3e208/svek-eng.pdf

Stock H. James & Watson M. Mark (2012) Introduction to Econometrics, third edition. Harlow: Pearson Education. p.694 and p.704.

Strukturinvest Fondkommission (n.d.) Del 28 Volatilitetsstrategi. Strukturakademin. Collected: 2020-12-20. Available: https://www.strukturinvest.se/upload/Strukturakademin/Strukturakademin%20del%2028%20-%20Volitetsstrategi.pdf

Tkacz, G. (2007), "Gold Prices and Inflation". Research Department, Bank of Canada. https://www.bankofcanada.ca/wp-content/uploads/2010/02/wp07-35.pdf

Tsay, R.S. (2005) Analysis of Financial Time Series: Third Edition. Chicago: John Wiley & Sons. Available: https://edisciplinas.usp.br/pluginfile.php/2302390/mod_resource/content/1/TSAY%20-%20Analysis%20of%20Financial%20Time%20Series%20%282010%29.pdf

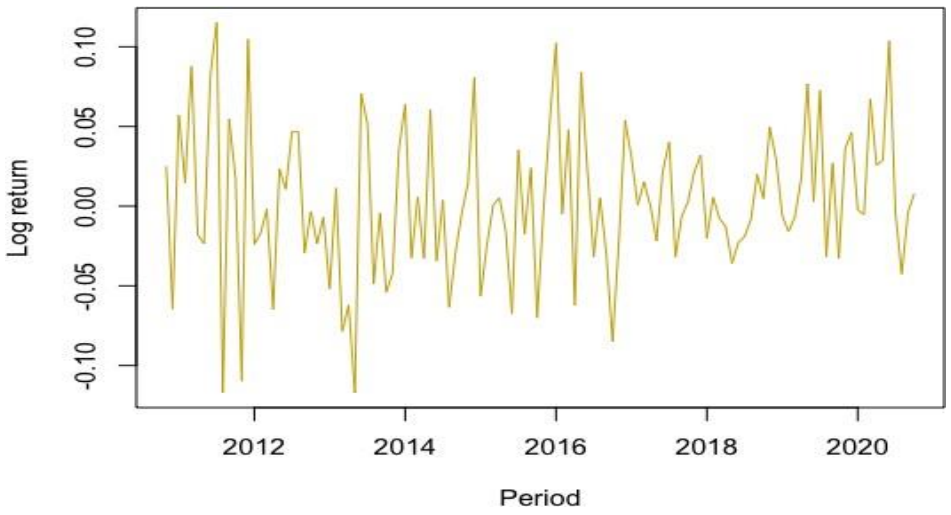
Tully, E., & Lucey, B. M (2007) "A power GARCH examination of the gold market". Research in international business and finance, Vol.21(2), pp.316-325. https://doi.org/10.1016/j.ribaf.2006.07.001

Yahoo Finance. (2021). Global stocks mixed as investors weigh recovery hopes and inflation fears. Collected 2021-02-19, from https://finance.yahoo.com/amphtml/news/stocks-futures-latest-uk-europe-us-markets-reflation-inflation-085231643.html

6.1 Appendix 1

Figure 6.1.1

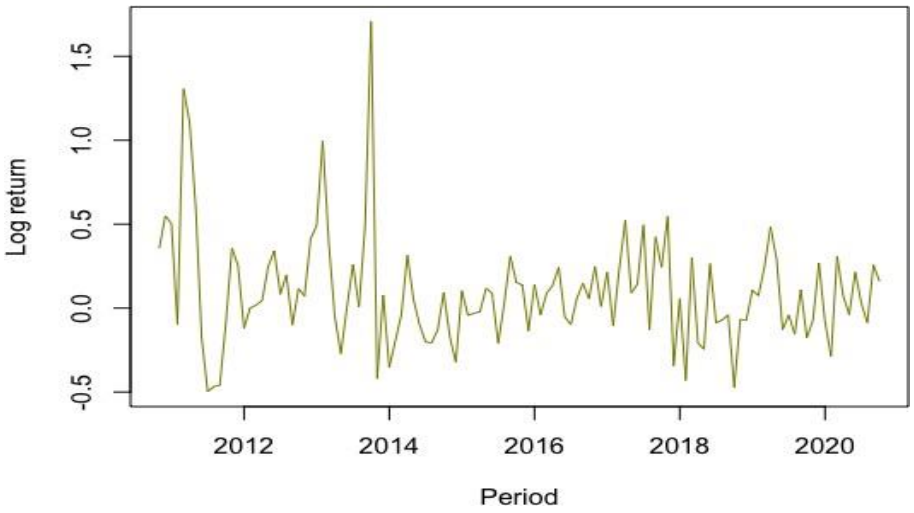
Log Return of Gold



Note. The logarithmic return of gold, portraying its volatility. Data: Bloomberg.

Figure 6.1.2

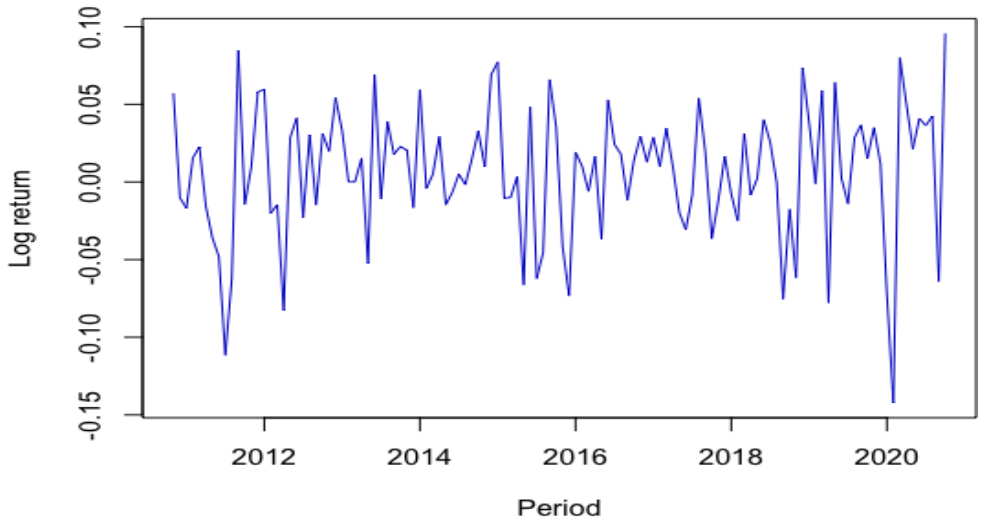
Log Return of Bitcoin



Note. The logarithmic return of bitcoin, portraying its volatility. Data: Bloomberg.

Figure 6.1.3

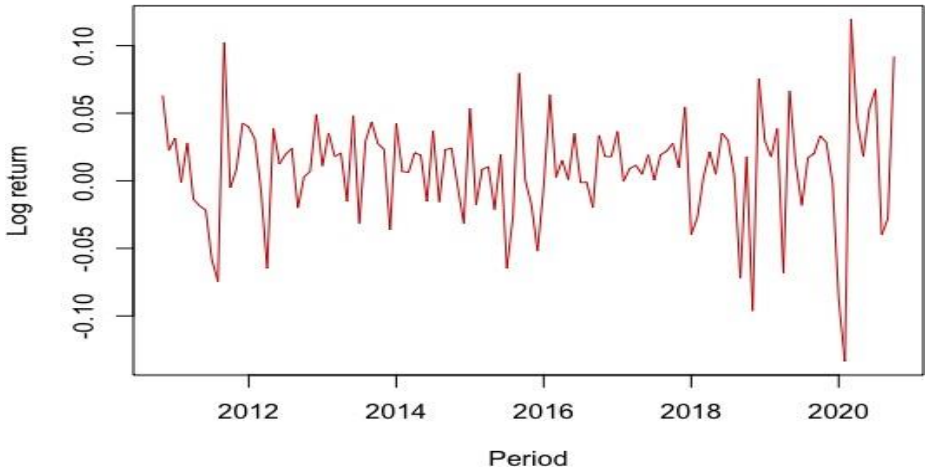
Log Return of OMXSPI



Note. The logarithmic return of OMXSPI, portraying its volatility. Data: Bloomberg.

Figure 6.1.4

Log Return of the S&P 500

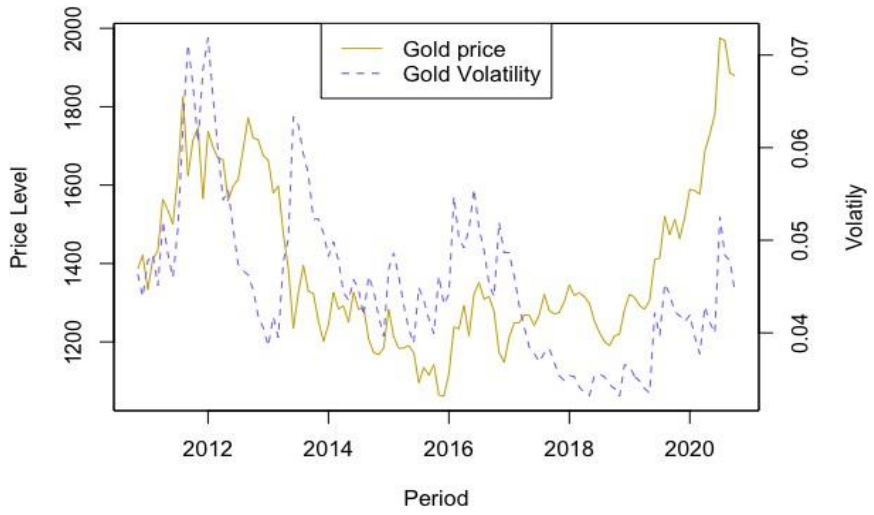


Note. The logarithmic return of the S&P 500, portraying its volatility. Data: Bloomberg

6.2 Appendix 2

Figure 6.2.1

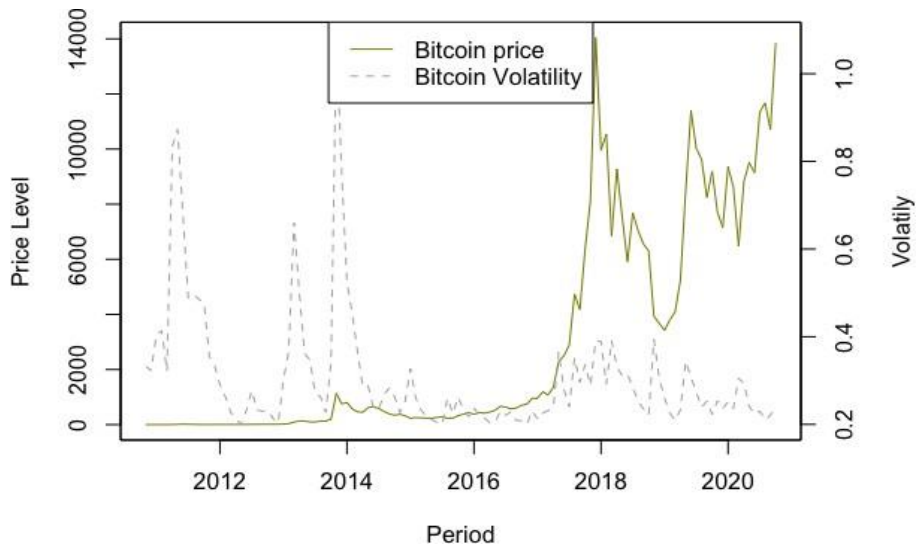
Price Level and Volatility of Gold



Note. The price levels and conditional volatility of gold. Data: Bloomberg.

Figure 6.2.2

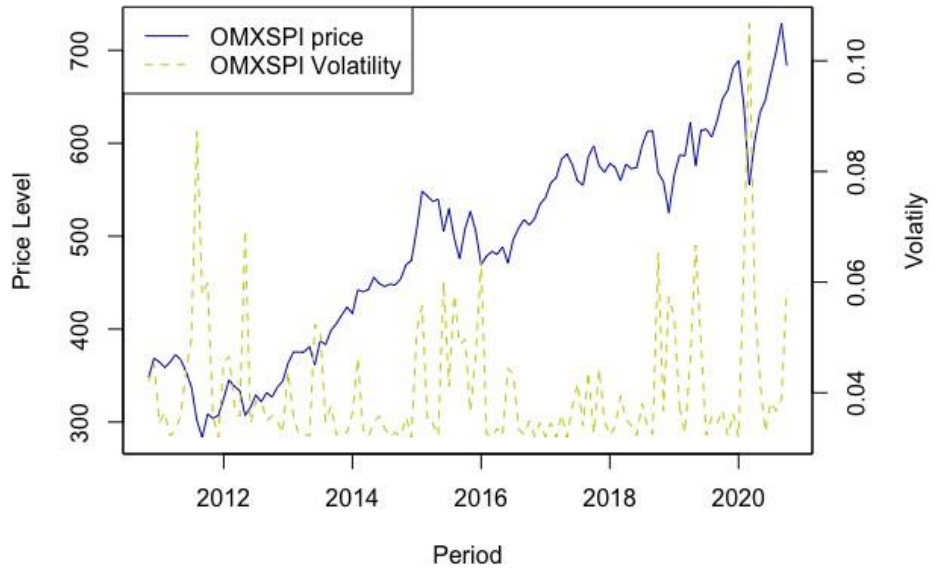
Price Level and Volatility of Bitcoin



Note. The price levels and conditional volatility of bitcoin. Data: Bloomberg.

Figure 6.2.3

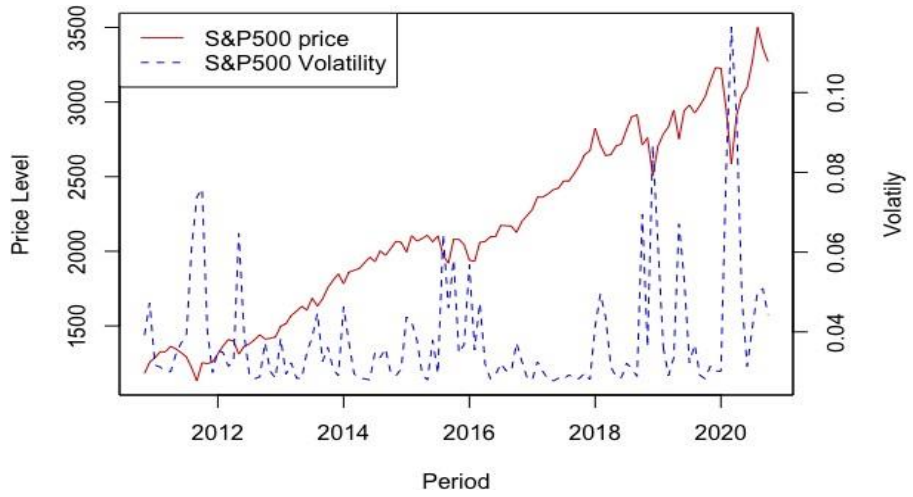
Price Level and Volatility of OMXSPI



Note. The price levels and conditional volatility of OMXSPI. Data: Bloomberg.

Figure 6.2.4

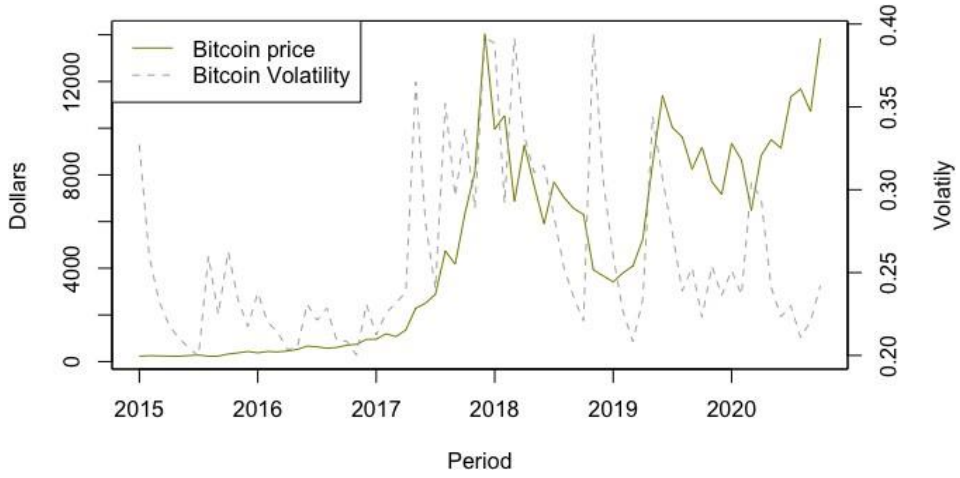
Price Level and Volatility of the S&P 500



Note. The price levels and conditional volatility of the S&P 500. Data: Bloomberg.

Figure 6.2.5

Price Level and Volatility of Bitcoin the last Five Years.



Note. The price levels and conditional volatility of bitcoin. Data: Bloomberg.