Erasmus University Rotterdam

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Bachelor Thesis in Accounting

A Comparative Analysis of Volatility in Cryptocurrencies and High Technology Firm Stocks: An Empirical Approach

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Abstract

This paper analyses the volatility of cryptocurrencies and high technology firm stock prices. This analysis is done by empirical methods, such as an OLS regression and a time series analysis. The OLS regressions are used to investigate whether the volatility of cryptocurrencies is significantly higher than the volatility of high technology firm stock prices. The time series analysis is done by performing a GARCH (1,1) model to analyse how the volatility changes over time during COVID-19 and the adaption period. This research finds that the volatility of cryptocurrencies is significantly higher than the volatility of stock prices and that there may be volatility clustering in the analysed time period.

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Introduction

Volatility in the cryptocurrency market. Millions of investors try to buy and sell cryptocurrencies at the most optimal moment, while keeping track of the cryptocurrencies exchange rates and trying to trade at the right time. In practice this seems almost impossible because of the extreme volatility that these cryptocurrencies experience. In the stock market, investing yields more in the long term than in the short-term due to price fluctuations. For cryptocurrencies, however these price fluctuations are even more unpredictable (Brasser, 2024). But what are cryptocurrencies? According to the European Commission, cryptocurrencies are defined as *'a digital representation of value or rights which may be transferred and stored electronically, using distributed ledger technology, such as in a blockchain, or similar technology'*. A characteristic of these cryptocurrencies is that they are not stored centrally. Cryptocurrencies are spread across several computers and there is no authority that manages them (De Nederlandsche Bank, n.d.).

The cryptocurrency market and stock market differs fundamentally from each other. However, there are some similarities between them. For instance, the same analytical methods can be applied for both cryptocurrencies and stock, such as calculating the log return and perform a time series analysis on the volatility (Durcheva & Tsankov, 2019). Previous research about the cryptocurrencies and their volatility, often use traditional stock prices to compare the volatility of stock prices with the volatility of cryptocurrencies (Malladi & Dheeriya, 2021). However, it might be better to analyse the volatility of cryptocurrencies by comparing it to a specific type of stock, such as high technology firm stock prices rather than regular traditional stocks. Since these instruments are more similar in characteristics. This leads to the following research question:

To what extent and in which way does the volatility of cryptocurrencies differ from the volatility of traditional firm stock prices?

This research focuses on the cryptocurrencies and stock prices of high technology firms. The findings of this research question are interesting and relevant. Prior research has mainly focused on the volatility of cryptocurrencies and compared the cryptocurrencies with traditional stock. Furthermore, other cryptocurrencies are compared with each other (Liu & Serletis, 2019). Besides that, there are other papers that focuses on the global stock market and the gold prices to determine the volatility of the cryptocurrencies. It was suggested that other areas of cryptocurrency and their volatility could be investigated (Malladi & Dheeriya, 2021). All these studies compared the volatility of the cryptocurrencies to the stock market prices. It is however unclear to what extent stock prices can be used to compare with the prices of cryptocurrencies to analyse the volatility. In addition, the majority of the previous research is based on the time period before COVID-19, and it is interesting to investigate the volatility during and after the pandemic (Chowdhury, 2020). Furthermore, from a social aspect this research could be interesting for investors who are considering investing in cryptocurrencies or stock. For instance, investors who are more risk averse could choose the option with the least volatility. Therefore, the reason to analyse how and to what extent the volatility of cryptocurrencies and stock prices differ from each other and how it can be used to compare those in research.

1. Literature Review

In this section, existing literature about cryptocurrencies and their volatility is examined. This paper researches the differences between the volatility of cryptocurrencies and the volatility of the stock prices of high technology firms. Therefore, this paper first defines what cryptocurrencies and the blockchain technology are. After that, it examines the literature about the volatility of the cryptocurrencies and the stock market volatility.

1.1. Cryptocurrencies

First, it is important to define cryptocurrencies. Cryptocurrencies are a form of digital assets that are designed to be used like traditional money. The value of these currencies is set through transactions and does not hold an intrinsic value. That is similar to most traditional currencies. Unlike traditional currencies, cryptocurrencies are not controlled by any central authority, for instance the central bank. No organisation ensures and stabilizes the value of the cryptocurrencies. These are by nature decentralized and illustrate within the cyberculture the characteristics of libertarian ideals (Tredinnick, 2019). The rise of cryptocurrencies causes, because of the libertarian characteristics, an existential threat to traditional finance. Cryptocurrencies abolish the so-called “middleman”, such as a financial institution. Various research anticipates a potential revolution in the financial inclusion. However, the technology of cryptocurrencies does have benefits. It holds the potential for cheap, secure, and close-to-instant transactions. This leads to allowing billions of people to join the internet commerce. People are able to pay for goods and services and furthermore they are able to be paid, outside the traditional banking and credit card infrastructure (Härdle et al., 2020).

1.2. Blockchain Technology

The underlying technology of the cryptocurrencies, the technology of the blockchain, has drawn the attention of many organisations. Blockchain has the potential to change the ways to maintain the security and integrity in all sorts of transactions. Furthermore, blockchain plays a crucial role in the technology of the cryptocurrencies.

A blockchain is a sequence of units, called *blocks* that is constantly growing. By using cryptographic principles, these blocks are connected to each other in a secure manner. They can be kept together without risking the security of the records. Blocks can be of any size, but if the block is larger, the process of creating new blocks is slower, therefore the size of each block in a blockchain is set in many applications (Tredinnick, 2019). A blockchain can be seen as a unique database. A blockchain's structure is decentralized and distributed and is therefore often referred to as a distributed ledger technology. A cryptographic hashing function serves as the form of the chain. A hashing function is a one-way mathematical algorithm, where the so-called hash or digest transforms an input into an output (Härdle et al., 2020). All users are able to access the ledger, but only the users with a special cryptographic key can request to add a new record. Moreover, other users validate and determine whether new records should be added to the ledger. This system makes it nearly impossible to alter or fake the records (Joo et al., 2020).

1.3. Blockchain and cryptocurrencies

The cryptocurrency Bitcoin was the first digital asset (with no support and intrinsic value), that was based on the blockchain technology. Bitcoin uses the blockchain technology to ensure secure and transparent transactions without the need for a financial intermediary. The owners of Bitcoin each have two cryptographic keys. First, a public key; this is comparable to an e-mail address or a bank account number. This is the address of the Bitcoin wallet. The second key is the private key. This one can be seen as a password and gives the Bitcoin user the authority to transfer Bitcoins to another network user's wallet. An important distinction between the public and private key is that the public key can be shared with other users and the private key needs to be kept secret under any circumstances to avoid misuse.

When the Bitcoin owner ought to transfer Bitcoin to other Bitcoin users, the sender transmits a message to all the Bitcoin users. The message is signed with the private key. Other Bitcoin network users, the so-called "miners", compute a complicated mathematical computation to confirm that the sender has the authority to transfer the Bitcoins. The transactions of the Bitcoins are after the confirmation added to the ledger as a new block in the chain. Each new block holds the information of the previous blocks. Therefore, it is almost impossible to alter

recorded transactions in one block. Blockchain technology is because of that a transparent, secure, decentralized, and quick platform for implementing transactions (Joo et al., 2020).

1.4. Volatility cryptocurrencies

Cryptocurrencies are lately discussed to a great extent in the news, especially the exponential growth of the Bitcoin. Even though the cryptocurrency market is still rather young, the market capitalization has grown immensely. In 2017 the market capitalization of all the cryptocurrencies was approximately eighteen billion dollars, in 2018 it has grown to approximately 599 billion dollars. Since cryptocurrencies are recently developed, it is important to know and understand how the cryptocurrency ecosystem works. Liu and Serletis (2019) concluded that the price of cryptocurrencies and the volatility are important for investors and other market participants. Directly forecasting the volatility of the cryptocurrencies seems to cause direct effects on the transactions in the cryptocurrency market. This section discusses the prior research on the volatility of the cryptocurrencies.

Malladi & Dheeriya (2021) conducted a time series analysis to analyse the returns and volatilities of the cryptocurrencies Bitcoin, Ripple (XRP), Stock markets (S&P 500 index, MSCI World Index, MSCI Emerging Markets Index) and gold prices. The time-series methods that are used to explain the return and volatility of cryptocurrencies are GARCH, ARMAX and VAR. They concluded that global stock markets do not have a causal effect on Bitcoin. However, for smaller cryptocurrencies it is possible to have a causal effect on Bitcoin. They are besides that more sensitive to gold prices and the global stock market. Finally, they concluded that fear and other cryptocurrency returns have influence on the price fluctuations of the Bitcoin.

Another research focused on the relationship between the most used cryptocurrencies, Bitcoin and Ethereum, and the volatility of the exchange rate and stock index of Nigeria. To analyse the relationship, econometric tests have been used. The model EGARCH (1,1) revealed that the volatility of the stock market has a stronger reaction on bad news in the cryptocurrency market than the good news in the cryptocurrency market. The results are based on news of the same magnitude. It was therefore shown that the volatility of cryptocurrency returns has an important impact on the financial market in Nigeria. Besides that, the Granger causality test revealed a unidirectional causal relationship between the

Bitcoin and the stock market index in Nigeria. Based on this study in Nigeria, it can be concluded that the volatility of Bitcoin and Ethereum had a significant impact on the stock market price in Nigeria. These results are therefore limited to the Nigerian financial market (Jimoh & Benjamin, 2020).

Finally, prior research examined the volatility before and during the COVID-19 period. They used fifteen cryptocurrencies to conduct their research: Bitcoin, Zcash, Ethereum, Litecoin, Stellar, Monero, Dash, Nem, Tether, Eos, Binance, Cardano, Tron, Neo and Iota and volatility index (VIX). This research observed that there are structural breaks in all fifteen cryptocurrencies, which means that there are sudden or gradual changes in data used in this research, which makes the cryptocurrency market unpredictable. Furthermore, it is concluded that there is a positive dynamic correlation between all the cryptocurrencies, which means that the prices of the cryptocurrencies tend to move in the same direction. However, the dynamic correlation implies that this correlation is able to change over time. This research suggested to analyse the impact of COVID-19 on the volatility of the cryptocurrencies (Chowdhury, 2020).

1.5. Volatility stock market

This paper studied besides the cryptocurrency volatility, the stock market volatility. Important and interesting for research in the stock market is the stock market return and volatility. There is a large amount of research about the financial market volatility. The most used research method to analyse the volatility of the stock market is the GARCH model. Prior research showed that GARCH (1,1) model could precisely explain the volatility and return of data with symmetric information. With asymmetric information, asymmetric GARCH models are mostly used, for instance the EGARCH model. These models are used to capture bad news in the stock market (Bhowmik, 2020).

The stock market is popular due to the high return. However, investments in the stock market come with a high risk, because of constantly changing internal and external economic circumstances. Volatility in the stock markets has different definitions in different schools. Some researchers state that volatility is the level of fear prevailing in the market players' minds. The price variations of underlying financial market assets can, besides the fear, be

considered as volatility. When there is new information, the volatility in the stock market changes (Dhingra et al., 2024). They conducted research on the factors that cause turbulence in the financial markets. It was stated before that it was often concluded that oil prices, policy uncertainty and investor sentiments have a significant impact on the stock market volatility. However, they concluded that the impact of corporate governance, the increasing role of domestic institutional investors and algorithmic trading on stock market volatility have a more significance impact on the stock market volatility.

2. Hypothesis

This research focuses on how and to what extent the volatility of cryptocurrencies differs from the volatility of stock prices of traditional companies. After analysing the existing literature on cryptocurrency volatility, there are some possible expectations about the volatility of cryptocurrency and the volatility of traditional stock prices. From the prior research discussed in the literature review, it is clear that the stock prices are repeatedly used to compare it with or determine the volatility of cryptocurrencies.

It was stated that investing in common stock yields more in the long term due to short-term fluctuations. This means that in the short-term it is likely to make a loss on the investment in stock. For cryptocurrencies, the prices fluctuates even more, which leads to the first hypothesis:

H1: The volatility of cryptocurrencies are significantly higher than the volatility of stock prices of high technology firms.

Besides that, it was concluded in prior research that stock prices are more influenced to bad news in the cryptocurrency market compared to good news of the same magnitude. It is therefore interesting to look at the impact of news events for both the cryptocurrency market and the stock market. This paper focuses on the COVID-19 event. This leads to the second hypothesis:

H2: The sensitivity of news events to the volatility of cryptocurrencies are significantly higher than the volatility of stock prices of high technology firms.

Lastly, research observed that there are structural breaks in cryptocurrencies, which means that there are sudden or gradual changes in the data used in this research, which makes the cryptocurrency market unpredictable. It is however unclear how the volatility of both cryptocurrencies and stock prices changes, which leads to the last hypothesis for this research:

H3: The change of volatility of cryptocurrencies due to COVID-19 is significantly higher than the change of volatility of stock prices of high technology firms.

3. Methodology

To determine the spread and the tendency of the prices of the cryptocurrencies and high technology firm stock prices, simple statistic tests are performed. For both cryptocurrencies and firm stock daily data is used to determine the standard deviation, mean, median and the 25th and 75th percentile of cryptocurrencies and traditional stock. The descriptive statistics are presented in Table 2 in the section Results.

To investigate if there are significant differences between the cryptocurrencies and the traditional stock prices and Ordinary Least Squares (OLS) regression is performed with a signification level of five percent. The dependent variable in this regression is the volatility of the financial instrument. The independent variable is whether the instrument is a cryptocurrency or a traditional stock. The other independent variables are the closing price and the time period. Which leads to the formula:

$$(1)\ Volatility_i = \beta_0 + \beta_1 Instrument_i + \varepsilon_i$$

Thirdly, for the second hypothesis, this paper focuses on the COVID-19 period and the volatility for the relevant high technology companies and cryptocurrencies. The COVID-19 pandemic was a major shock to the economy and a good indicator as a news event to analyse whether cryptocurrencies react more strongly to news events compared to firm stocks. With this data three OLS linear regressions is performed. The three regressions analyse the impact of COVID-19 on the volatility of cryptocurrencies and firm stocks. The dependent variable for all three regressions is the volatility of the instrument. The independent variables for the first regression are whether the instrument is a cryptocurrency or a stock and whether the time period is COVID-19 or not. For regression 2.2 and 2.3 the independent variable is whether the time period is COVID-19 or not. With this information the formulas are as follows:

$$(2.1)\ Volatility_i = \beta_0 + \beta_1 Instrument_i + \beta_2 Time_i + \varepsilon_i$$

$$(2.2)\ Volatility\_Crypto_i = \beta_0 + \beta_1 Time_i + \varepsilon_i$$

$$(2.3)\ Volatility\_Stock_i = \beta_0 + \beta_1 Time_i + \varepsilon_i$$

Lastly, to investigate the trend over time, a time series regression is performed. Malladi & Dheeriya (2021) conducted a time series with a GARCH (1,1) model in their previous research. This paper follows the same model to conduct a time series to investigate the trend over time during the COVID-19 period and the COVID-19 adaption period. For this research the GARCH-model is used to determine the volatility over time for both the cryptocurrencies and traditional stock. This model is in addition used to see if there are to some extent trends that can be recorded or other patterns over time, especially in the covid-19 period. In this paper GARCH (1,1) is used for the variable *Log_Return for* both cryptocurrencies and stocks. The formula for the GARCH (1,1) model is as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

OLS assumptions

This paper performs an OLS Regression. This method has assumptions that needs to be taken into consideration while analysing the results from the regression. This paper is using three independent variables, which means that the Zero Conditional Mean probably does not hold for this research. This means that there could be more factors influencing the independent variables that influences the dependent variable. In this case there could be other factors influencing the instrument, time and log return that influences the volatility of the instrument. Therefore, for this paper it could be possible that the regressions performed with OLS contains Omitted Variable Bias. This paper speaks for this reason only about associations and not causal effects. For the OLS regression, heteroscedastic-robust standard errors are used, so that no heteroskedastic standard errors are allowed in the model.

4. Data

This paper research to what extent and for what reason the volatility of cryptocurrencies differs from the volatility of the stock prices of traditional firms. This section discusses the sample selection of the data that is used to perform the analysis between cryptocurrencies and high technology firm stock prices.

For this research, historical prices of cryptocurrencies and high technology firm stocks is needed to analyse the volatility. The time period chosen for this research will be the period during and after COVID-19. First the data from the time period 2019-2020 is examined. This timeframe seems feasible while cryptocurrencies are actively traded since 2013 (Liu & Serletis, 2019). After that the time period 2021-2022 will be examined. The COVID-19 period itself is interesting, since the outcomes of volatility could differ because of the pandemic. Since there is no prior research about that time period, it is worth to mention the period after COVID-19, which is called the 'adaption' period in this paper. This is the reason why this paper studied the COVID-19 period and COVID-19 'adaption' period separately. Besides, this paper does research on the stock prices of high technology firms to conclude what the differences are between the volatility of the cryptocurrencies and the stock prices.

The data about the cryptocurrencies that is used for this paper is obtained from CoinGecko. CoinGecko is a database that was founded in 2014. Their goal is to extend access to crypto data to everyone and provide the users of relevant and actionable insights. Besides CoinMarketCap, CoinGecko is the largest database for historical data about cryptocurrencies (CoinGecko, 2024). This paper focuses on the 10 cryptocurrencies of the CoinGecko database, these are: Bitcoin (BTC), Ethereum (ETH), Tether (USDT), BNB, Ripple (XRP), USDC, Dogecoin (DOGE), Cardano (ADA), Litecoin (LTC) and Chainlink (LINK). These specific cryptocurrencies are in the top 20 in the CoinGecko database and are chosen because of the available historical data between the periods 2019-2020 and 2021-2022. In Table 1.1 and 1.3 are the sample selection and distribution for the cryptocurrencies presented.

Besides cryptocurrencies, this paper focuses in addition on stock prices of traditional firms. This paper uses data from high technology firms, since these firms are more volatile than low technology firms and therefore more suitable to be compared to the volatility of cryptocurrencies. The high technology firms this research utilise are Apple Inc., Microsoft Corp., NVIDIA Corp, Meta Platforms Inc., ASML Holding NV, Oracle Corp., Adobe Inc. The historical data for the stock prices of these firms is obtained via Yahoo!Finance database. Table 1.2 and 1.4 represent the sample selection and the distribution for the high technology firm stocks.

TABLE 1.1: Sample selection during COVID_19

Panel A Sampling selection procedure of the CoinGecko database

Sampling procedure

The sample needs to consist of ten cryptocurrencies and is selected by the following criteria:
the cryptocurrency must have historical data for the
period 2018-2022
The cryptocurrency must be in the top 20 largest cryptocurrencies in the CoinGecko database

N = number of observations
Observations are the snapped moments of the price of each cryptocurrency.
N = 7309

Panel B Sample distribution

Cryptocurrency	Ticker	Period	Frequency	Percentage	Cumulative Frequency
Bitcoin	BTC	2019-20	731	10%	731
Ethereum	ETH	2019-20	731	10%	1462
Thether	USDT	2019-20	730	10%	2192
BNB	BNB	2019-20	731	10%	2923
USDC	USDC	2019-20	731	10%	3654
Ripple	XRP	2019-20	731	10%	4385
Dogecoin	DOGE	2019-20	731	10%	5116
Cardano	ADA	2019-20	731	10%	5847
Litecoin	LTC	2019-20	731	10%	6578
Chainlink	LINK	2019-20	731	10%	7309

Panel A of this table reports the sample selection procedure of the cryptocurrencies during the COVID-19 period. Panel B of this table presents the chosen cryptocurrencies.

TABLE 1.2: Sample selection stock during COVID_19

Panel A Sampling selection procedure of the Yahoo!Finance database

Sampling procedure

The sample consists of the historical data of ten firms and is selected by the following criteria:
There must be historical data available from the period 2018-2022
The firms chosen for this sample selection are high technology firms due to the similarity with cryptocurrencies

N = number of observations
Observations are the snapped moments of the price of each stock
N = 3528

Panel B Sample distribuition

Company	Stock	Period	Frequency	Percentage	Cumulative Frequency
Apple Inc.	AAPL	2019-20	504	14%	504
Microsoft Corp.	MSFT	2019-20	504	14%	1008
NVIDIA Corp.	NVDA	2019-20	504	14%	1512
ASML Holding N.V.	ASML	2019-20	504	14%	2016
Meta Platforms, Inc.	META	2019-20	504	14%	2520
Oracle Corp.	ORCL	2019-20	504	14%	3024
Adobe Inc.	ADBE	2019-20	504	14%	3528

Panel A of this table reports the sample selection procedure of the high technology firm stocks during the COVID-19 period. Panel B of this table presents the chosen firms and stocks.

TABLE 1.3: Sample selection after COVID_19

Panel A Sampling selection procedure of the CoinGecko database

Sampling procedure

The sample needs to consist of ten cryptocurrencies and is selected by the following criteria:
the cryptocurrency must have historical data for the period 2018-2022
The cryptocurrency must be in the top 20 largest cryptocurrencies in the CoinGecko database

N = number of observations
Observations are the snapped moments of the price of each cryptocurrency.
N = 7300

Panel B Sample distribuition

Cryptocurrency	Ticker	Period	Frequency	Percentage	Cumulative Frequency
Bitcoin	BTC	2021-22	730	10%	730
Ethereum	ETH	2021-22	730	10%	1460
Thether	USDT	2021-22	730	10%	2190
BNB	BNB	2021-22	730	10%	2920
USDC	USDC	2021-22	730	10%	3650
Ripple	XRP	2021-22	730	10%	4380
Dogecoin	DOGE	2021-22	730	10%	5110
Cardano	ADA	2021-22	730	10%	5840
Litecoin	LTC	2021-22	730	10%	6570
Chainlink	LINK	2021-22	730	10%	7300

Panel A of this table reports the sample selection procedure of the cryptocurrencies during the adaption period. Panel B of this table presents the chosen cryptocurrencies.

TABLE 1.4: Sample selection stock after COVID_19

Panel A Sampling selection procedure of the Yahoo!Finance database

Sampling procedure

The sample consists of the historical data of ten firms and is selected by the following criteria:
There must be historical data available from the period 2018-2022
The firms chosen for this sample selection are high technology firms due to the similarity with cryptocurrencies

N = number of observations
Observations are the snapped moments of the price of each stock
N = 3521

Panel B Sample distribuition

Company	Stock	Period	Frequency	Percentage	Cumulative Frequency
Apple Inc.	AAPL	2021-22	503	14%	503
Microsoft Corp.	MSFT	2021-22	503	14%	1006
NVIDIA Corp.	NVDA	2021-22	503	14%	1509
ASML Holding N.V.	ASML	2021-22	503	14%	2012
Meta Platforms, Inc.	META	2021-22	503	14%	2515
Oracle Corp.	ORCL	2021-22	503	14%	3018
Adobe Inc.	ADBE	2021-22	503	14%	3521

Panel A of this table reports the sample selection procedure of the high technology firm stocks during the adaption period. Panel B of this table presents the chosen firms and stocks.

5. Results

In this section the regressions and time series that are discussed in the section methodology are performed, analysed and discussed.

5.1. Descriptive statistics

Table 2 summarizes the descriptive statistics of the variables used in the main analysis of this paper. The descriptive statistics summarizes the variables for cryptocurrencies and stock prices separately during COVID-19 and after COVID-19. Interesting to see is that the mean of the volatility of the cryptocurrencies is higher than the mean of the volatility of the stock prices during both 2019-2020 and 2021-2022. Therefore, we see that the average log return for the cryptocurrencies and stock prices are during COVID-19 approximately the same and after COVID-19 the log return of cryptocurrencies is slightly higher than the log return of the stock prices. An interesting remark is that even though the average log returns are approximately the same during COVID-19, the average volatility of cryptocurrencies during that period is still higher than the average volatility of high technology firm stock prices.

5.2. Hypothesis 1

In Table 3 the OLS regression results are presented to test the first hypothesis: *The volatility of cryptocurrencies are significantly higher than the volatility of stock prices of high technology firms.* This regression analyses whether cryptocurrencies cause higher volatility compared to firm stock prices.

The coefficient for the control variable *Instrument* is as shown in Table 3 positive and significant at a one percent significance level. This means that when the instrument is a cryptocurrency, the volatility increases by approximately 0.02 US Dollars. Given this information, it can be said that there is a positive association between the certainty that the instrument is a cryptocurrency and the volatility. This means that the volatility of cryptocurrencies compared to the volatility of firm stocks becomes higher. Therefore, the volatility of cryptocurrencies are significantly higher than the volatility of stock prices of high

technology firms, which means that the first hypothesis discussed in section two can be accepted at a five percent significance level.

5.3. Hypothesis 2

In Table 4 the OLS regression results are presented to test the second hypothesis: *The sensitivity of news events to the volatility of cryptocurrencies are significantly higher than the volatility of stock prices of high technology firms.* This regression analyses whether the volatility of cryptocurrencies reacts stronger to COVID-19 compared to the volatility of firm stock prices.

Model 2.1 shows in general if the time period has an impact on the volatility of the instrument. The first coefficient, instrument, is positive and significant at a one percent significance level. This means that if the instrument takes the value one and is therefore a cryptocurrency, the volatility increases by 0.02 US Dollars, given that there is no COVID-19 period. The time coefficient is negative and significant. Which means that during the COVID-19 period, the volatility decreases by 0.01 US Dollars, given that the instrument takes the value zero, and therefore is a stock. This means that the time period being COVID-19 indeed has an association with the volatility of cryptocurrencies and firm stock prices.

To analyse this further, model 2.2 and 2.3 in table 4 analyses cryptocurrencies and firm stock prices separately. The time coefficient in model 2.2 is negative and significant. Which means that during the COVID-19 period, the volatility for cryptocurrencies decreases by approximately 0.01 (-0.007) US Dollars. The time coefficient in model 2.3 is likewise negative and significant. Which means that during the COVID-19 period, the volatility for firm stock prices decreases by approximately 0.01 (-0.003) US Dollars. In table 4 is shown that the volatility for cryptocurrencies in model 2.2 is slightly lower than the coefficient for firm stock prices in model 2.3. The time coefficient of cryptocurrencies is significantly lower than the time coefficient of the high technology stock prices. This means that the volatility of cryptocurrencies seems to be more sensitive to the COVID-19 period. From this it could be said that the volatility of cryptocurrencies seems to have a slightly stronger and significant association with the COVID-19 period compared to the volatility of firm stock prices.

Therefore, the sensitivity of news events to the volatility of cryptocurrencies are significantly higher than the volatility of stock prices of high technology firms, which means that the second hypothesis discussed in section two can be accepted at a five percent significance level.

5.4. Hypothesis 3

In table 5 the results of the GARCH (1,1) model on the variable *Log_Return* are presented. This model is an econometric model that is used to predict the volatility for the returns of a financial assets, in this paper cryptocurrencies and high technology firm stocks (Investopedia, 2021). This GARCH model is performed to test the third hypothesis: *The change of volatility of cryptocurrencies due to COVID-19 is significantly higher than the change of volatility of stock prices of high technology firms.*

The constant term for the log return is approximately zero (-0.0000363). This term is not significant, which means that the average log return does not significantly differ from zero. In the GARCH (1,1) model, the constant term is approximately zero (0.0000000933) and significant at a one percent significance level. This means that the long-term average volatility in absence of shocks, in this case the absence of the COVID-19 shock, is approximately zero for both cryptocurrencies and stock prices together. The ARCH L1 coefficient seems to be positive and significant at a one percent significance level. This means that 25.9 percent of the lagged squared residuals leads to an increase of the current volatility. The GARCH L1 coefficient is positive and significant as well at a one percent significance level. This means that 81.5 percent of the lagged conditional variance leads to an increase in the current volatility. This high percentage means that there could be volatility clustering. This means that due to the high volatility for both cryptocurrencies and firm stock prices during the COVID-19 period, both cryptocurrencies and firm stock prices are likely to experience continued high volatility in the subsequent period. The sum of the ARCH L1 and GARCH L1 coefficients is close to one, which means that the volatility shocks could have a long-term impact on future volatility. This does mean that both cryptocurrencies and high technology firm stocks experiences higher volatility change over time due to the COVID-19 period. However, this does not say anything about cryptocurrencies experiencing significantly higher volatility than firm stock prices. It is likely that cryptocurrencies will experience higher volatility over time, due to

the previous regression results in table 4. It is shown there that cryptocurrencies experience a higher volatility level during COVID-19 and after that in comparison to firm stock prices.

Therefore, the last hypothesis can neither be accepted nor rejected, due to insufficient observations for cryptocurrencies and high technology stock prices to perform an empirical analysis with the GARCH (1,1) model during the COVID-19 period and the adaption period. It cannot be concluded that the change of volatility of cryptocurrencies due to COVID-19 is significantly higher than the change of volatility of stock prices of high technology firms. The only thing that can be observed is that there is likely to be volatility clustering and that it is very likely that volatility after the COVID-19 period is higher than during the COVID-19 period for both cryptocurrencies and high technology firm stock prices.

TABLE 2. Descriptive Statistics

Panel A: Descriptive statistics during COVID-19 (2019-2020)						
Variables	N	Mean	Std. Dev.	p25	Median	p75
Volatility_Crypto	7308	0.037	0.026	0.023	0.036	0.049
Volatility_Stock	3,527	0.021	0.012	0.014	0.018	0.024
Close_Price_Crypto	7309	954.475	3026.544	0.271	1.004	56.806
Log_Return_Crypto	7309	0.002	0.045	-0.013	0.000	0.016
Close_Price_Stock	3528	171.414	117.649	57.740	149.160	250.660
Log_Return_Stock	3528	0.002	0.024	-0.008	0.002	0.013
Panel B: Descriptive statistics after COVID-19 (2021-2022)						
Variables	N	Mean	Std. Dev.	p25	Median	p75
Volatility_Crypto	7,299	0.044	0.035	0.028	0.042	0.058
Volatility_Stock	3520	0.024	0.010	0.016	0.021	0.030
Close_Price_Crypto	7,300	4076.170	12112.970	0.999	4.216	332.290
Log_Return_Crypto	7,300	0.001	0.057	-0.018	0.000	0.019
Close_Price_Stock	3,521	292.926	195.072	143.160	243.120	396.360
Log_Return_Stock	3,521	0.000	0.026	-0.013	0.000	0.014

Panel A in this table reports the descriptive statistics of all test variables during the COVID-19 period. Panel B in this table reports the descriptive statistics of all test variables during the adaption period.

TABLE 3. The volatility of cryptocurrencies and stocks

Dependent variable =	*Volatility* *(1)*
Instrument	0.018***
	(0.00)
Constant	0.023***
	(0.00)
Observations	21,654
Adj. R Squared	0.092

Table 3 presents the results of the following estimated OLS Regression, which correspond to the first hypothesis:

$$Volatility_i = \beta_0 + \beta_1 Instrument_i + \varepsilon_i$$

The dependent variable is the volatility of the analysed instrument. And the control variable for this OLS Regression is the instrument. The sample consists of 21,654 closing price observations of cryptocurrencies and firm stock prices between 2019-2022. Detailed variables definitions are provided in appendix A. Robust standard errors are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

TABLE 4. Impact of COVID-19 on the volatility of cryptocurrencies and stocks

Dependent variable =	*Volatility (2.1)*	*Volatility (2.2)*	*Volatility (2.3)*
Instrument	0.018***		
	(0.00)		
Time	-0.006***	-0.007***	-0.003***
	(0.00)	(0.00)	(0.00)
Constant	0.026***	0.044***	0.024***
	(0.00)	(0.00)	(0.00)
Observations	21,654	14,607	7,047
Adj. R Sqaured	0.102	0.014	0.013

Table 4 presents the results of the following estimated OLS Regression, which correspond to the second hypothesis:

$$(2.1)\ Volatility_i = \beta_0 + \beta_1 Instrument_i + \beta_2 Time_i + \varepsilon_i$$

$$(2.2)\ Volatility\_Crypto_i = \beta_0 + \beta_1 Time_i + \varepsilon_i$$

$$(2.3)\ Volatility\_Stock_i = \beta_0 + \beta_1 Time_i + \varepsilon_i$$

The dependent variable is the volatility of the analysed instrument in all three equations. Equation 2.1 is based on the impact of COVID-19 on the volatility of both cryptocurrencies and firm stock prices. The control variables for this OLS Regression are the instrument and the time period. Equation 2.2 is based on the impact of COVID-19 on the volatility of cryptocurrencies. The control variable for this OLS Regression is the time period. Equation 2.3 is based on the impact of COVID-19 on the volatility of firm stock prices. The control variable for this OLS Regression is the time period. The sample consists of in total 21,654 closing price observations of cryptocurrencies and firm stock prices between 2019-2022. Detailed variables definitions are provided in appendix A. Robust standard errors are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

TABLE 5. Results GARCH(1,1) model for log return

Dependent variable =	*Log_Return*
Mean equation	
Constant	0.000
	(0.00)
Variance equation	
ARCH L1.	0.259***
	(0.00)
GARCH L1.	0.815***
	(0.00)
Constant	0.000***
	(0.00)

Table 5 presents the results of the following estimated GARCH (1,1) model, which correspond to the third hypothesis:

$$\sigma_t^2 = \alpha_0 + \alpha_1 \sigma_{t-1}^2 + \beta_1 \sigma_{t-1}^2$$

This GARCH model is performed on the variable *Log_Return*. This sample consists of 21,657 observations between the period 2019-2022. Detailed variables definitions are provided in appendix A. Standard errors are in parentheses. *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively.

6. Discussion and Conclusion

This paper analyses the volatility of cryptocurrencies and high technology firm stock prices. It does a comparative analysis between those two financial instruments, due to similarity in characteristics. This research focuses on how the volatility differs between the cryptocurrencies and the high technology firm stock prices. Therefore, it analyses the impact of COVID-19 on the volatility on both cryptocurrencies and high technology firm stock prices. This analysis aims to find an answer to the following research question:

To what extent and in which way does the volatility of cryptocurrencies differ from the volatility of traditional firm stock prices?

To answer this research question, this paper first analysed the volatility of cryptocurrencies and high technology firm stock prices using an Ordinary Least Squares (OLS) regression. The results of this regression showed that the volatility of cryptocurrencies is as a matter of fact significantly higher than the volatility of high technology firm stock. As a result, the first hypothesis was accepted.

Secondly, this paper investigated how sensitive cryptocurrencies and high technology firm stocks are to news events, focusing on the COVID-19 pandemic. An OLS regression was also performed to analyse this. The results of the regression showed that the COVID-19 pandemic has a negative and significant association with the volatility of both cryptocurrencies and high technology firm stock prices. Furthermore, the cryptocurrencies and stock prices were analysed separately. This showed that the COVID-19 period had a stronger negative and significant association with the volatility of cryptocurrencies compared to the volatility of high technology firm stock prices. This seems to imply that cryptocurrencies are more sensitive to news events and therefore the second hypothesis was accepted.

Finally, this paper examined how the volatility changes over time during and after the COVID-19 period by using a GARCH (1,1) model. The results of the GARCH model shows that there is a high percentage of the lagged conditional variance that leads to an increase in the current volatility. This implies that there could be volatility clustering. Both cryptocurrencies and firm

stock prices are likely to experience continued high volatility in the subsequent period, due to previous high volatility. However, it was not possible to analyse the change in volatility over time for the cryptocurrencies and stock prices separately, due to insufficient data between the period 2019-2022. Thus, it could not be concluded that the change of volatility of the cryptocurrencies over the COVID-19 period is significantly higher compared to the volatility of the high technology stock prices. This means that the third hypothesis is neither accepted nor rejected.

Returning to the research question. Based on the hypotheses and results, this paper shows that the volatility of cryptocurrencies is significantly more volatile than the volatility of high technology firm stock prices. This means that the prices of cryptocurrencies fluctuate more often compared to the high technology firm stock prices that have been researched. This difference in volatility between cryptocurrencies and stock prices does have several reasons. One of the reasons examined in this paper is sensitivity to news events. It can be seen that cryptocurrencies react more strongly to news events, such as the COVID-19 pandemic, and therefore have a stronger association with volatility compared to the stock prices of high technology companies. Hence, it can be concluded that both cryptocurrencies and high technology firm stocks are volatile. However, the reaction of news events or shocks on the volatility of cryptocurrencies is by far stronger than the reaction of news events or shocks on the volatility of the high technology firm stock prices, which is one of the reasons that the cryptocurrencies are more volatile than the stock prices. For investors or potential investors, this means that they should consider whether they want to invest in cryptocurrencies as this results in higher price fluctuations, despite the fact that in the analysed COVID-19 period the average log returns for both cryptocurrencies and stock prices are approximately equal to each other.

7. Recommendations

This research is adding relevant information to the existing literature, due to the fact that there is not sufficient research done about the volatility of cryptocurrencies and stock prices during and after the COVID-19 period. However, this paper was limited to a dataset of ten cryptocurrencies and seven high technology firms. This could mean that the results would differ when other cryptocurrencies and high technology firms are used. Furthermore, with this specific dataset it was not possible to perform the time series analysis for cryptocurrencies and stock prices separately. Therefore, it could not be concluded whether the volatility of the cryptocurrencies or high technology firm stocks changed more over the COVID-19 period.

Future research could focus on a larger dataset with more and different cryptocurrencies and high technology firm stocks, to determine whether these results would be consistent. Furthermore, the larger dataset could be used to see whether the volatility for cryptocurrencies changes significantly more over time than the volatility of stock prices. Besides that, this research only examine one news event, that is the COVID-19 pandemic. Future research could investigate multiple news events and see whether the volatility of cryptocurrencies still responds more strongly to those news events compared to stocks. Finally, several factors could additionally be examined than merely the news events, such as differences in the characteristics of cryptocurrencies and stock prices.

Appendix

Appendix A. Variable definitions

Variable	Definition
	Variables used in the main analysis
Volatility_Crypto	The volatility of the cryptocurrencies. This is calculated by taking the standard deviation of the monthly stock log returns during the COViD-19 period and the adaption period.
Volatility_Stock	The volatility of the stock prices of high technology firms. This is calculated by taking the standard deviation of the monthly stock log returns during the COViD-19 period and the adaption period.
Close_Price_Crypto	The daily closing price of the cryptocurrencies during the COVID-19 period and the adaption period (Source: CoinGecko)
Log_Return_Crypto	The daily percentage change in the return of the cryptocurrecies over the time period COVID-19 and the adaption period. This is calculated by taking the logarithm of the closing prices and divide n by n-1.
Close_Price_Stock	The daily closing price of the stock of high technology firms during the COVID-19 period and the adaption period (Source: Yahoo!finance)
Log_Return_Stock	The daily percentage change in the return of the stock prices of high technology firms over the time period COVID-19 and the adaption period. This is calculated by taking the logarithm of the closing prices and divide n by n-1.
Time	An indicator wether the analysed period is during the COVID-period or the adaption period. Variable is coded as one if it is during the COVID-19 period and zero otherwise.
Instrument	An indicator wether the analysed instrument is a cryptocurrency or a stock of a high technology firm. Variable is coded as one if the instrument is a cryptocurrency and zero otherwise.

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