Are cryptocurrencies good hedges against inflation?

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ABSTRACT,

Since the 1990's, continuous surges of inflation have not been seen in developed markets, meaning that investors might not be well informed of where to invest their money during times of high inflation. Inflation reduces the purchasing power of consumers and is the cause of many problems. While the performance of asset classes such as stocks, commodities, and fixed income assets during inflationary times has been researched extensively, the performance of newer assets such as cryptocurrencies has not been studied as much. Additionally, this newer asset class has not gone through a period of prolonged inflation. With the recent rise of inflation, both individual and institutional investors might be very interested in the performance of cryptocurrencies during inflationary times. This research aims to find out whether cryptocurrencies possess characteristics which have in the literature been found to be helpful to hedge against inflation. This research was conducted on the two biggest cryptocurrencies by market capitalization, Bitcoin and Ethereum. The cryptocurrencies' daily returns were followed for a period of 5 years and compared to the daily inflation rate during the same period of time. To analyze the variables over time a Vector Autoregression model was built. Besides this, a regression analysis is conducted, to determine the Fisher coefficient. Finally, a hedging demand variable was calculated. These are indicators of an asset's inflation hedging ability. While the cryptocurrencies showed tremendous return numbers over the period of time tracked, they did not meet the all the criteria which would, be required for them to be called inflation hedges. All 3 methods employed indicated that when it comes to inflation hedging, cryptocurrencies should not be the asset class to invest in to protect the investor's purchasing power from inflation, meaning that investors should only invest in cryptocurrencies for speculative purposes.

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1. INTRODUCTION

Very generally, inflation can be defined as increases in the price level of goods and services (Johnson et al., 1971) or a continuously falling value of the currency (Arnold & Auer, 2015). When inflation occurs, fewer goods and services can be purchased with each unit of currency. The purchasing power of the consumer has decreased. Inflation is often determined by the increase in the price of a basket of goods known as the Consumer Price Index (CPI). This CPI basket consists of goods and services people generally spend their money on. The basket is different for every country and is reviewed on a regular basis to ensure the representativeness of consumer spending. Neville et al. (2021) add to this that this basket may be appropriate for some part of the population, and not appropriate for another part. Each individual faces their own inflation rate, while the CPI generalizes inflation into a single index. When items or the prices of items in the basket change, the total cost of the basket changes. The percentage change in total basket price from year to year is called inflation (Gooding, 2011). When the price of the basket has increased, we speak of inflation while we speak of deflation when the price of the basket has decreased.

The purpose of financial investing is to consume but at a later point. For this reason, returns of investments need to be greater than the decrease in purchasing power caused by inflation (Fama & Schwert, 1977). When an investment improves the financial position of the investor by the same amount or more than the loss caused by inflation, an investment is called an inflation hedge (Johnson et al., 1971)(Bodie, 1976). Thus, the investment reduces or eliminates the possibility that the real return on the asset will fall below a specified value. Furthermore, Bekaert & Wang (2010), state that securities' nominal returns need to at the very least be positively correlated with inflation in order to be good inflation hedges. This means that the nominal returns of said securities increases when inflation increases. Thus, an inflation hedge is an asset that has the following characteristics:

- Has positive or zero real returns
- Has nominal returns that are positively correlated with inflation

Cryptocurrencies are a relatively new asset class and are gaining a lot of traction recently. As they are a relatively new asset class, their inflation hedging properties have not been researched as extensively as other asset classes such as stocks, commodities such as gold and inflation-indexed assets such as TIPS. Besides that, there has not been a longer period of high inflation in developed markets in the past decades (Neville et al., 2021). This means that it is possible that cryptocurrencies perform well during periods of high inflation. Cryptocurrencies have a few characteristics that could prove to positively impact their ability to hedge against inflation, namely:

- Cryptocurrencies usually have a fixed maximum supply and a fixed road to reaching this maximum supply. To name an example, Bitcoin has a maximum supply of 21 million Bitcoins, which will all be mined by the year 2140.
- Cryptocurrencies can be staked for staking rewards, which is a benefit that is similar to earning dividends on stock returns.
- Some cryptocurrencies are burned through use, removing them from circulation in the process. This makes the cryptocurrencies deflationary, and automatically creates scarcity.

There are also a few reasons why they might not be good hedges against inflation, namely:

- Cryptocurrencies are very volatile. Bitcoin is 5 times more volatile than the S&P500 or gold (Harvey et al. 2021)
- Some people still consider cryptocurrencies as not valid investment assets. Taleb (2021) states that bitcoin is neither a short nor a long-term store of value and that as a result bitcoin is worth exactly 0.
- Cryptocurrencies are very sensitive to government interventions, technological flaws, hacks, scams and rug pulls.

1.1 Research focus

The focus of this research is to test whether investments made in cryptocurrencies during the past 5 years would have protected the investor's money from losing value from inflation. Since cryptocurrencies have grown tremendously since their invention it is to be expected that especially early investors experienced returns which protected their money from inflation. However, this research also aims to test whether cryptocurrencies show inflation hedging abilities such as having positive or zero real returns and nominal returns that are positively correlated with inflation. As there are thousands of cryptocurrencies, the focus of this research will be on the two most well-known cryptocurrencies, Bitcoin and Ethereum. Bitcoin and Ethereum are the two largest cryptocurrencies by market capitalization, and Bitcoin is also the first cryptocurrency to exist.

1.2 Research question

This paper intends to answer the following research questions:

(i) Do cryptocurrencies have inflation hedging properties?

(ii) Can investing in cryptocurrencies protect an investor's purchasing power from decreasing as a result of inflation?

1.3 Academic & practical relevance

Inflation impacts many aspects of the economy. Investments from businesses become more expensive leading to less real investment returns. Consumers' purchasing power is reduced, resulting in smaller consumer spending. Interest rates may be increased to combat rising inflation, resulting in lower bond prices, and the list goes on. Because of this, it is crucial for investors to understand inflation, and when possible, protect (hedge) themselves from the negative influence that inflation can have on the real value of their investments. The global economic crisis of 2008 and the inflation that took place at the same time, and the recent high inflation numbers have made inflation hedging especially relevant. The effects of small price increases in the short term may seem negligible, but these small increases may turn out to have a substantial effect on real asset returns (Spierdijk & Umar, 2013). Long-term investors, like pension funds, which experience increasing liabilities with rising inflation and promise their policyholders an inflation-linked pension scheme, may be extra interested in the inflation hedging properties of assets. But even the everyday consumer which suffers from rising price levels may be interested in protecting themselves against inflation. The inflation hedging ability of conventional assets such as stocks, commodities and TIPS has been researched extensively, but newer assets such as cryptocurrencies, which could prove to have inflation hedging abilities, are not yet as well researched. Ever since the 1990s there has not been an extended period during which the developed world experienced high levels of inflation. Cryptocurrencies did not exist yet during that phase of high inflation, which makes them a very interesting and relevant topic for research.

2. LITERATURE REVIEW

This section gives insight into existing research and literature that form the basis for this research. It will also showcase how the topic of inflation hedging developed throughout time.

2.1 Inflation hedging

In the parts above, the importance of hedging your money against the impact of inflation has been discussed. In this section inflation ability hedging of stocks, commodities such as gold and inflation-indexed assets such as TIPS and the relevant literature will be further discussed. Most research about inflation hedging is centred around the theory first introduced by Fisher (1930). He states that there is a hypothetical relationship between asset returns and inflation. The nominal return of assets can be expressed as the sum of an expected real return and an expected rate of inflation. The real return and the inflation rate are not correlated, meaning that it is expected that nominal asset returns and inflation move in parallel with each other.

2.2 Inflation hedging with stocks

According to Lintner (1975), there are in theory two important reasons that would make stocks good hedges against inflation. Namely that equities are claims against actual assets that have values expected to keep up with changes in inflation. Next to that, firms are debtors, using leverage against their capital. Shareholders benefit from inflation as the firm's debts decrease in value.

In the short run, stock returns are negatively correlated to expected and unexpected inflation (Bodie, 1976). To hedge against inflation, the stocks need to be sold short. Jaffe & Mandelker (1976) Fama & Schwert (1977) and Gultekin (1983) all find that there is a negative relationship between the inflation rate and stock returns in the short run. To determine whether stock returns are positively correlated to inflation, Jaffe & Mandelker (1976), used almost a century of inflation data and an equally weighted portfolio of the NYSE and found that stock returns and inflation appear to be independent of each other, indicating a weak to no relationship. Due to possible flawed data, they updated their sample size from almost a century to only 1953 to 1971 as the CPI tracking was done far more accurately after 1953. They now found that stock returns are significantly negatively related to inflation. Fama & Schwert (1977) find no explanation for the negative relationship between inflation and stock returns, implying that Fisher's theory might have been incorrect. Gultekin (1983), who studied 26 countries for the relationship between stock returns and inflation, found that there is a consistent lack of a positive relationship between the two. Fama (1981) found a potential reason for the persistently negative relationship between stock returns and inflation. Fama (1981) mentions that since inflation acts as a proxy for economic trends, there is no direct interaction between stock returns and inflation. Stocks benefit from expected economic activity while increasing inflation will lead to decreasing economic activity. Therefore the negative relationship that was found by different, independent studies may be spurious. After Fama (1981), in later studies, several alternative reasons for the negative relationship between inflation and stock returns have been suggested. One of the reasons has to do with the time period analysed in the research. In the long run, a positive correlation between inflation and stock returns was found by Boudoukh and Richardson (1993) and affirmed by Solnik & Solnik (1997) and Lothian & Simaan (1998). Lothian & McCarthy (2001) give hardy evidence that stock prices have kept up with the general increases in the price level, for this they used 210 years of data. Similar to previous research, they also find that there is a negative relationship between inflation and stock returns in the short run. Schotman & Schweitzer (2000) show that stocks provide a hedge against inflation if the investment horizon is at least 15 years. The literature in general seems to agree that in the short-run stocks are poor inflation hedges because of the negative correlation between stock returns and inflation. However, studies conducted after 1980 tend to find a positive correlation in the long-run, implying that in the long-run stocks do have some inflation hedging abilities.

2.3 Inflation hedging with gold and commodities

One of the first research where the inflation hedging literature was extended from the stocks market to the gold market was from Chua and Woodward (1982). They found that outside of the United States, investing in gold would not have protected the investor's money against domestic inflation. However the period that was investigated was very limited, only from 1975 to 1980. This was because gold trading was illegal in the US before 1975. This has, however, limited the validity of the research. Jaffe (1989) used a multi-asset framework from 1971 to 1987 and found that the returns of gold are independent of the returns of other assets, meaning that gold can be used to diversify the portfolio. McCown & Zimmerman (2006) find that an investor's portfolio does not increase with systematic risk once gold is added to it.

Jaffe (1989) adds that gold should not be used to hedge against inflation though. Mahdavi & Zhou (1997) were one of the first ones to find that gold might be used to forecast inflation. A reason they give for this is that the CPI basket tends to take more time to adjust to new information than gold. This means that before inflation can be seen in the CPI it can already be seen in the prices of gold. Laurent (1994) and Spierdijk & Umar (2013) mention that the price of gold and commodities act more volatile than the CPI, meaning that investors should take care of this when making hedging decisions. Beckmann & Czudaj (2013) state that there is widespread consensus that gold's price level reflects inflation expectations. Spierdijk & Umar (2013) further state that commodity prices are the main drivers of inflation rates. Taylor (1998) studied 4 precious metals, gold, silver, platinum and palladium, over a time period of 82 years. He found that gold was not a long-run hedge against inflation for the entire period of 1914 to 1996. However, he found that in the periods before 1939 and around the OPEC oil crisis of 1979 the precious metals were hedges against inflation. This result indicated that it is important to take account of structural breaks when researching about the inflation hedging properties of gold. In a similar vein, Eugeni & Krueger (1994) state that the prices of commodities and gold may fluctuate heavily based on events that cause shifts in supply and demand. They further state that these type of events typically only cause a temporary shift in supply and demand and revert itself after some period of time. Levin et al. (2006) analysed monthly data from 1976 to 2005 and show that gold moves statistically in a significant one to one relation with the price level of the United States. McCown & Zimmerman (2007) find a positive correlation between expected future inflation and the price of gold in the United States. This correlation rises as the time period increases. They also find that gold can be used to hedge against inflation, especially at longer horizons. Although most of the aforementioned studies have suggested that inflation and returns for holding gold co-move over extended time horizons, recent studies are more sceptical about this. For example, Erb & Harvey (2013) found an outlier in the data. After excluding the outlier they concluded that there is not much evidence to be found that gold is an effective inflation hedge. Another example is Batten et al. (2014), who noted that a structural break in the US inflation regime took place in 1984.

For this reason they restricted their analysis to the years 1985 to 2012. During their analysis they found the variables to not be cointegrating. To conclude, earlier research indicates a positive relationship between inflation and gold prices, while more recent research leads to the conclusion that this relationship has come from outliers in the data and structural breaks in inflationary regimes.

2.4 Inflation hedging with Inflation Linked Bonds

Treasury Inflation Protected Securities (TIPS), or Inflation Linked Bonds (ILB's) are bond securities which have returns that are protected from inflation. When inflation increases, the principal of the security increases with the same amount. The coupon payment is then made as a percentage on the changed principal value of the security. Both the principal and the coupon are thus protected from inflation. These ILB's were already issued by the state of Massachusetts in 1790. They are issued because it would make the debt payments more closely reflect the exchange that is manifested in a contract. The value of the payment might is more challenging to protect over time (Garcia & Van Rixtel, 2007). They add that the bonds can also be used by central banks to observe inflation expectations of investors. Bekaert & Wang (2010) state that ILB's will cost less to issue when investors fear inflation risk, because the investors need to be compensated for carrying the risk when investing in normal bonds. However, when investors do not fear inflation risk, the ILB's will cost more to issue. Bekaert & Wang (2010) further state that the ILB market only makes up a tiny proportion of the government debt, and thus ILB's have low liquidity compared to regular bonds. Furthermore, the inflation exposure faced by investors might not equal an inflation index because of lagging or biased index measurement. Swinkels (2012) states that ILB's have a low correlation to other assets, meaning that they can be used to diversify a portfolio. However, Briere & Signori (2009) state that in the United States, ILB's no longer contribute diversification benefits when compared to nominal bonds since 2003. Amenc et al. (2009) demonstrate that if the goal is to hedge short-term liability risk, and liabilities are corrected for inflation, then investing the full portfolio into ILB's is the best approach. To conclude, ILB's hedge the investors investment against inflation, but lagging behind inflation calculations, and limited liquidity limit their use for investors outside of being used as portfolio diversification due to their low correlation to other asset classes.

3. METHODOLOGY

To determine the inflation hedging ability of assets, several methods have been employed in the literature. In later chapters it will be determined whether Bitcoin and Ethereum show inflation hedging abilities by applying a vector autoregressive (VAR) model, calculating the Fisher coefficient through a regression analysis and calculating the hedging demand of Bitcoin and Ethereum. Below these methods are briefly explained.

3.1 VAR-model

Spierdijk & Umar (2013) use a vector autoregressive (VAR) model to scan an asset's hedging ability. A VAR-model follows multiple variables as they change over time. When applied to this research, expected and break-even inflation and the returns of Bitcoin and Ethereum will be followed over a period time. Each VAR model has three variables, one of the inflation rates, being expected or break-even inflation, and Bitcoin and Ethereum returns. In a VAR model, each of the variables at time point t can be predicted using its own and the other variables' values at previous moments of measurement. Depending on the amount of lag used in the model, the amount of previous measurements increases. For example, if a lag of 1 is used, the value at a certain time t is predicted by taking all the values of the variables at time point t-1. Similarly if a lag of 4 is used, the value at time t is predicted by taking the variables at time points t-4, …, t-1. Thus, each of the variables are modelled as follows:

$$\pi_t = \mu_1 + \sum_i^p R(Btc)_{t-i} + \sum_i^p R(Eth)_{t-i} + \sum_i^p \pi_{t-i} + \varepsilon_1$$

$$R(Btc)_t = \mu_2 + \sum_i^p \pi_{t-i} + \sum_i^p R(Eth)_{t-i} + \sum_i^p R(Btc)_{t-i} + \varepsilon_2$$

$$R(Eth)_t = \mu_3 + \sum_i^p \pi_{t-i} + \sum_i^p R(Btc)_{t-i} + \sum_i^p R(Eth)_{t-i} + \varepsilon_3$$

π_t is the one-period expected or break-even inflation rate, $R(Btc)_t$ is the one-period nominal return of Bitcoin, and $R(Eth)_t$ is the one-period nominal return of Ethereum. $\mu_{1,2,3}$ is the constant and $\varepsilon_{1,2,3}$ is the error term with $E(\varepsilon_1) = E(\varepsilon_2) = E(\varepsilon_3) = 0$. P is the amount lags used.

3.2 The Fisher coefficient

The Fisher coefficient has been briefly touched upon earlier, but it can be used as a measure of inflation hedging effectiveness. A Fisher coefficient of 1 implies a perfect hedge, whereas a Fisher coefficient of 0 or lower means that the asset is an adverse inflation hedge, and between 0 and 1 an imperfect inflation hedge.

To determine the Fisher coefficient in the analysis of the time series used in this research, a regression analysis needs to be made of 5 year nominal asset returns on 5 year expected and break-even inflation. This regression will look as follows:

$$R_t^{(k)} = \mu + \beta\pi_t^{(k)} + \varepsilon_t$$

Where $R_t^{(k)}$ is the nominal return of the asset from time period t to k, μ is a constant, β is the Fisher coefficient, $\pi_t^{(k)}$ is the expected or break-even inflation rate from time period t to k and ε_t is the residual over the time period. The value for the Fisher coefficient is key in determining whether the asset is a good hedge against inflation. If the Fisher coefficient is positive, the nominal returns are positively correlated with inflation, indicating that the asset is a hedge against inflation.

3.3 Hedging demand

Schotman & Schweitzer (2000) use the hedging demand as a measure of an asset's hedging capability. They view assets that have a higher value of hedging demand as assets that are better at hedging against inflation. The hedging demand can be calculated through the following formula:

$$\Delta = \rho \sqrt{\left(\frac{Var_t\left[\pi_t^{(k)}\right]}{Var_t\left[R_t^{(k)}\right]}\right)}$$

Where Δ is the hedging demand of an asset, ρ is the correlation between asset returns and the inflation rate over period K, $Var_t[\pi_t^{(k)}]$ is the variance of the inflation over the k period of time, and $Var_t[R_t^{(k)}]$ is the variance of the asset returns over the k period of time.

4. DATA

4.1 Data gathering

All the data for this research was gathered from the Federal Reserve Economic Database (FRED). The data used from their database are the following:

- Bitcoin daily prices from May 12th 2017 to May 12th 2022
- Ethereum daily prices from May 12th 2017 to May 12th 2022
- The 5-year expected inflation rate of the United States daily, from May 12th 2017 to May 12th 2022
- The 5-year Break-even inflation rate of the United States, daily from May 12th 2017 to May 12th 2022. The break-even inflation rate is the difference between the yield of a nominal bond and the yield on an ILB.

4.2 Data preparation

The data of Bitcoin and Ethereum was recorded 7 times per week, whereas the inflation numbers were recorded 5 times per week, only on weekdays. The data has been corrected for this. The Bitcoin and Ethereum data from Saturdays and Sundays were excluded from this research, and since the interest of this research is on returns, the returns from Friday to Monday have been taken in those instances that the data was excluded. Furthermore, the FRED has been contacted to infer about whether the data are all taken from the same moment in time. This was not the case. The cryptocurrencies were recorded daily at 7 PM Pacific Summer Time (PST), while the inflation data was recorded daily at 3 PM PST. Finally, there were some missing values, mainly in the inflation data, but also one in the crypto data. These data have been filled with their previous value. With the knowledge of these limitations the research will be conducted. All of the data used had 1304 data entries.

4.3 Time series analysis

At the beginning of the time series, the price of Bitcoin was around $1.700, and the price of Ethereum around $85. At the end of the time series the prices of Bitcoin and Ethereum have risen to around $29.000 and $2.000 respectively, an increase of around 1600% for Bitcoin and 2250% for Ethereum. However, this does not necessarily mean that either of these assets are good hedges against inflation, as it was mentioned earlier in this paper that positive real returns is not the only characteristic of an inflation hedge. The asset's nominal return should also be positively correlated with inflation. In the appendix, figures 1 through 9 showcase what the time series looks like graphically, and below, tables 1 through 3 show some sample statistics.

Table 1: Sample statistics for time series of daily break-even and expected inflation and daily nominal returns of Bitcoin and Ethereum.

	BTC	Eth	BE-CPI	Exp. CPI
Mean	0,339%	0,453%	1,930%	1,990%
St. dev	4,900%	6,500%	0,581%	0,244%
Skewness	0,060	0,478	0,368	-0,690
Kurtosis	5,461	5,997	0,435	0,619
Q1%	-12,893%	-16,760%	0,580%	1,320%
Q5%	-7,051%	-8,984%	0,950%	1,520%
Q10%	-5,207%	-6,635%	1,360%	1,690%
Q50%	0,273%	0,080%	1,810%	2,010%
Q90%	5,666%	7,584%	2,740%	2,250%
Q95%	8,411%	10,806%	3,000%	2,320%
Q99%	14,600%	19,345%	3,410%	2,450%
Start sample	12-5-2017	12-5-2017	12-5-2017	12-5-2017
# observ.	1304	1304	1304	1304

Table 2: correlation matrix of break-even inflation rate and returns of Bitcoin and Ethereum

	Break-even inflation rate 5 years	Return Ethereum	Return Bitcoin
BE-inflation rate 5 years	1	-	-
Return Ethereum	-0,025	1	-
Return Bitcoin	-0,047	0,701	1

Table 3: correlation matrix of expected inflation rate and returns of Bitcoin and Ethereum

	Expected inflation rate 5 years	Return Ethereum	Return Bitcoin
Expected inflation rate 5 years	1	-	-
Return Ethereum	-0,032	1	-
Return Bitcoin	-0,043	0,701	1

The daily returns of BTC and Ethereum are approximately normally distributed. For Bitcoin, the mean and standard deviation are respectively 0,339% and 4,9% and for Ethereum the mean and standard deviation are respectively 0,453% and 6,5%. Ethereum's returns are a bit more skewed than that of Bitcoin. Both the returns have low kurtosis, implying that they have little outliers. This is also visible in figures 5 and 6 for Bitcoin and Ethereum respectively.

The returns of Bitcoin and Ethereum throughout the 5 year time period have a correlation of 0,70, meaning that they are quite strongly positively correlated. As mentioned before, in order for an asset to be a good hedge against inflation, it needs to be positively correlated to inflation. Over the 5 year time period, Bitcoin and Ethereum's nominal returns were negatively correlated with both 5 year expected inflation and 5-year break-even inflation. This would lead to the assumption that the inflation hedging property of nominal returns being positively correlated with inflation is not fulfilled. However, it is possible that for a shorter time period, for example, 1 year, the assets show inflation hedging properties. To determine this, a rolling correlation over time was made. This can be seen in figures 8 and 9. As can be seen from these rolling correlations, there are time intervals where they show positive correlations with inflation over the previous 1-year time period. However, even when the rolling correlation graphs are positive, they are of very low correlation, at most about 0,25. This leads to the suspicion that the assets are not good hedges against inflation. The next chapter contains a more in-depth analysis.

5. RESULTS

5.1 VAR-model results

The VAR model was created in the statistical program R. R has a function which recommends the number of lags to be used in the model is based on the Akaike's An Information Criterion (AIC), the Hannan-Quinn (HQ) information criteria, the Schwarz Criterion (SC) or the Final Prediction Error (FPE) criterion. For the model with break-even inflation, the model recommended 3 lags for the AIC and FPE criteria, and 1 lag for the HQ and SC criteria. The results for 3 and 1 lag can be seen in tables 6 and 7 in the appendix respectively. In a similar vein, the model with expected inflation recommended 5 lags for the AIC and FPE criteria and 1 lag for the HQ and SC criteria. The results for 5 and 1 lag can be seen in tables 8 and 9 in the appendix respectively. In tables 6 through 9 the values that are statistically significant, meaning that they have a p-value lower than 0,05, are underlined. It can be seen that most values are not statistically significant, which means that from the model it cannot be proven that they are not zero. This means that in the VAR(3) break-even inflation model of table 5, the variable Ethereum returns is only statistically significantly influenced by the returns of Bitcoin with a lag of 3 and its own returns with a lag of 3. Almost the same happened for the variable Bitcoin returns. It is only influenced by its own return with a lag of 3 and the return of Ethereum with a lag of 3, and the addition of the constant which also shows a significance. None of the inflation lags appear to have any effect on the returns of the assets, and vice-versa the break-even inflation is not influenced by the returns of the assets, inflation is affected by some of its own previous values however. Something similar occurs with the VAR(1) model of break-even inflation. The variable Ethereum returns is not significantly influenced by any of the other variables, neither is Bitcoin, and inflation is only affected by its own former value.

The VAR(1) and VAR(5) models of expected inflation show a similar pattern. There is the odd exception, but generally the previous values of the variables do not seem to have a significant impact on predicting the next value. Finally, the adjusted R^2 values of the returns are very low every time, while for the inflation equations it is much higher. The low values of adjusted R^2 mean that only a very small proportion of the return variables can be explained by the model. This could imply that the model is not very appropriate, but it could also be due to the nature of the variables used, which are returns of cryptocurrencies which tend to be very volatile. However, due to the earlier mentioned low amount of statistically insignificant values in the results of the model, it is very possible that the model has room for improvement.

5.2 Fisher model results

The regression analysis was conducted in SPSS. A summary of the SPSS output can be found in the table below.

Table 4: Summary of SPSS regression output.

Type of inflation	Asset	OLS function	Fisher coefficient
Break-even	BTC	R(BTC) = 1,097 - 0,393π + ε	-0,393
Break-even	Eth	R(Eth) = 0,991 - 0,279π + ε	-0,279
Expected	BTC	R(BTC) = 2,057 - 0,863π + ε	-0,863
Expected	Eth	R(Eth) = 2,141 - 0,848π + ε	-0,848

As can be seen in the table, for both the assets and with both forms of inflation the Fisher coefficient is negative, which leads to the assumption that the assets are adverse inflation hedges.

5.3 Hedging demand results

As described earlier, the hedging demand can be used as a measure of an asset's hedging ability, and can be calculated through a formula. The calculation of the hedging demand can be found in the table below.

Table 5: results of hedging demand calculation

Asset	Var.	Inflation	Var.	Var(I)/Var(A)	ρ	Δ
BTC	0,240 %	Break-even	0,003 %	1,408%	-0,047	-0,554 %
Eth	0,428 %	Break-even	0,003 %	0,790%	-0,025	-0,220 %
BTC	0,240 %	Expected	0,001 %	0,249%	-0,043	-0,215 %
Eth	0,428 %	Expected	0,001 %	0,140%	-0,032	-0,118 %

As mentioned earlier, Bitcoin and Ethereum are negatively correlated with both break-even and expected inflation. Thus it was to be expected that the hedging demand for the assets would be negative as well, as the hedging demand function is simply a scaled version of the correlation coefficient. Moreover, even for shorter time frames, as analyzed in the rolling correlation of figures 8 and 9, the correlation coefficient between the assets and inflation is always negative or slightly above zero. Even with a correlation coefficient of positive 0,25 which is approximately the highest value achieved by any of the assets in the rolling correlations, the hedging demand is at most around 3%, which is not very high.

6. DISCUSSION

All three methods for determining whether cryptocurrencies are inflation hedges seem to show similar results. Based on the criteria and tests, cryptocurrencies are not good hedges against inflation. However, since the returns over the period were incredibly high the cryptocurrencies did in theory hedge against inflation over the time frame in which they were followed.

Because of their high returns, the assets can be used for speculative purposes by investors who are willing to take the risk of adding them to their portfolio. Even while the assets have dropped to about half of their all-time-high's at the end of the time series used, and at the moment of writing dropped down even further.

7. CONCLUSION

The cryptocurrencies analyzed in this research had positive real returns, but not nominal returns which are correlated to inflation. Meaning that they only hit one of the two criteria of being an inflation hedge. Investing in cryptocurrencies can protect the investor's money against losing its purchasing power due to inflation, however this is not due to the inflation hedging properties that the literature suggests the assets should have in order to be an inflation hedge. The reason for investing in cryptocurrencies is based on this research thus mostly speculative.

8. LIMITATIONS AND FUTURE DIRECTION

In this research Bitcoin and Ethereum have been analyzed over a period of five years. Limitations of this research, or possibilities for future research are to either increase or decrease the timeframe which was analyzed and increase the amount of crypto assets which were analyzed. For instance, the paper which was for a lot of aspects used as an example, Spierdijk & Umar (2013) had a timeseries with a large amount of inputs similar to this research. However, they divided the time series up into periods of a month, 6 months, 12 months, 24 months, 36 months, 48 months, 60 months and 120 months. This research has done a rolling correlation, however that was the only other timeframe that was analyzed and only for a brief moment. More crypto assets could have been analyzed to improve the research. However, during the time frame which was analyzed, Bitcoin dominance ranged between approximately 38% and 70% and Ethereum dominance ranged between approximately 7% and 25%. Dominance is a value used to indicate what percentage of the total global crypto market capitalization consists of one currency. Thus, it means that at any point during the time series Bitcoin and Ethereum always made up for 45% of the market cap of all of the cryptocurrencies, and they had a very big influence on which direction the market moved. Therefore it is doubtful that including more cryptocurrencies would have yielded a result which is vastly different from the results of this research.

9. ACKNOWLEDGMENTS

I would like to conclude by thanking my supervisor Jörg Osterrieder for helping me on my way throughout the entirety of the research process. Next to that help from others has helped me a lot in this research. In special I would like to thank Luisa Rensing for helping me with formatting the thesis and Frits Tuininga for sharing his knowledge of the program R which was used to create the VAR model.

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11. APPENDIX

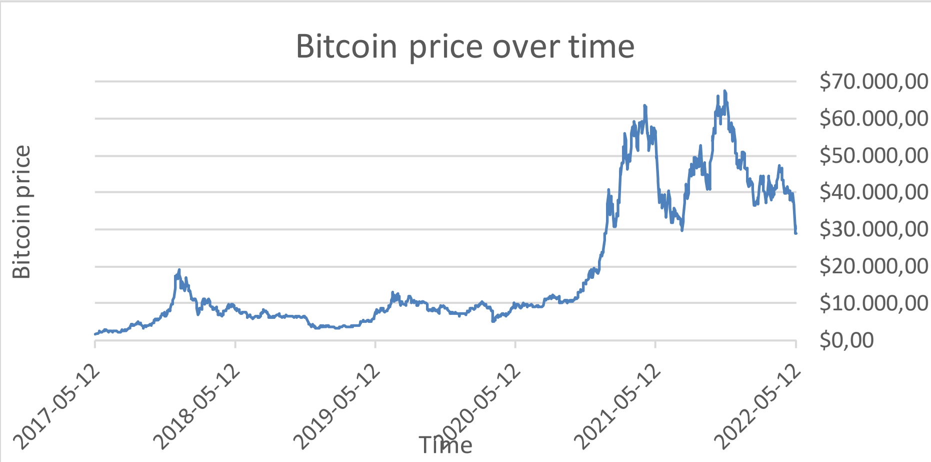

Figure 1: Bitcoin price over time

Figure 2: Ethereum price over time

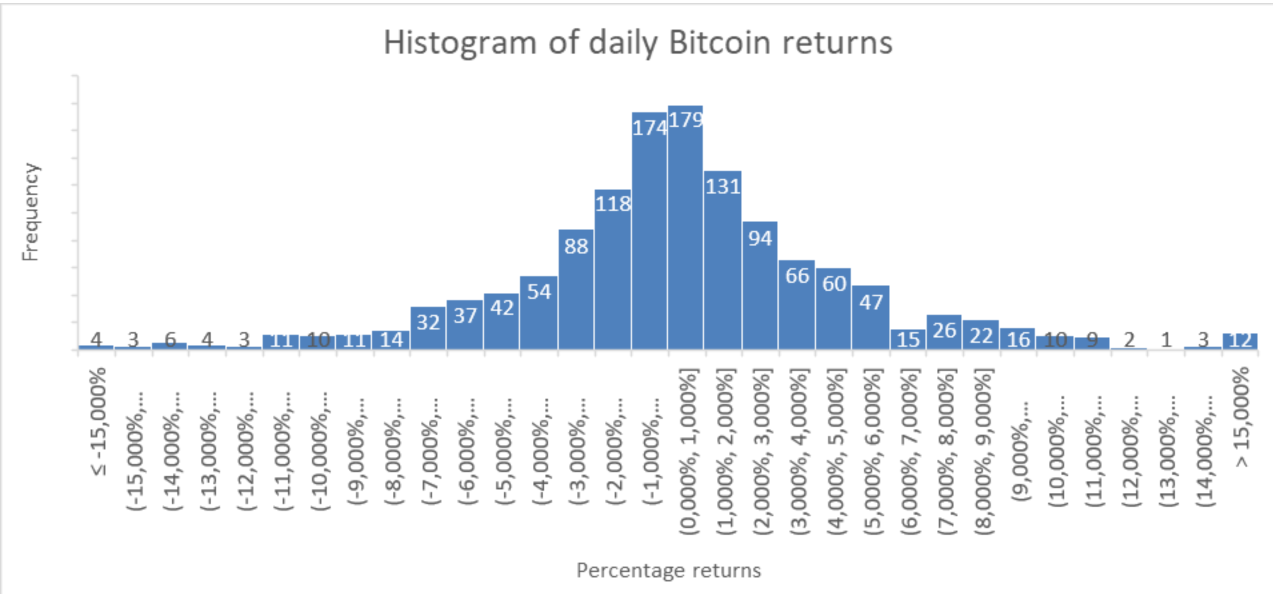

Figure 3: Histogram of daily Bitcoin returns

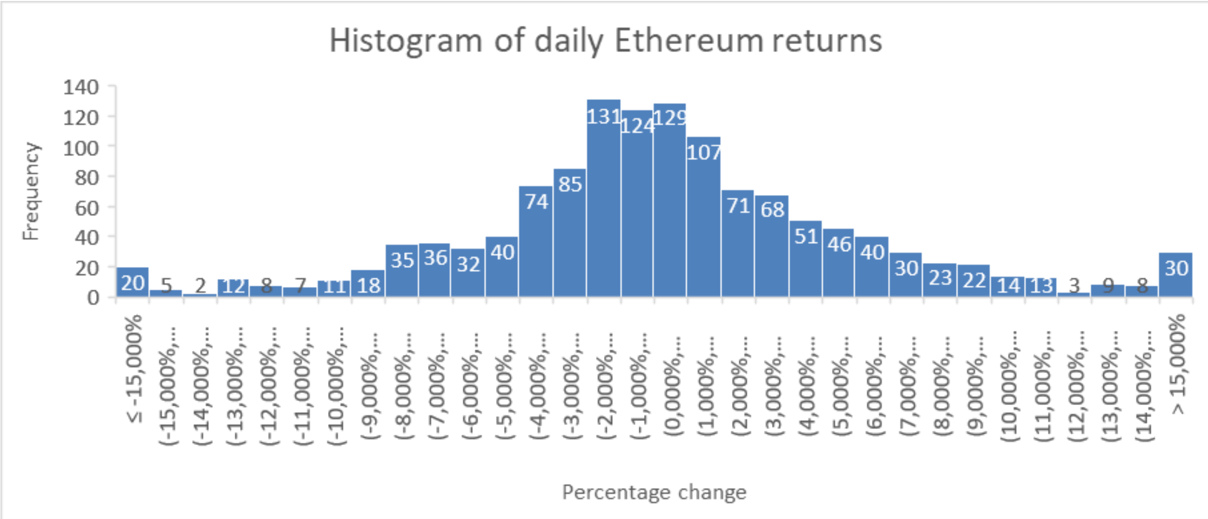

Figure 4: Histogram of daily Ethereum returns

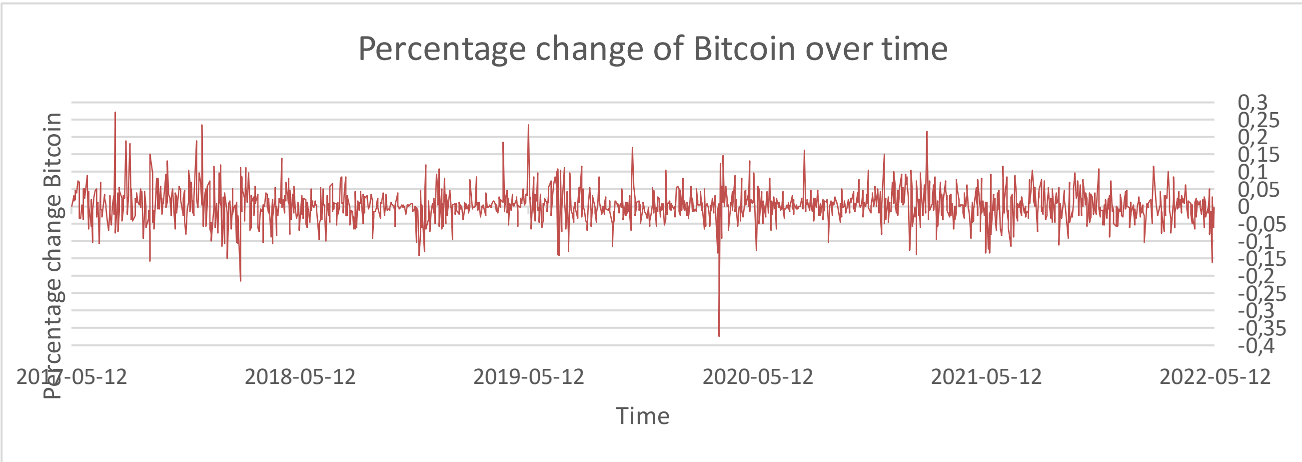

Figure 5: Percentage change of Bitcoin over time

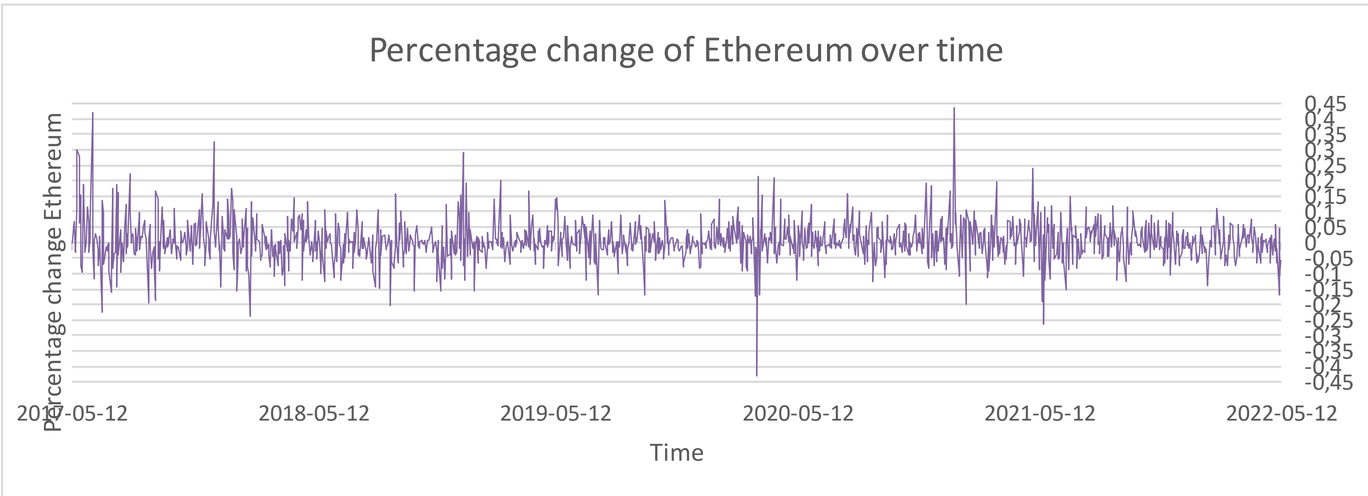

Figure 6: Percentage change of Ethereum over time

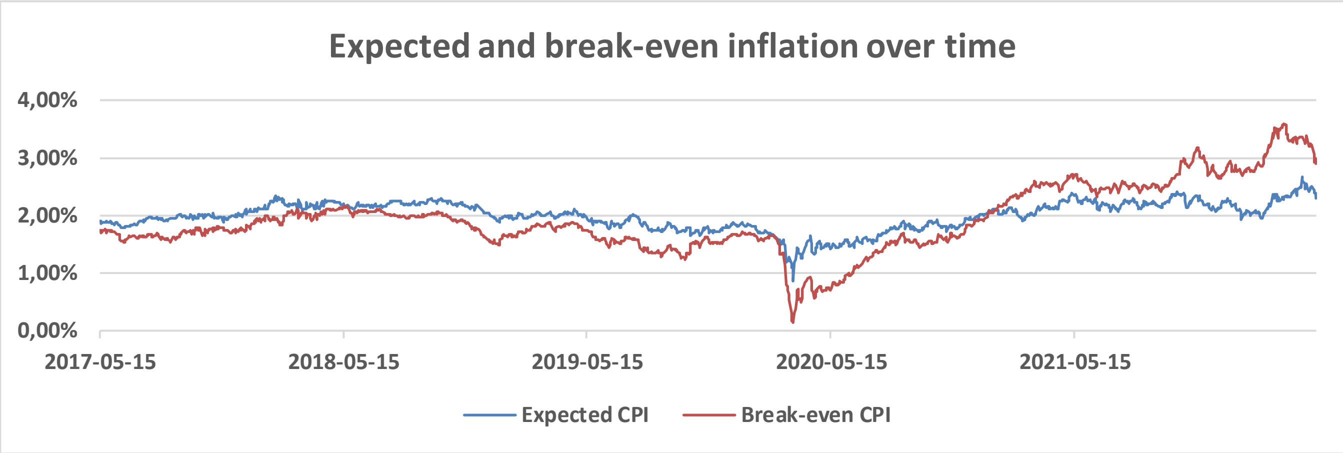

Figure 7: Expected and break-even inflation rate over time

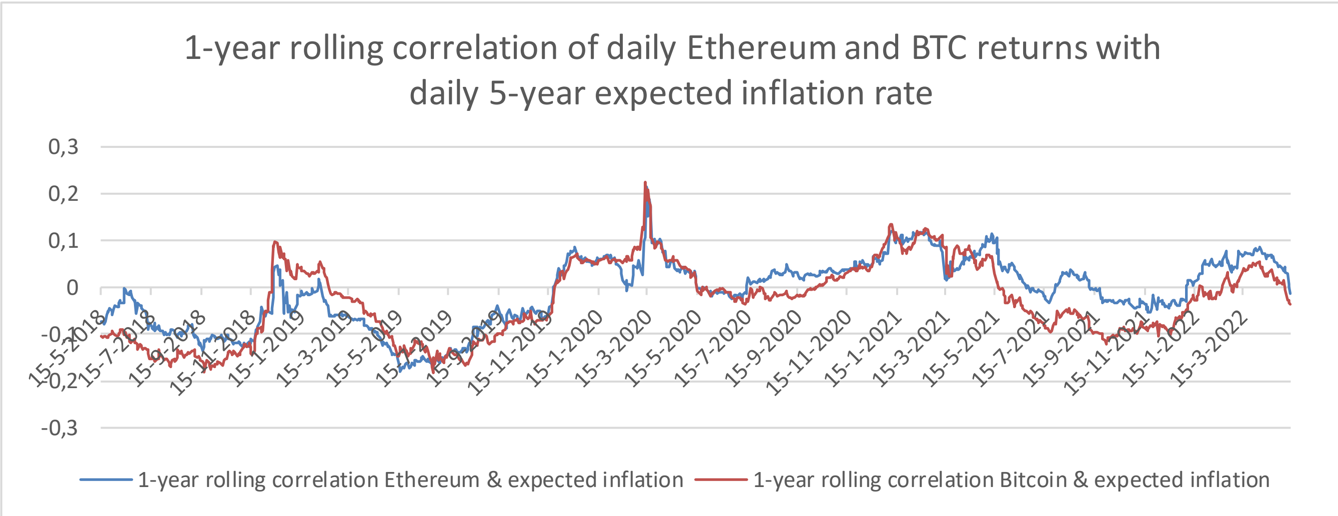

Figure 8: 1-year rolling correlation of Ethereum and Bitcoin with Expected inflation rate

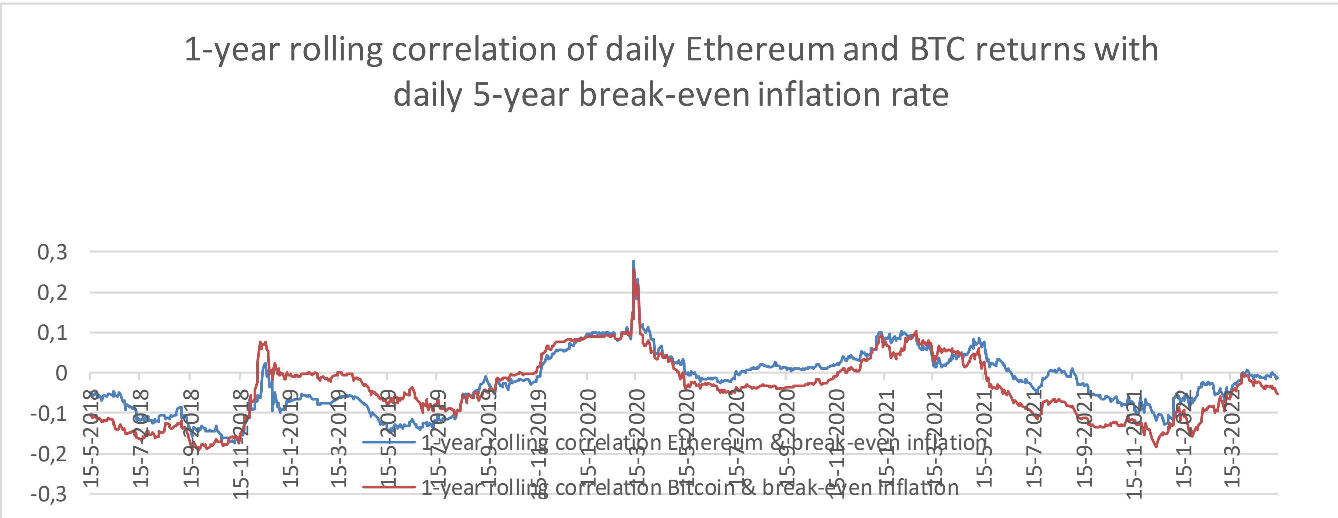

Figure 9: 1-year rolling correlation of Ethereum and Bitcoin with break-even inflation rate

Table 6: Estimation results for VAR(3) model with BE-inflation

Dependent variable R(Eth)	Estimate	Std. Error	t value	Pr(>|t|)
R(Eth)t-1	0,006	0,039	0,151	0,880
R(BTC)t-1	-0,061	0,052	-1,192	0,233
π(BE)t-1	4,935	4,613	1,07	0,285
R(Eth)t-2	0,034	0,039	0,879	0,380
R(BTC)t-2	0,018	0,052	0,339	0,734
π(BE)t-2	-0,135	6,795	-0,02	0,984
R(Eth)t-3	<u>-0,103</u>	<u>0,039</u>	<u>-2,655</u>	<u>0,008</u>
R(BTC)t-3	<u>0,182</u>	<u>0,052</u>	<u>3,5</u>	<u>0,000</u>
π(BE)t-3	-5,146	4,628	-1,112	0,266
constant	1,091	0,631	1,729	0,084
Adjusted R-squared:	0.010			
Dependent variable R(Btc)	Estimate	Std. Error	t value	Pr(>|t|)
R(Eth)t-1	-0,055	0,029	-1,899	0,058
R(BTC)t-1	0,029	0,039	0,737	0,461
π(BE)t-1	3,390	3,460	0,980	0,327
R(Eth)t-2	0,056	0,029	1,928	0,054
R(BTC)t-2	-0,023	0,039	-0,579	0,562
π(BE)t-2	-5,286	5,096	-1,037	0,300
R(Eth)t-3	<u>-0,060</u>	<u>0,029</u>	<u>-2,042</u>	<u>0,041</u>
R(BTC)t-3	<u>0,096</u>	<u>0,039</u>	<u>2,474</u>	<u>0,013</u>
π(BE)t-3	1,473	3,471	0,425	0,671
const	<u>1,140</u>	<u>0,473</u>	<u>2,409</u>	<u>0,016</u>
Adjusted R-squared:	0.008			
Dependent variable π(BE)	Estimate	Std. Error	t value	Pr(>|t|)
R(Eth)t-1	-0,000	0,000	-0,068	0,946
R(BTC)t-1	0,000	0,000	1,746	0,081
π(BE)t-1	<u>1,072</u>	<u>0,028</u>	<u>38,564</u>	<u>0,000</u>
R(Eth)t-2	0,000	0,000	0,488	0,626
R(BTC)t-2	0,000	0,000	0,542	0,588
π(BE)t-2	-0,008	0,041	-0,195	0,845
R(Eth)t-3	-0,000	0,000	-1,236	0,217
R(BTC)t-3	<u>0,001</u>	<u>0,000</u>	<u>3,12</u>	<u>0,002</u>
π(BE)t-3	<u>-0,065</u>	<u>0,028</u>	<u>-2,343</u>	<u>0,019</u>
const	0,003	0,004	0,74	0,460
Adjusted R-squared:	0.996			

Table 7: Estimation results for VAR(1) model with BE-inflation

Dependent variable R(Eth)	Estimate	Std. Error	t value	Pr (>|t|)
R(Eth)t-1	0,012	0,039	0,315	0,753
R(BTC)t-1	-0,068	0,052	-1,312	0,190
π(BE)t-1	-0,357	0,312	-1,142	0,257
const	1,154	0,630	1,833	0,067
Adjusted R-squared:	0.000			
Dependent variable R(Btc)	Estimate	Std. Error	t value	Pr (>|t|)
R(Eth)t-1	-0,050	0,029	-1,735	0,083
R(BTC)t-1	0,022	0,039	0,561	0,575
π(BE)t-1	-0,441	0,234	-1,888	0,059
const	<u>1,203</u>	<u>0,471</u>	<u>2,554</u>	<u>0,011</u>
Adjusted R-squared:	0.003			
Dependent variable π(BE)	Estimate	Std. Error	t value	Pr (>|t|)
R(Eth)t-1	0,000	0,000	0,182	0,855
R(BTC)t-1	0,000	0,000	1,757	0,079
π(BE)t-1	<u>0,999</u>	<u>0,002</u>	<u>528,281</u>	<u>0,000</u>
const	0,002	0,004	0,729	0,466
Adjusted R-squared:	0.995			

Table 8: Estimation results for VAR(1) model with expected inflation

Dependent variable R(Eth)	Estimate	Std. Error	t value	Pr(>|t|)
R(Eth)t-1	-1,162	0,742	-1,565	0,118
R(BTC)t-1	-0,068	0,052	-1,312	0,190
π(Exp)t-1	0,012	0,039	0,3	0,765
Const	2,778	1,489	1,866	0,062
Adjusted R-squared:	0.001			
Dependent variable R(Btc)	Estimate	Std. Error	t value	Pr(>|t|)
R(Eth)t-1	-1,119	0,555	-2,016	0,044
R(BTC)t-1	0,023	0,039	0,581	0,561
π(Exp)t-1	-0,051	0,029	-1,761	0,078
const	2,580	1,114	2,316	0,021
Adjusted R-squared:	0.004			
Dependent variable π(Expected)	Estimate	Std. Error	t value	Pr(>|t|)
R(Eth)t-1	0,989	0,004	231,939	0,000
R(BTC)t-1	0,000	0,000	1,315	0,189
π(Exp)t-1	-0,000	0,000	-0,749	0,454
const	0,022	0,009	2,621	0,009
Adjusted R-squared:	0.976			

Table 9: Estimation results for VAR(5) model with expected inflation

Dependent variable R(Eth)	Estimate	Std. Error	t value	Pr(>|t|)
R(Eth)t-1	1,05	4,852	0,216	0,829
R(BTC)t-1	-0,063	0,052	-1,22	0,223
π(Exp)t-1	0,003	0,039	0,065	0,948
R(Eth)t-2	6,609	6,362	1,039	0,299
R(BTC)t-2	0,005	0,052	0,101	0,920
π(Exp)t-2	0,041	0,039	1,056	0,291
R(Eth)t-3	-2,676	6,390	-0,419	0,675
R(BTC)t-3	0,181	0,052	3,504	0,000
π(Exp)t-3	-0,101	0,039	-2,623	0,009
R(Eth)t-4	-12,690	6,359	-1,995	0,046
R(BTC)t-4	-0,000	0,052	-0,006	0,995
π(Exp)t-4	0,076	0,039	1,963	0,050
R(Eth)t-5	6,593	4,870	1,354	0,176
R(BTC)t-5	-0,005	0,052	-0,098	0,922
π(Exp)t-5	0,011	0,039	0,295	0,768
const	2,578	1,493	1,727	0,084
Adjusted R-squared:	0.015			
Dependent variable R(Btc)	Estimate	Std. Error	t value	Pr(>|t|)
R(Eth)t-1	0,869	3,669	0,237	0,813

R(BTC)t-1	0,030	0,039	0,78	0,436
π(Exp)t-1	-0,050	0,029	-1,705	0,088
R(Eth)t-2	2,048	4,812	0,426	0,670
R(BTC)t-2	-0,030	0,039	-0,766	0,444
π(Exp)t-2	0,057	0,029	1,949	0,052
R(Eth)t-3	-4,744	4,833	-0,982	0,326
R(BTC)t-3	0,106	0,039	2,719	0,007
π(Exp)t-3	-0,064	0,029	-2,191	0,029
R(Eth)t-4	-3,611	4,809	-0,751	0,453
R(BTC)t-4	-0,052	0,039	-1,314	0,189
π(Exp)t-4	0,076	0,029	2,61	0,009
R(Eth)t-5	4,369	3,683	1,186	0,236
R(BTC)t-5	0,028	0,039	0,709	0,478
π(Exp)t-5	-0,052	0,029	-1,786	0,074
const	2,443	1,129	2,164	0,031
Adjusted R-squared:	0.013			
Dependent variable π(Expected)	Estimate	Std. Error	t value	Pr(>|t|)
R(Eth)t-1	0,845	0,028	30,298	0,000
R(BTC)t-1	0,000	0,000	1,31	0,190
π(Exp)t-1	-0,000	0,000	-0,479	0,632
R(Eth)t-2	0,124	0,037	3,383	0,001
R(BTC)t-2	0,001	0,000	1,871	0,062
π(Exp)t-2	-0,000	0,000	-0,418	0,676
R(Eth)t-3	-0,017	0,037	-0,467	0,641
R(BTC)t-3	0,000	0,000	0,231	0,817
π(Exp)t-3	0,000	0,000	1,189	0,235
R(Eth)t-4	-0,063	0,037	-1,729	0,084
R(BTC)t-4	0,000	0,000	0,368	0,713
π(Exp)t-4	-0,000	0,000	-0,081	0,936
R(Eth)t-5	0,104	0,028	3,73	0,000
R(BTC)t-5	0,000	0,000	0,177	0,859
π(Exp)t-5	0,000	0,000	1,175	0,240
const	0,014	0,009	1,58	0,114
Adjusted R-squared:	0.977			