978-607-96203-0-11

RED INTERNACIONAL DE INVESTIGADORES EN COMPETITIVIDAD

Las opiniones y los contenidos de los trabajos publicados son responsabilidad de los autores, por tanto, no necesariamente coinciden con los de la Red Internacional de Investigadores en Competitividad.

Performance of Bitcoin Market Prices Before and During the COVID-19 Pandemic

Michael Demmler[1]
Gibran Aguilar Rangel*
Ignacio Almaraz Rodríguez**

Resumen:

Las criptomonedas surgen como una forma innovadora de dinero, siendo Bitcoin el ejemplo más importante. El presente estudio explora el desempeño financiero del Bitcoin para el periodo enero de 2018 a mayo de 2022, tomando como fecha focal el anuncio de la pandemia de COVID-19 por parte de la OMS, se dividió el total del periodo de muestra en dos submuestras con la finalidad de responder la siguiente pregunta de investigación: ¿Qué diferencias pueden encontrarse en las series de datos del precio de mercado de Bitcoin antes y después de la pandemia de COVID-19? El estudio está basado en un diseño de investigación cuantitativa que incluye el análisis de momentos estadísticos y pruebas econométricas para cambios estructurales.

Los resultados principales arrojan diferencias claras en los momentos estadísticos de las dos submuestras. Asimismo, un punto de quiebre estructural en la serie de datos ha sido identificado usando una prueba de Chow.

Palabras clave: Bitcoin, criptomoneda, COVID-19 pandemia, análisis de series de tiempo

Abstract

Cryptocurrencies emerged in recent years as a new, innovative form of money from which Bitcoin by far is the most important example. The present study explores the financial performance of Bitcoin for the period January 2018 to May 2022 taking the announcement of the COVID-19 pandemic by the WHO as the crucial date to divide the whole sample period in two subsamples in order to answer the following research question: Which differences can be found in the data series of market prices of Bitcoin before and during the COVID-19 pandemic? The study is based on a quantitative research design including the analysis of statistical moments and econometric tests for structural changes. Main results show clear differences in the statistical moments of the two subsamples. Furthermore, one structural breakpoint in the data series is identified using the Chow test.

Key words: Bitcoin, cryptocurrency, COVID-19 pandemic, time series analysis

[1]** Universidad Autónoma de Querétaro

Introduction

On the one hand, during the last decade a new and innovative kind of money emerged principally based on peer-to-peer networks and cryptography called cryptocurrencies. Nowadays, there exist thousands of different cryptocurrencies. However, by far Bitcoin is the most important one referring to usage, impact and investment value. On the other hand, the COVID-19 pandemic started in late 2019 in China, was declared a pandemic by the World Health Organization (WHO) in March 2020 and has had a fundamental impact on the international economic and financial markets since then. Hence, it is of interest to investigate about the performance of cryptocurrencies, especially Bitcoin, during the ongoing COVID-19 pandemic.

Therefore, the present study aims to work on the following research question: Which differences can be found in the data series of market prices of Bitcoin before and during the COVID-19 pandemic? In order to answer the outlined research question, an exploratory and quantitative research design is chosen based on the analysis of statistical moments as well as econometric tests for structural changes. The whole sample dataset contains 1612 daily logarithmic returns of Bitcoin for the period 01/01/2018 to 05/31/2022. Furthermore, the whole sample dataset is divided into two subsamples – one before the pandemic (01/01/2018 – 03/10/2020) and one during the pandemic (03/11/2020 – 05/31/2022) – in order to directly address the research question of the study.

The remainder of the paper is structured as follows. After this short introductory part, the second chapter (Literature Review) gives an overview of the necessary theoretical and contextual background referring to cryptocurrencies, Bitcoin and the impact of the COVID-19 pandemic on financial markets. The subsequent chapter (Methodological Design) outlines the methodological approach of the study. Section 4 (Results) presents and interprets the results of the study. Finally, the paper presents some concluding remarks in the fifth section.

Literature Review

Fundamentals of Cryptocurrencies and Bitcoin

For thousands of years, humanity has established different ways for paying or trading goods, going all the way back to the barter system, which proved too cumbersome. Later, precious metals were used as a form of currency, but due to the scarcity of said metals, they were later replaced with government issued currencies (FIAT). There have been improvements over the years, such as the banking system, checks, debit cards, credit cards and electronic transfers, but these improvements all rely on the same mentioned standard currency (Velde, 1998).

Bitcoin, which can be characterized as the most well-known and popular cryptocurrency, emerged in 2008, thanks to the work by Bitcoin´s originator Satoshi Nakamoto. In a self-published

white paper it is described how this form of online cash would work, notably how it would bypass financial institutions while offering high level security for each transaction (Nakamoto, 2008). Bitcoin, however, wasn't the first attempt to create a secure, purely digital, decentralized currency. Already in 1983 David Chaum started publishing about the need for an alternative to the current traditional payment systems arguing that in the digital era, with the internet taking over people's homes, more privacy would be needed and that the government, banks and other private institutions wouldn't be able to provide it. Hence, digicash was created (Abrar, 2014).

However, Digicash couldn't gain the attraction that Chaum had envisioned, it went bankrupt a few years after its creation. Nevertheless, the project inspired other companies, like e-gold and PayPal (out of those only PayPal remains). The main differences of these proposals in comparison to current cryptocurrencies can be found in the centralization of operations and that they merely represented a transaction of an outside value, e-gold was backed by gold and PayPal transfers FIAT money (Matos, 2018).

In 1996 an essay was published by Law, Sabett and Solinas, titled "How to make a mint: the cryptography of anonymous electronic cash". If the title sounds familiar that is because it basically describes a system like bitcoin, with decentralized transactions and completely anonymous (Law et al, 1996). The idea was later picked up by a computer scientist who proposed BitGold, a mechanism to create smart contracts and bypass financial institutions. Around this time another article appeared outlining the basis for an anonymous, digital cash system titled b-money (Dai, 1998). This work would later be cited in the Bitcoin proposal.

The technology that partly enabled Bitcoin to be an actual viable cryptocurrency, unlike it's theoretical predecessors was the Blockchain, which is a mechanism to record and share data by distributing it in a series of digital ledgers, which are in turn distributed in different servers (Delahaye, 2016). The advantages of this system against a centralized one, is that it allows for a more secure environment and does not need a central figure of approval which results in time and cost advantages in comparison to traditional payment systems (Barber et al, 2012).

In the beginning, Bitcoin had no real monetary value, it was more of a virtual reward for people, called *miners*, willing to explore the software and do the so-called *mining* which refers to the process of solving complicated mathematical puzzles by computers. In 2010 the first actual transaction with Bitcoin was realized as a programmer negotiated 10,000 Bitcoins in order to get some pizza, thus stablishing the first monetary value for the cryptocurrency. After this event, more miners became attracted to the idea of actually trying to gain money out of Bitcoin. Consequently, they started trading it and the value of Bitcoin started to grow (Matos, 2018).

In 2011, the infamous website Silk Road unleashed a new array of possibilities for the cryptocurrency. Although this site was principally used to deal, among other things, with illicit substances, it also showed the viability of Bitcoin as an actual currency and not just a hobby or a trading instrument. Consequently, the anonymity part of Bitcoin appealed to more than just people wanting to buy drugs and organizations like Wikileaks started accepting donations in form of Bitcoin since it couldn't be tracked or frozen by governments unlike other assets. In this year Bitcoin reached parity with the US dollar and promptly passed it (Matos, 2018).

During the next years more legitimate businesses (like Microsoft) started accepting Bitcoin as a mean of payment and also other cryptocurrencies began to appear. Currently, according to CoinMarketCap (2022) there exist about 9,500 different cryptocurrencies. Nevertheless, Bitcoin remains by far the most popular one with the highest value. Bitcoin´s tremendous price increases as well as its boom and bust cycles in recent years attracted a new kind of market participants, the investors (speculators), who saw beyond the value as a currency and started using it as an investment asset. However, their influence resulted in even higher risk measures for the cryptocurrency market which leads to the current widespread academic opinion that cryptocurrencies, as for example Bitcoin, need to be characterized as high risk assets (Cheah and Fry, 2015; Moosa, 2020) vulnerable to continuous speculative phenomena, as for example speculative bubbles (Demmler and Fernández, 2022).

COVID-19 Pandemic and its Impact on International Financial Markets

The date of the creation of Bitcoin as a concept (and shortly after a reality) is no coincidence. In 2008 the Subprime Financial Crisis left people with a deep distrust for traditional banks and financial institutions as a whole. Hence, the idea of a currency that had nothing to do with the banking sector appealed to more people than ever.

By 2020, the financial crisis of 2008 was just a memory. Financial markets had bounced back and many market participants, affected by it, had recovered somehow. But then the COVID-19 pandemic hit. At the beginning of the pandemic in early 2020, there was a certain optimism that it wouldn't affect that much in financial and economic terms and that it was just a temporary crisis. However, as weeks and months passed, infections and death tolls increased exponentially and businesses started shutting down on an international scale. Consequently, it became clear that another financial and economic crisis had already started (Adekoya & Oliyide, 2022).

The COVID-19 pandemic has been an unprecedented event for a number of reasons, mainly for how many people have been affected by it. Although it presumably started in late 2019 in a region of

China, the virus quickly spread throughout the world at an infection rate never seen before. Even remote, rural regions found themselves dealing with the pandemic sooner rather than later. The main element that allowed the virus to spread so rapidly was the currently global interconnectedness, i.e. one person could unknowingly hop on a plane and carry the virus to the other side of the world in a matter of hours. So not only was the virus very contagious, but people can travel further and faster than ever. This same interconnectedness applies to the financial markets. Just as in 2008 the financial crisis affected not only the United States, but a lot of other countries. Also the financial impact of the pandemic started to reverberate in the different global markets (Samitas et al, 2022).

There are several factors that come into play when talking about the impact of the pandemic on the economic and financial markets. Firstly, COVID-19 can diminish the workforce of any given country, which means that the productivity of the country will be diminished. Furthermore, as stated earlier, living in an interconnected world, the global supply chain becomes affected (Samitas et al., 2022), resulting in a lower productivity worldwide.

Another factor is uncertainty (Deev and Plíhal, 2022). Financial markets tend to do well when, in case of low uncertainty levels, they can predict rather well the future. However, the pandemic skewered many of these predictions as the expected growth rates of certain industries did not materialize. Moreover, other industries (such as the travel and tourism industries) fell completely apart without a certain date of recovery. Investors generally do not like the unknown which is linked to the third factor – fear.

For a while, all the news shows, social media, articles, etc., contained a vast range of information about the pandemic – how many deaths per day, the number of infected people, businesses shutting down, shortage of medical supplies, among other alarming information, which was needed, but also caused a great deal of panic in the market participants. According to Long et al (2021) clearly there exists a correlation between how emotional or alarming were the news in a given point of time during the pandemic and the performance of the economic and financial markets.

In particular, at the beginning of 2020 the pandemic had a significant negative impact on the returns of several international stock markets, as for example S&P 500, Nasdaq Composite Index, DAX 30, Nikkei 225 (Shehzad et al, 2020). However, after first public stimulus packages and vaccine trial news equity markets started to recover again beginning in spring 2020 despite the ongoing global health care crisis (Rahman et al, 2021). The same (short-term negative return effect at the start of 2020 and a beginning recovery in spring 2020) is true for the cryptocurrency markets as, for example, Bitcoin (Chen et al, 2020).

Nevertheless, viewing the pandemic as a whole, prices of commodities and the financial markets in general, have become very unstable (Adekoya and Oliyide, 2022). It is believed that this volatility

is related to the pandemic and will revert once the pandemic ends. However, there's not a clear end in sight. So, according to Deev & Plíhal (2022) it is up to public policy makers to implement policies that will bring stability to the markets.

Even if some industries have recovered, the elements of uncertainty and fear remain present within the international markets in 2022. Although factories and businesses are mostly fully operational worldwide, financial markets are still in turmoil. Moreover, according to Deev and Plíhal (2022) public policies generally can have an impact in stabilizing the markets in the short term, but those effects may not last.

Methodological Design

As already mentioned the research question of the present study is as follows: Which differences can be found in the data series of market prices of Bitcoin before and during the COVID-19 pandemic? Consequently, the research objective is to study historic Bitcoin market prices between 2018 and 2022 in order to find possibly existing statistical differences using analysis of statistical moments as well as tests for structural changes. In general, the present study can be characterized as exploratory and quantitative.

The present study uses daily closing prices of Bitcoin obtained from yahoo!finance (2022) for the period 01/01/2018 until 05/31/2022 which are converted into logarithmic returns in order to obtain the respective statistical moments of the return distribution of the cryptocurrency. The whole sample period contains 1612 daily market prices (01/01/2018 – 05/31/2022). In order to analyze potential differences in Bitcoin market price behavior before and during the COVID-19 pandemic, the whole sample is divided into two subsamples – Period 1 and Period 2, respectively. Period 1 contains 800 observations and covers the period 01/01/2018 to 03/10/2020. Period 2, also referred to as the pandemic subsample, includes 812 observations for the period 03/11/2020 until 05/31/2022. The crucial date 03/11/2020 to divide the whole sample into two subsamples (one before and one during the pandemic) was chosen as on this date the WHO publicly announced the existence of the COVID-19 pandemic as a serious threat to the global healthcare systems (WHO, 2020).

In a first step, the whole sample period as well as the two defined subsamples of daily returns will be analyzed and compared according to the following statistical moments (obtained with MS Excel software): daily return mean, standard deviation, coefficient of variation, maximum and minimum daily return as well as kurtosis and skewness. In a second step, and in order to substantiate the descriptive statistical analysis, Bitcoin market prices are econometrically analyzed searching for possibly existing structural changes using the Chow test. According to Gujarati and Porter (2010) structural changes can be characterized as abrupt and significant changes in the parameters of a

regression model within time series analysis. In other words, tests for structural changes determine if in a given linear regression, the values of the parameters (intercept and slope coefficients) of the model remain constant throughout the whole period. If affirmative, no structural changes exist in the data series. If regression parameters significantly change, hence, a structural breakpoint exists. In this case, the whole period (pooled) regression does not adequately explain the behavior of the analyzed variables and should be replaced by 2 (or even more, in case of several structural changes) *new* regressions which explain the respective subsamples more accurately.

The present study uses the Chow test (based on Chow (1960)) in order to identify the existence and the specific date of possibly occurring structural changes in the time series of Bitcoin market prices. As the Chow test works best for small samples, this part of the analysis uses monthly closing prices of Bitcoin for the period 01/2018 until 05/2022 (in total 53 observations). The test is carried out with RStudio and follows the subsequent hypotheses:

H_0: No existence of structural change – p-value > 0.05

H_1: Existence of structural change – p-value < 0.05

Results

Analysis of Statistical Moments of Return Distributions

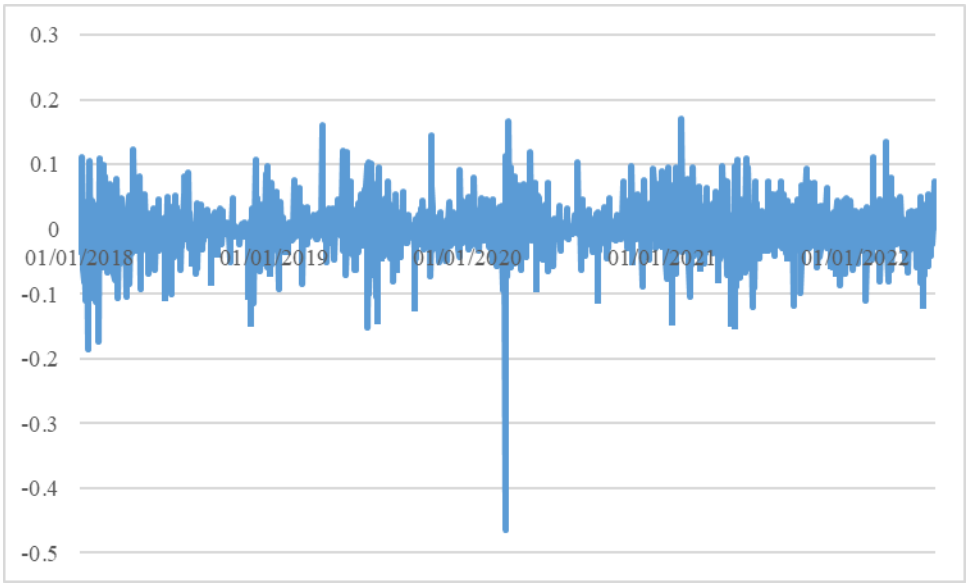
First of all, daily Bitcoin market prices, the derived daily return as well as statistical moments of the return distributions should be presented and analyzed. Figures 1 and 2 present the historic behavior of Bitcoin market prices (Figure 1) and returns (Figure 2) for the period 01/01/2018 to 05/31/2022.

As can be seen in Figure 1, Bitcoin market prices show extreme behaviors throughout the whole period. The sample period starts on 01/01/2018 with a market price of USD 13,657 and ends on 05/31/2022 at USD 31,792. The maximum (minimum) price during the sample was reached on 11/08/2021 (12/15/2018) with USD 67,567 (USD 3,237). During the first year of the sample one can identify a significantly negative tendency as a consequence of the crash of the Bitcoin bubble in late 2017. During 2019 prices recovered and entered a relatively stable phase until spring 2020. In March 2020 one can clearly identify a short-term negative effect on Bitcoin market prices due to the beginning COVID-19 pandemic. Nevertheless, it appears that the negative impact of the pandemic was just short-term as prices started to recover again already beginning in April 2020. Starting in late 2020 until the end of the sample (May 2022) Bitcoin market prices shown astonishing and extreme movements in the form of various boom and bust cycles which pushed the cryptocurrencies to new historic heights. Currently, it seems that the Bitcoin market undergoes a difficult period of important negative tendencies in its market price.

Figure 1: Daily Bitcoin market prices (01/01/2018 – 05/31/2022).

Source: Authors own elaboration based on data obtained from yahoo!finance (2022).

Figure 2: Daily Bitcoin returns (01(01/2018 – 05/31/2022).



Source: Authors own elaboration based on data obtained from yahoo!finance (2022).

Figure 2 shows the daily returns of Bitcoin market prices between January 2018 and May 2022. As can be seen, periods of high volatility alternate constantly with episodes of relatively few volatility. An extreme value for the minimum daily return can be found with -46.47 % on 03/12/2020 – one day after the pandemic announcement of the WHO. Table 1 presents the statistical moments of

the different samples – Whole Sample Period (01/01/2018 – 05/31/2022), Period 1 (01/01/2018 – 03/10/2020) and Period 2 (03/11/2020 – 05/31/2022).

Table 1: Statistical moments of the different samples.

	Whole Sample	Period 1	Period 2
Mean return	0.000501897	-0.000727592	0.001713215
Standard Deviation	0.039772928	0.03853297	0.040945517
Coefficient of variation	79.24523094	-52.95961817	23.89980711
Maximum return	0.171820562	0.16004198	0.171820562
Minimum return	-0.464730175	-0.184581725	-0.464730175
Kurtosis	13.49541854	3.145114946	21.69470291
Skewness	-1.070086756	-0.252229808	-1.753678138

Source: Authors own elaboration based on data obtained from yahoo!finance (2022).

As shown in the second column of Table 1, Bitcoin has a positive daily mean return (0.000502) during the whole sample period and a risk measured by the standard deviation of 0.039773. The coefficient of variation represents a simple measure of the risk-return profile of an asset and is calculated by dividing the standard deviation by the mean return. Consequently, the coefficient of variation expresses how many units of risk have to be accepted in order to obtain one unit of return. Generally, the lower the coefficient of variation the better as low values of this indicator represent a more favorable risk-return profile. As can be seen, the coefficient of variation of Bitcoin during the whole sample has a very high value of 79.25. Hence, during the whole sample period investors had to accept more than 79 units of risk in order to obtain one unit of return what characterizes Bitcoin during the whole sample period as a high-risk asset.

Also considering maximum daily return (0.171821) and minimum daily return (-0.464730) for the whole sample, one can get an idea of the significant and broad distribution of possible Bitcoin returns. The relatively high value for the kurtosis of 13.5 indicates that Bitcoin´s return distribution for the whole sample period is far from being normally distributed (kurtosis would be 0). Hence, the elevated value of kurtosis of 13.5 indicates a strong concentration of historic returns around their mean. Finally, the considerably negative skewness of -1.07 for the whole period shows that most daily returns during the sample were greater than their mean of 0.000502.

In order to address the research question of the present study about statistical differences in Bitcoin market prices, statistical moments are also determined for the period before (Period 1) and during (Period 2) the COVID-19 pandemic. Results are shown in the third and fourth column of Table 1. As can be seen, Bitcoin´s daily mean return during the pandemic subsample (0.001713) is much higher than before the pandemic when it actually had a negative value (-0.000728). Bitcoin´s

standard deviation is roughly on the same level before and during the pandemic with a slightly higher risk in Period 2 (0.040946) than in Period 1 (0.038533). The risk-return profile for Bitcoin expressed by its coefficient of variation is much better in Period 2 (value of 23.90) what is also far below the coefficient of variation for the whole sample (79.25). The coefficient of variation for Period 1 is highly unfavorable with a negative value of -52.96 due to the negative mean return during this subsample.

Maximum and minimum daily returns are more extreme in Subsample 2 (0.171821 and -0.46473) in comparison with Subsample 1 (0.160042 and -0.184582). Kurtosis of Bitcoin returns during Period 1 is 3.15 and during Period 2 21.69 indicating that during both periods returns are not distributed normally. Actually Period 1 and 2 return distributions are characterized by a higher than normal concentration of historic returns around their mean. Moreover, the much higher kurtosis value of Subsample 2 indicates an even stronger concentration of historic returns around their mean than in Subsample 1. Return skewness is negative in both subsamples – highly negative for Period 2 (skewness value of -1.75) and moderately negative for Period 1 (skewness value of -0.25) – indicating that most daily returns during the sample period were greater than their mean what is much more pronounced for Period 2 than for Period 1.

Test for Structural Changes in Bitcoin Price Data

As outlined in the methodology section, in order to substantiate the descriptive statistical analysis, Bitcoin market prices are econometrically analyzed searching for possibly existing structural changes using the Chow test. Table 2 presents the results of the Chow test considering monthly closing prices of Bitcoin for the period 01/2018 to 05/2022.

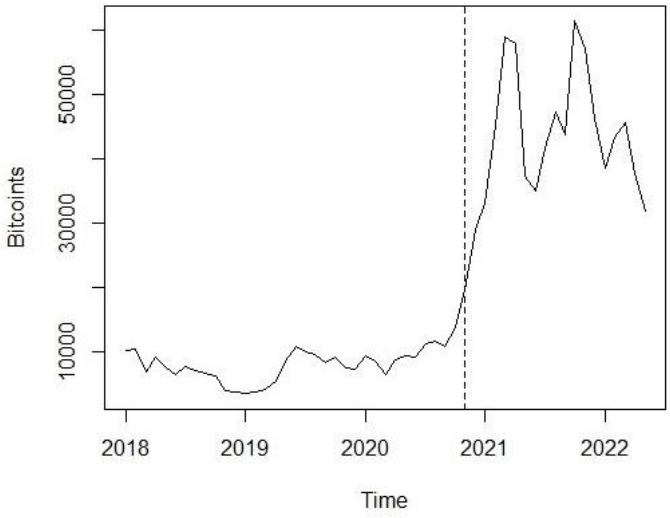
Table 2: Chow test results.

	Bitcoin
sup. F	396.22
p-value	< 2.2e-16
number of structural changes	1
breakpoint date	11/2020

Source: Authors own elaboration.

According to the results shown in Table 2, the null hypothesis can be rejected as the p-value lies far below 0.05. Hence, the alternative hypothesis is accepted, i.e. exactly one structural change in the time series of monthly Bitcoin market prices can be identified. As shown in Table 2 and Figure 3, this structural change can be dated to November 2020.

Figure 3: Structural change in monthly Bitcoin market prices.



Source: Author´s own elaboration using RStudio.

Discussion of Results

As presented in Subsection 4.1, the two analyzed subsamples – Subsample 1 (01/01/2018 – 03/10/2020) and Subsample 2 (03/11/2020 – 05/31/2022) – clearly show a fundamentally different behavior of their daily logarithmic returns. In particular, the mean return is positive for the pandemic subsample and negative for Subsample 1 – the latter mainly because of the crash of the Bitcoin Bubble of 2017 (analyzed, for instance, in Demmler and Fernández (2022)) at the beginning of the sample. Furthermore, Period 2 shows more extreme values for maximum and minimum daily return as well as kurtosis and skewness than Period 1. With respect to the risk-return profile of Bitcoin, one can clearly identify a much more favorable coefficient of variation in Period 2 in comparison to Period 1. Hence, interestingly the overall performance of Bitcoin during the pandemic subsample was much better than before it.

Analyzing the data for the beginning of the COVID-19 pandemic, one cannot identify a lasting effect on Bitcoin market prices. Although, for sure a significantly negative short-term impact is obvious as shown by the minimum daily return of -46.47% on 03/12/2020 – the day immediately after the announcement of the pandemic by the WHO on 03/11/2020. Nevertheless, in line with Chen, Liu and Zhao (2020) also we can find a relatively rapid recovery of Bitcoin prices in spring 2020 after this first immediate pandemic shock in March 2020.

Taking a longer-term perspective, as outlined by the analysis in Subsection 4.2 it took until November 2020 for a fundamental structural change to occur in Bitcoin market prices. After this structural change Bitcoin market prices clearly show a much better performance which in effect resulted in the presented much more favorable characteristics of Bitcoin´s return behavior in Period 2 in comparison with Period 1.

Our results also coincide with other studies as, for example, Cheah and Fry (2015) and Moosa (2020) who characterize Bitcoin as a highly risky asset. For all samples (whole sample, Period 1 and Period 2) we find relatively high standard deviations of returns in comparison to their means which result in high coefficients of variation in the whole sample and Period 2 and in an even negative coefficient in Period 1. Furthermore, minimum and maximum daily returns for all analyzed samples are rather extreme. Finally, our results for the Bitcoin market are also in line with Adekoya and Oliyide (2022) who find high volatility and unstable prices during the pandemic for financial markets in general.

Concluding Remarks

The research question of the present study was at follows: Which differences can be found in the data series of market prices of Bitcoin before and during the COVID-19 pandemic? In order to answer the mentioned research question, an exploratory and quantitative research design using analysis of statistical moments and econometric tests for structural changes was implemented. According to the announcement date of the global COVID-19 pandemic (03/11/2020) the whole sample of 1612 daily logarithmic returns was divided into two subsamples – Period 1 (01/01/2018 – 03/10/2020) and Period 2 (03/11/2020 – 05/31/2022).

Main results show important differences between Period 1 and Period 2 with respect to mean returns, coefficients of variation, maximum and minimum daily returns as well as kurtosis and skewness. Surprisingly, Bitcoin´s performance was more favorable during the pandemic subsample in comparison to before the pandemic (Period 1). Nevertheless, besides a short-term impact of the beginning pandemic in mid-March 2020, Bitcoin´s market prices started to recover rapidly afterwards in spring 2020. According to the results of the Chow test, there exists one structural change in Bitcoin´s market price time series in November 2020. Especially after this breakpoint Bitcoin´s performance characteristics changed significantly and the cryptocurrency reached new historic heights, but also entered a prolonged episode of continuous boom and bust cycles.

The principal results of the present paper are also in line with other studies which characterize Bitcoin as a highly risky investment vehicle and identify high volatility measures and unstable prices during the pandemic for financial markets in general. One could derive several new fields of research

for future studies. For example, one can think of the inclusion of other cryptocurrencies in order to have a more widespread picture of the cryptocurrency market in general.

References

Abrar, W. (2014). Untraceable electronic cash with Digicash. *Network and Communication Privacy SS*, (June), 2–5. https://doi.org/10.13140/RG.2.1.1900.3040

Adekoya, O. B., & Oliyide, J. A. (2022). Commodity and financial markets' fear before and during COVID-19 pandemic: Persistence and causality analyses. *Resources Policy*, *76*(August 2020), 102598. https://doi.org/10.1016/j.resourpol.2022.102598

Dai, W. (1998). b-money.

Deev, O., & Plíhal, T. (2022). How to calm down the markets? The effects of COVID-19 economic policy responses on financial market uncertainty. *Research in International Business and Finance*, *60*(18). https://doi.org/10.1016/j.ribaf.2022.101613

Delahaye, J.-P. (2016). Cryptocurrencies and Blockchains. *Inference: International Review of Science*, *2*(4). https://doi.org/10.37282/991819.16.38

Law, L., Sabett, S., & Solinas, J. (1996). How To Make a Mint: the Cryptography of Anonymous Electronic Cash. *The American University Law Review*, *46*(4), 1131–1162. Retrieved from http://digitalcommons.wcl.american.edu/cgi/viewcontent.cgi?article=1389&context=aulr

Matos, Ia. (2018). *Análisis De Las Criptomonedas En La Economia Actual*. ICAI.

Nakamoto, S. (2008). Bitcoin: A peer-to-peer electronic cash system. *Transforming Government: People, Process and Policy*. https://doi.org/10.1108/TG-06-2020-0114

Samitas, A., Kampouris, E., & Polyzos, S. (2022). Covid-19 pandemic and spillover effects in stock markets: A financial network approach. *International Review of Financial Analysis*, *80*(October 2021), 102005. https://doi.org/10.1016/j.irfa.2021.102005

Velde, F. (1998). Lessons from the history of money. *Economic Perspectives*, *32*(1), 17–25. https://doi.org/10.20506/rst.32.1.2181

Shehzad, K., Xiaoxing, L., & Kazouz, H. (2020). COVID-19's disasters are perilous than Global Financial Crisis: A rumor or fact? *Finance Research Letters, 36*. DOI: https://doi.org/10.1016/j.frl.2020.101669

WHO (2020). *WHO Director-General's opening remarks at the media briefing on COVID-19* - 11 March 2020. Retrieved on 06/09/2022 from: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

yahoo!finance (2022). *Bitcoin USD* (BTC-USD). Retrieved on 06/09/2022 from: https://finance.yahoo.com/quote/BTC-USD/history?p=BTC-USD