risks

MDPI

Article

The Effect of COVID-19 Transmission on Cryptocurrencies

Nesrine Dardouri [1], Abdelkader Aguir [2,*] and Mounir Smida [1]

[1] MOFID LAB, Faculty of Economics and Management of Sousse, University of Sousse, Sousse 4000, Tunisia; nesrine.dardouri91@gmail.com (N.D.)
[2] Groupe ESPI, Laboratoire ESPI2R, 92300 Paris, France
* Correspondence: a.aguir@groupe-espi.fr

Abstract: In recent years, Bitcoin and other cryptocurrencies like Ethereum and Dogecoin have emerged as important asset classes in general, and diversification and hedging instruments in particular. The recent COVID-19 pandemic has provided the chance to examine and assess cryptocurrencies' behavior during extremely stressful times. The methodology of this study is based on an estimate using the ARDL model from 22 January 2020 to 12 March 2021, allowing us to analyze the long-term and short-term relationship between cryptocurrencies and COVID-19. Our results demonstrate that there is cointegration between the chosen cryptocurrencies in the market and COVID-19. The results indicate that Bitcoin, ETH, and DOGE prices were affected by COVID-19, which means that the pandemic seriously affected the three cryptocurrency prices.

Keywords: COVID-19; coronavirus; cryptocurrency; price volatility; liquidity

1. Introduction

Global crises have a direct and strong effect on financial markets. Climate disasters, political upheaval, epidemics, and military conflicts can endanger our lives, infrastructure, health, and international relations. These radical changes constitute an international danger for the economy and companies. They are a source of great uncertainty that threatens investments in the financial markets. Sadly, the 2019 coronavirus pandemic fits this image because of the frustration of the global economy and warnings about the stock markets. A 30% share was quickly lost by the Canadian and US stock markets, wiping out several gains made over the past decade. A considerable number of research studies have revealed why the COVID-19 pandemic plunged the financial markets into a whirlwind, why this crisis is unique, and how business leaders and governors can support the economy during this particularly busy time. During a time of bleak growth prospects, low inflation, and low interest rates, the pandemic had significant effects. The coronavirus pandemic and its associated measures, such as social distancing and confinement, were not without drawbacks in the economic sphere. In fact, they generated a decline in production, a reduction in tax revenues, an increase in expenditure, and enhanced assistance to the most affected families and businesses to cover them against unemployment, bankruptcy, and loss of income. This led to both a deterioration in the budget balance of most countries and an increase in the public debt ratio for others, as confirmed by the IMF (2020) in its report related to COVID-19's effects on global public finances, published in April 2020.

According to a World Bank report published in 2020, the coronavirus pandemic destabilized the world economy, causing a recession resulting from the activity decline noticed in the first quarter of 2020 in China, which was expected to cover other affected countries, namely the United States and the Eurozone. We have also witnessed a reduction in commodity prices, especially the prices of petroleum and industrial metals, as well as global extreme volatility in the stock markets due to uncertainty over time and the possible future consequences of this pandemic, not to mention the devaluation of currencies in

check for updates

Citation: Dardouri, Nesrine, Abdelkader Aguir, and Mounir Smida. 2023. The Effect of COVID-19 Transmission on Cryptocurrencies. *Risks* 11: 139. https://doi.org/10.3390/risks11080139

Academic Editor: Mogens Steffensen

Received: 15 March 2023
Revised: 6 June 2023
Accepted: 10 July 2023
Published: 27 July 2023

emerging and developing economies, such as the outflow of capital from these economies exceeding those of the 2008 financial crisis.

Since we are interested in financial market instability, the IMF (2020) noted in its Global Financial Stability Report that the global financial markets were significantly affected by the coronavirus pandemic, causing a sharp decline in stock prices, a widening of credit spreads in the markets, and a lowering of oil prices as well as bond yields. The widened divergence in asset prices quickly led to the tightening of financial conditions. There were short-term financial pressures in the core funding markets and a sharp deterioration in market liquidity. Regarding the consequences of the health crisis on the banking and financial system, several researchers, such as Aguir (2018), Beck (2020), Corbet et al. (2022), Boone (2020), and Ashraf (2020), emphasize financial instability over time in the absence of appropriate response measures, which include the apparent absence of sincere communication from authorities on the pandemic; a lack of liquidity; a lack of assistance for companies and families at risk; a lack of communication between supervisory bodies and banks; inadequate response measures; solvency problems for companies, households, and banks, leading to an increase in non-performing loans; fears of contagion effects after interbank interconnection, uncertainty, and mismanagement of credit risk; and a lack of international cooperation for national regulations.

The coronavirus destabilized China and the world, leading to a deterioration in the balance of payments, which, in turn, decreased foreign exchange reserves and increased consumption and inflation. However, a decline in exports was recorded with a fall in the global demand for minerals and commodity prices, which reduced public revenue and increased the public deficit as public spending increased. All of this translates into a spike in inflation, fueling uncertainty and instability. As a result, family well-being deteriorates, economic activity contracts, and unemployment increases.

Given the multisectoral impacts of this crisis, McKibbin and Fernando (2021) noted that the COVID-19 shock required the mobilization of monetary, fiscal, and health policies in order to support demand, household production, and vulnerability. Thus, to promote the negative socio-economic state of the banking and financial sector during the health crisis, response measures were proposed by several researchers, such as Cochrane (2020), Beck (2020), and Boone (2020). The proposed response measures are containment and social distancing, providing liquidity to the financial system to keep pace with budgetary constraints and credit support for the economy, budgetary support for employees added to households and businesses that have difficulties in repaying loans or financing their operations, resorting to loan restructuring for families and businesses that have the financial capacity and difficulty in repaying loans, the honesty of communication from authorities concerning the pandemic, the free movement of goods and capital in regional economic groupings, the transparency and regularity of speaking with the monetary and regulatory authorities, the international cooperation of national regulators, and finally, financially supporting the countries hit hardest in the international community. Some analysts are not in favor of easing monetary policies at the moment. For example, the FED should not lower its key rate when stores are closed, which is considered a solution to a fundamental problem according to the study proposed by Cochrane (2020). This study first discusses all the COVID-19 pandemic characteristics around the world in Section 1. In fact, we present the extent of this form of money as well as a theoretical literature review. We address the relationship between virtual currency and health crises based on the different perspectives of economic thought. We briefly present, in the beginning, the effects on the financial market based on the social effects of the health crisis on cryptocurrencies. The rest of this paper is structured as follows. Section 2 analyzes cryptocurrencies and COVID-19. Section 3 introduces the data used to empirically study the period from 2020 to 2021. Our main empirical results are presented in Section 4. In Section 5, we have analyzed the results. We have then examined the various updates of the research work before ending with the conclusion.

2. COVID-19 and Cryptocurrencies

The COVID-19 pandemic has moderately spread around the world, causing economic recession and imposing heavy economic penalties on the economy. However, effective action to combat this pandemic by determining the socioeconomic factors that can generate significant benefits for global economic development can prevent losses resulting from reduced trade and FDI tourism flows that undermine long-term economic growth (Aysan et al. 2020).

The world is facing the threats of COVID-19, which are breaking down and destroying the economy via various channels. Demir et al. (2020), Zaremba et al. (2020), and Kristoufek (2020) explore the volatility relationship between "Bitcoin" and the Chinese stock markets. This relationship has considerably tightened during COVID-19.

The recent COVID-19 pandemic has acted as a rigorous stress test for global markets (Iqbal et al. 2021). Not only has this pandemic caused significant disruptions in equity and commodity markets worldwide, leading to negative returns, but it has also introduced a higher level of uncertainty and volatility, affecting the cryptocurrency markets as well. This contagion has created a unique situation, which is difficult to explain in modern financial history (Baker et al. 2020; Khan et al. 2023). It is notable that any period of financial stress can have a ripple effect on cryptocurrency markets. Recent research indicates that the transmission of stress occurs from traditional to crypto markets, which causes investors to avoid crypto assets during financial crises (Matkovskyy and Jalan 2019). This is primarily due to the significant changes in the distribution of cryptocurrency returns, particularly for Bitcoin, as demonstrated by the copula-based quantile models (Bouri et al. 2018). Furthermore, a study conducted on a diverse sample of 30 different indices and 973 cryptocurrencies revealed that cryptocurrencies' safe haven characteristic is contingent upon both the specific market and region. Additionally, their capacity to hedge against market risks is found to be quite limited (Wang et al. 2020). Since the early days of the pandemic, Bitcoin has shown a strong correlation with stock markets and lost value with other financial markets as a result of a lack of demand for risky assets, i.e., a lack of demand in an undetermined situation (Borgards and Czudaj 2020). Still, some studies found that cryptocurrencies do not behave like traditional assets, including stocks, commodities, and currencies. Hence, investors' enthusiasm is driven by news and extreme events, which causes cryptocurrency returns to increase (Liu and Tsyvinski 2018; Rognone et al. 2020). After encountering contrasting findings regarding the behavior of cryptocurrencies, it becomes intriguing to scrutinize the efficacy of these assets amidst the recent pandemic—a highly exceptional occurrence distinguished by unparalleled attributes. Several scholars have endeavored to chronicle the ramifications of this global health crisis, shedding light on its implications for cryptocurrencies on the yields of Bitcoin. They discovered that its performance was lackluster in such circumstances and demonstrated a significant correlation with stock markets (Conlon and McGee 2020). A few researchers have even drawn comparisons between Bitcoin and gold, reaching the conclusion that Bitcoin does not live up to its reputation as "digital gold" (Conlon and McGee 2020). Gold, once again, has proven its superiority as a natural hedge against market catastrophes similar to the current pandemic. Certain rational voices have advised individuals to temper their expectations regarding Bitcoin's capabilities, considering it to be more of a hedge against fiat currency rather than a safeguard against significant market downturns and failures, as highlighted in a recent study by Ali (2020). In the face of adversity, Bitcoin seems to be receiving widespread criticism, as it is considered to be a total failure in the recent market turmoil. Only a few, if any, paid attention to the fact that a detailed analysis of the situation is not symmetrical; rather, only specific market conditions related to S&P and Bitcoin mounts are rented from co-movements (Bouri et al. 2017). Likewise, another study reported that nonlinear methodologies more effectively extract the asymmetric impact of negative and positive news in relation to cryptocurrency markets (Bouri et al. 2018; Katsiampa et al. 2019).

Volatility presents distinct asymmetry in comparison to the equity markets, showing a greater sensitivity to negative shocks compared to positive shocks induced by noisy traders (Baur and Dimpfl 2018) in the cryptocurrency market. Bouri et al. (2018) suggest using non-linear and non-traditional techniques to study Bitcoin behavior in order to unravel its hidden patterns and characteristics. Using such a literature guide, it is necessary to determine whether the recent COVID-19 outbreak has an asymmetric impact on the returns of major cryptocurrencies. For example, large and small increases in the pandemic severity can differently affect the cryptocurrency market not only in its entirety but also in the case of bullish and bearish scenarios.

3. Review of Empirical Literature

Since 1870, the COVID-19 outbreak has caused epidemic stagnation with an alarming speed for the global economy (IMF 2020). The impact on the global economy, finance, and the commodities market has led to a severe global economic crisis (Ahmed and Sarkodie 2021). Amidst the global health crisis caused by the COVID-19 pandemic, many nations implemented various measures in order to mitigate viral transmission. These particular measures encompassed social distancing protocols, travel restrictions, and the enforcement of lockdown policies (Sarkodie and Owusu 2021). Implementing these containment measures has deeply impacted the already fragile global economy, surpassing the repercussions of the 2008 financial crisis and leading to the deepest recession ever since World War II (World Bank 2020). Notably, emerging and developing markets are anticipated to face more severe defaults compared to their developed counterparts due to the financial strains resulting from the COVID-19 pandemic (IMF 2020). Consequently, the pandemic is supposed to leave enduring effects on human capital, global value chain systems, and investor and consumer confidence. Even if the COVID-19 epidemic is brought under control, a swift restoration of global economic activities to their previous state is unlikely (Cavus et al. 2021). Hence, it is imperative to continue implementing effective strategies to restrict the spread of viruses until universal access to vaccines is achieved, thereby ensuring collective immunity among populations. One cryptocurrency that has gained substantial popularity is Bitcoin, known for its innovative characteristics such as simplicity and transparency, as demonstrated by its peer-to-peer electronic payment system (Nakamoto 2008). Previous research on cryptocurrencies, particularly Bitcoin, predominantly focused on specific aspects such as security, legality, and technical considerations (Barber et al. 2012). Notably, during the COVID-19 pandemic, Bitcoin experienced a significant surge, with a 300% increase in value in 2020, fueled by speculation in financial markets and investors' search for alternative assets due to low market interest rates (Bloomberg 2021).

The bullish gains were influenced, in part, by financial markets where investors considered using Bitcoin in order to hedge against the recent inflation caused by the global pandemic, despite the fair stability in some countries such as the United States. It has always been said that the printing of money by the central bank will lead to inflation or depreciation of the currency over time.

However, existing studies suggest considering Bitcoin as an asset according to an efficient market hypothesis (Jakub 2015).

The COVID-19 outbreak is said to have affected cryptocurrencies' efficiency, particularly Ethereum and Bitcoin. However, it recovered more quickly in late March 2020 (Naeem et al. 2021). In fact, Bitcoin's average monthly volatility was higher than that of gold (Dwyer 2015).

Evidence from GARCH and EGARCH models reveals that Bitcoin volatility is too unstable in speculative periods, whereas S&P 500 and the fear index (VIX) influence its volatility in stable periods (López-Cabarcos et al. 2021).

The safe haven effect of cryptocurrencies triggers upside volatility during the uncertainty caused by a pandemic (Bouoiyour and Selmi 2020). Therefore, cryptocurrencies can be used by investors in the case of diversifying portfolio assets (Briere et al. 2015).

Unlike the existing literature, Ofori et al. (2021) assessed the effect of COVID-19 health outcomes on the price volatility of the cryptocurrency market in their study. They proved the role of COVID-19 as an indicator of economic uncertainty affecting market signals.

In addition, they explored the structural effects of the global pandemic on cryptocurrencies by examining their predictive power.

Cryptocurrencies, in particular, the top five in terms of capitalization, including Bitcoin (BTC-USD), Ethereum (ETH-USD), XRP (XRP-USD), Bitcoin Cash (BCH-USD), and Cardano (ADA-USD), have captured the researchers' attention. Furthermore, the financial literature examines them in terms of efficiency, hedging properties, performance, and relationships with traditional financial assets.

Bitcoin is considered the first cryptocurrency distributed in cutting-edge blockchain system technology. Due to this, more than two thousand cryptocurrencies adhere to Bitcoin. They are continuously traded on stock markets 24 h a day and 7 days a week. For example, "Ethereum" is a global platform that expands its source to the extent that investors can run their smart contracts for decentralized applications.

Even the "Ripple" system, based on a central structure, aims to network among international financial institutions to reduce their transaction costs and accelerate global payments.

Following the unexpected increase in Bitcoin prices since 2017, people have shown great interest in cryptocurrencies, causing their rapid growth. These attempts have encouraged investors, researchers, crowdfunding managers, and portfolio managers to assess both short- and long-term relationships between different cryptocurrencies in the stock market.

Several research studies were conducted to investigate the price bubbles in cryptocurrencies in general and Bitcoin in particular, in addition to trading strategies and opportunities, such as the studies of Giudici and Pagnottoni (2019) and Agosto and Cafferata (2020).

Finally, investors focus on Bitcoin when creating their investment strategies. This is because it can provide long-term resilience and sustainability against geopolitical risks due to the trend and long-term relationship between Bitcoin and COVID-19.

Likewise, soon after the COVID-19 outbreak, a lot of studies exploring the impact of the recent pandemic on cryptocurrencies emerged. Opting for a two-point value at risk, Conlon and McGee (2020) showed that Bitcoin does not act as a safe haven and moves similarly to the S&P 500 stock index. When the "Bitcoin" cryptocurrency is included along with the S&P 500 in the portfolio, the risk of a dramatically falling portfolio increases and the gains continuously increase.

Therefore, the ability of Bitcoin to shelter itself from turbulence is suspected. After the outbreak of the COVID-19 pandemic, Corbet et al. (2022) documented sharp short-term dynamic correlations between 'Bitcoin' and Chinese stock markets. However, Conlon and McGee (2020) also focused on Bitcoin, "Ethereum", and "Tether" properties during the pandemic from a global stock investors' perspective. They showed that "Bitcoin" and "Ethereum" cannot be a safe bet because of the increased downside risk when including these cryptocurrencies in wallets. However, "Tether," the anchor to the US dollar, serves as a cover during COVID-19. In addition, according to Kristoufek (2020), the COVID-19 pandemic provided an opportunity to test Bitcoin's value. Using the quantile correlations of Bitcoin and the S&P 500 index during the pandemic, it was noticed that the history of Bitcoin's value is not as accurate as that of gold, which is considered to have a much higher value. In this context, Lahmiri and Bekiros (2020) compared cryptocurrency behavior with international stock markets during COVID-19.

4. Description of Variables and Estimation Method

This study is based on daily data for the period from 2020 to 2021. The total cases under the USA index are accessible from the data.europa.eu database. This index measures the number of daily cases of COVID-19 in the United States as well as the number of deaths and "stringency-index". We use the daily US historical closing prices of cryptocurrencies, such as Bitcoin (BTC), Ethereum (ETH), and Dogecoin (DOGE) extracted from the CoinDesk database.

In this study, we used a methodology based on an estimate using the ARDL (autoregressive distributed lags) model. It allows analyzing both the long-term and short-term relationships between cryptocurrencies and COVID-19 with both integrated order (0) and order (1) variables (Dardouri et al. 2023).

The existence of a cointegration relationship among the variables of an econometric model was tested using the delayed cointegration test (Dardouri et al. 2023; Pesaran et al. 1999, 2001). This choice was motivated by the fact that it offered the advantage of being more effective for studies with small sample sizes. Unlike traditional cointegration tests, such as the Engle and Granger (1987) test, the Johansen (1988) test, and the Johansen and Juselius (1990) test. However, this technique is applicable when the order of integration of the series exceeds 1. Furthermore, this method is also beneficial because of its ability to estimate both long-term and short-term dynamics within the same econometric model. The ARDL specification employed for analyzing the relationship between cryptocurrencies and COVID-19 is represented by Equation (1):

$$\begin{gathered}\Delta cryptocurrencies_t = \alpha_0 + \sum_{i=0}^{p} \alpha_{1i} \Delta cryptocurrencies_{t-i} + \sum_{i=0}^{q} \alpha_{2i} \Delta Total- \\ cases - covid_{t-i} + \sum_{i=0}^{q} \alpha_{3i} \Delta death_{t-i} + \sum_{i=0}^{q} \alpha_{4i} \Delta stringency - index_{t-i} + \\ \beta_1 cryptocurrencies_{t-1} + \beta_2 total - cases - covid_{t-1} + \beta_3 \mathrm{Death}_{t-1} + \\ \beta_4 stringency - index_{t-1} + \varepsilon_t\end{gathered} \tag{1}$$

However, the dependent variable with its long-term equilibrium level may not immediately follow any change in one of its determinants. Thus, the speed of adjustment between the long- and short-term levels of the dependent variables can be captured by estimating the following error correction model:

$$\begin{gathered}\Delta cryptocurrencies_t = \alpha_0 + \sum_{i=0}^{p} \alpha_{1i} \Delta cryptocurrencies_{t-i} + \\ \sum_{i=0}^{q} \alpha_{2i} \Delta Total - cases - covid_{t-i} + \sum_{i=0}^{q} \alpha_{3i} \Delta \mathrm{Death}_{t-i} + \\ \sum_{i=0}^{q} \alpha_{4i} \Delta stringency - index_{t-i} + \theta \mu_{t-1} + \varepsilon_t\end{gathered} \tag{2}$$

where Δ is the first difference operator that represents the error correction term (ECT) of our model. The ECT measures the adjustment speed of the imbalance between the short- and long-term dependent variables. We assumed that the ECT has a negative and significant sign (Gujarati 2022). In order to verify the cointegration relationship, each variable integration order must be established. Hence, the Phillips–Perron test (PP) and the structural break test (breakpoint test), which are commonly utilized unit root tests for assessing and confirming the integration order of the series, are used. In fact, these tests are more specifically conducted with various specifications in order to ascertain whether the series is stationary at the level or in differences. The null hypothesis for the latter is non-stationarity, whereas the alternative hypothesis suggests stationarity. Subsequently, we need to examine the presence of a cointegration relationship. However, our primary focus is on the terminal cointegration test, primarily relying on the Wald statistic F. The null hypothesis of this test confirms that no cointegrating relationship exists. The Bounds test involves two steps as follows: first, estimating the model (1) using ordinary least squares (OLS), and then assessing the joint nullity of the long-term multipliers using the F-test (Dardouri et al. 2023). So, the following two hypotheses are proposed:

H0: $\alpha 1 = \alpha 2 = \alpha 3 = \alpha 4 = 0$.

Against the alternative hypothesis

H1: $\alpha 1 \neq \alpha 2 \neq \alpha 3 \neq \alpha 4 \neq 0$.

Lastly, the final step involves comparing the calculated F-statistic with the critical value. In fact, for a given significance level, Pesaran et al. (2001) provided two sets of critical values. The first set is calculated by assuming that all variables included in the ARDL model are integrated of order zero, I(0). The second set, however, is calculated by assuming that the variables are integrated of order I(1). If the calculated F-statistic exceeds the upper critical limit, non-cointegration can be rejected, indicating the presence of a cointegration relationship. If the calculated F-statistic is lower than the lower critical value, we cannot reject the null hypothesis of non-cointegration. In case the test statistic falls between the bounds, a conclusive inference cannot be made without knowing the order of the underlying regressor integration. Once estimated, the cointegration equations are utilized for calculating the long-run elasticities. If a cointegrating relationship is not detected, the short-term causal relationship is examined. After specifying our model, we proceeded with several specification tests, including: (i) the Jarque–Bera normality test to assess the normality of the residuals, (ii) the Breusch–Godfrey LM test to examine the series correlation, (iii) the ARCH test to evaluate heteroscedasticity, and (iv) the RESET test to check the model specification by examining the regression error. The results of these tests are presented and discussed in the following section.

5. Results and Discussions

Before analyzing these variables using the ARDL approach proposed by Pesaran et al. (2001), we used unit root tests to assess the variable integration order. All the variables are described in Table 1. Table 2 shows that all the variables integrated are of order 2 I(2), except the stationary "stringency-index" variable at level I(0). In fact, these results confirm that all the variables have an order of integration lower than 2.

Table 1. Variable descriptions.

Variables	Symbols	Definitions	Sources
Bitcoin	BTC	It is a cryptocurrency, a virtual currency designed to act as money and a form of payment outside the control of any one person, group, or entity.	CoinDesk Database
Ethereum	ETH	It is an open-source, distributed software based on blockchain technology. It has its own native cryptocurrency.	CoinDesk Database
Dogecoin	DOGE	It is a peer-to-peer, open-source cryptocurrency categorized as an altcoin.	CoinDesk Database
Total cases covid	Total-_cases_covid	The number of confirmed COVID-19 cases per day.	Data.europa.eu (accessed on 14 March 2023)
Death	death	COVID-19 deaths include people who had a positive molecular for COVID-19, who died without fully recovering from COVID-19, and who had no alternative cause of death identified.	Data.europa.eu (accessed on 14 March 2023)
Stringency index	Stringency_index	It is a composite measure based on nine response indicators including school closures, workplace closures, and travel bans.	Data.europa.eu (accessed on 14 March 2023)

The results of the stationarity tests lead us to study the relationship between COVID-19 and cryptocurrencies by applying cointegration tests related to the ARDL approach. The Bounds test requires the appropriate degree selection of delay (Feridun and Shahbaz 2010), which is the AIC criterion in our case. The test results are shown in Table 3.

Table 2. Stationarity tests.

Variables	PP Test		Breakpoint Test	
	In Level	**First Difference**	**In Level**	**First Difference**
stringency_index	−3.010 ** [0.0347]	−20.09 * [0.0000]	−9.13 ** (10 March 2020)	−17.29 ** (2 February 2020)
total_cases_usa	4.58 [1.000]	−3.01 ** [0.0345]	−3.06 (18 October 2020)	−12.88 ** (10 February 2020)
Death	2.79 [1.000]	−9.68 * [0.000]	−4.13 (10 September 2020)	−6.98 ** (2 October 2020)
Bitcoin	−2.72 [1.000]	−20.98 * [0.0000]	−1.46 (16 December 2020)	−22.46 ** (22 January 2021)
ETH	1.38 [0.9990]	−21.27 * [0.0000]	−3.20 (2 January 2020)	−22.78 ** (22 January 2020)
DOGE	−0.45 [0.8970]	−22.14 * [0.0000]	−12.20 (28 January 2021)	−22.10 *** (9 February 2020)

The optimal number of delays for the ADF tests is determined using SC, whereas the bandwidth parameter is used for the PP tests. The critical values for both the ADF and PP tests were provided by MacKinnon (1996). The delay levels, represented by the figures within brackets, are chosen based on the Schwarz information criterion. The figures enclosed in square brackets indicate the automatically selected Newey–West bandwidth using the Bartlett kernel. It is worth mentioning that only the constant term is considered in these tests. Significance levels, denoted by (*), (**), and (***) correspond to statistical significance at the 1%, 5%, and 10% thresholds, respectively.

Table 3. Bounds test results.

Dependent Variable	Lag Selection	F-Statistics	Decision
Bitcoin	(12,0,5,1)	8.201329	cointegration
ETH	(11,0,11,12)	7.994581	cointegration
DOGE	(12,0,7,0)	9.326993	cointegration
Significance	I0 Bound	I1 Bound	
10%	2.37	3.2	
5%	2.79	3.67	
2.5%	3.15	4.08	
1%	3.65	4.66	

The results show that the statistical F calculated for the two models is always greater than the critical value calculated by Pesaran et al. (2001) at the 1% threshold. This confirms the existence of at least one long-term relationship between the variables in the United States for the study period, which brings us back to estimating Equation (1) using the ARDL technique.

The estimation results are shown in Table 4.

Table 4. Long-term relationships.

Variable	Bitcoin			ETH			DOGE		
	Coefficient	**T-Ratio**	**Prob.**	**Coefficient**	**T-Ratio**	**Prob.**	**Coefficient**	**T-Ratio**	**Prob.**
stringency_index	117.05	3.25	0.0012	3.84	3.5	0.0005	0.000185	2.46	0.0144
total_cases_usa	0.003	9.48	0	0.0001	10.5	0	2.27	5.95	0
Death	−0.11	−5.06	0	−0.003	−4.81	0	−1.28	4.37	0.0036
C	8972.022	7.19	0	230.1634	6.97	0	0.000815	0.3	0.7641

The ARDL cointegration method has many advantages over other cointegration methods due to its suitability for analyzing variables of different orders. It is also a more efficient estimator for small samples (Pesaran et al. 2001). The ARDL model estimates for each cryptocurrency are presented in Table 4. For Bitcoin, the long-term dynamics indicate that the cases of COVID-19, as well as the severity index measuring the strict policy in a country, affect BTC. The signs are positive and significant. For ETH and DOGE, the signs of the coefficients are similar to those of BTC. There is a negative interaction between cryptocurrency and the number of deaths. However, three negative relationships were found, indicating that the three cryptocurrencies used in the study are influenced by fluctuations in deaths. The diagnostic test results are shown in Table 5.

Table 5. Diagnostic test results.

	Bitcoin	ETH	DOGE
	LM Version	**LM Version**	**LM Version**
χ^2 (serial correlation) [1]	0.306310 [0.7363]	0.91514 [0.339]	3.566488 [0.0292]
χ^2 (functional form) [2]	2.196762 [0.1391]	0.0063429 [0.937]	12.18248 [0.0005]
χ^2 (normality) [3]	1709,535 [0.0000]	0.34375 [0.842]	35,592.36 [0.0000]

[1] The Breusch–Godfrey LM test statistic for no serial correlation; [2] White′s test statistic for homoscedasticity; [3] The Jarque–Bera statistic for normality.

To validate the model, several econometric tests need to be conducted on the residuals. The diagnostic test results for the three chosen ARDL models are presented in Table 4. The normality of the distribution is confirmed using the Jarque–Béra test. Additionally, the absence of residual correlation is indicated by the results of the Breusch-Godfrey Lgrage multiply test, and the absence of heteroskedasticity is demonstrated by the Breusch–Pagan–Godfrey test. Furthermore, the Ramsey Reset test confirms the linear specification of our model. The Granger causality test results are shown in Table 6.

Table 6. Granger causality tests.

Null Hypothesis	Results
Total_Cases_USA does not Granger-cause Bitcoin	0.0153 **
Total_Cases_USA does not Granger-cause ETH	0.0003 *
Death does not Granger-cause ETH	0.0224 **
Death does not Granger-cause DOGE	0.0085 *
Total_Cases_USA does not Granger-cause DOGE	0.0002 ***

Significance levels denoted by (*), (**), and (***) correspond to statistical significance at the 1%, 5%, and 10% thresholds, respectively.

The causality test in the sense of Granger shows that the cases of COVID-19 affect the three cryptocurrencies studied in this work, while the deaths cause only ETH and DOGE.

6. Conclusions

Over the past years, the global COVID-19 pandemic and the sharp rise in Bitcoin prices have greatly influenced the financial market. Such influences include, but are not limited to, trading strategies between different cryptocurrencies, portfolio diversification, forex markets, and macroeconomic policy. The financial and commodity markets around the world plummeted because of the global COVID-19 outbreak. The total number of confirmed cases and deaths reached a staggering 8,546,919 and 456,726 (20 June 2010, 1815 p.m. Beijing time), respectively. The Dow Jones and S&P 500 suffered as much as a 30% drop in value, recording the worst daily decline in their history in March 2020. In addition, markets in Asia, Europe, the UK, and Australia also recorded similar results, according to a study by Aysan et al. (2021). Due to the volatile structure of cryptocurrencies in the stock market, investors and portfolio managers periodically ask for shocks that can change the degrees across cryptocurrencies based on the co-movement of their price returns (Aysan et al. 2021). Findings about the volatility causes and co-movement directions in the market by explicit factors can be difficult to measure from time to time because of the precarious cyclical circumstances throughout the system. This study has analyzed the cointegration of major cryptocurrencies based on daily prices in the crypto market using the ARDL model. The chosen cryptocurrencies were "Bitcoin, Ethereum, and Dogecoin". The datasets were taken from coinmarketcap (2020) from 22 January 2020 to 12 March 2021. The result of this model demonstrates that there is a cointegration between the chosen cryptocurrencies and COVID-19 in the market. Before performing the estimate, we applied two distinct unit root tests to determine the stationarity of the three cryptocurrencies and the COVID-19 variables. Then, before moving on to the cointegration test to test the existence of a long-term relationship between the three series of cryptocurrency prices and COVID-19, we checked the appropriate order of delays. After choosing the optimal shift order, the cointegration test was carried out at the terminals. In addition, a staggered autoregressive lagging model (ARDL) was used to investigate the long-term cointegration relationship between the variables. The results indicate that Bitcoin, ETH, and DOGE prices have been affected by the COVID-19 pandemic. This implies that the pandemic has seriously affected all three cryptocurrency prices.

This paper analyzed the impact of the COVID-19 pandemic on the cryptocurrency market, focusing on the market value, network value, realized value, and trading signals. Our study found that cryptocurrencies, particularly Bitcoin and alternative coins, exhibit a changing average price over time, indicating a non-stationary process. On the other hand, the health outcomes of COVID-19 display a weakly dependent process, suggesting a long-term reproductive effect with increased reported cases and deaths. When COVID-19 cases and deaths increased by 3.77% and 3.65% daily, we noticed an average daily market price increase of 0.58% for Ethereum, 0.44% for Bitcoin, 0.36% for Litecoin, and 0.15% for Bitcoin Cash. The analysis of different cryptocurrencies revealed their relationship with the COVID-19 pandemic. Positive market signals contribute to maximizing market prices, whereas negative market signals and unobserved common factors can lead to market price recessions. To mitigate risks during price recessions, investors should diversify their investments rather than sell all cryptocurrencies. This diversification strategy can generate higher dividends during the rebound effect triggered by positive market signals. Future research could concentrate on examining the effects of shocks similar to COVID-19 by comparing them to previous shocks. Investors and portfolio managers actively investing in financial assets will find our observations particularly valuable. Our findings provide insights for regulators and investors regarding risk management and optimal asset allocations. Additionally, authorities should closely monitor the evolution of financial assets and exercise caution to prevent the negative repercussions of infectious shocks.

Author Contributions: Conceptualization, N.D. and A.A.; methodology, N.D.; software, N.D.; validation, N.D. and A.A.; analysis, N.D. and A.A.; resources, N.D. and A.A.; writing—original draft, N.D. and A.A.; writing—review and editing, N.D. and A.A.; visualization, N.D. and A.A.; supervision, N.D. and A.A.; project administration, N.D., A.A. and M.S.; funding acquisition, A.A. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflict of interest.

References

Agosto, Arianna, and Alessia Cafferata. 2020. Financial bubbles: A study of co-explosivity in the cryptocurrency market. *Risks* 8: 34. [CrossRef]

Aguir, Abdelkader. 2018. Central bank credibility, independence, and monetary policy. *Journal of Central Banking Theory and Practice* 7: 91–110. [CrossRef]

Ahmed, Maruf Yakubu, and Samuel Asumadu Sarkodie. 2021. Counterfactual shock in energy commodities affects stock market dynamics: Evidence from the United States. *Resources Policy* 72: 102083. [CrossRef]

Ali, Inayat. 2020. COVID-19: Are we ready for the second wave? *Disaster Medicine and Public Health Preparedness* 14: e16–e18. [CrossRef]

Ashraf, Badar Nadeem. 2020. Stock markets' reaction to COVID-19: Cases or fatalities? *Research in International Business and Finance* 54: 101249. [CrossRef]

Aysan, Ahmet Faruk, Asad Ul Islam Khan, and Humeyra Topuz. 2021. Bitcoin and altcoins price dependency: Resilience and portfolio allocation in COVID-19 outbreak. *Risks* 9: 74. [CrossRef]

Aysan, Ahmet, Farrukh Kayani, and Umar Nawaz Kayani. 2020. The Chinese inward FDI and economic prospects amid COVID-19 crisis. *Pakistan Journal of Commerce and Social Sciences* 14: 1088–105.

Baker, Scott R., Nicholas Bloom, Steven J. Davis, and Stephen J. Terry. 2020. *Covid-Induced Economic Uncertainty*. Cambridge, MA: National Bureau of Economic Research.

Barber, Simon, Xavier Boyen, Elaine Shi, and Ersin Uzun. 2012. Bitter to better—How to make bitcoin a better currency. In *Financial Cryptography and Data Security: 16th International Conference, FC 2012, Kralendijk, Bonaire, Februray 27–March 2, 2012, Revised Selected Papers 16*. Berlin/Heidelberg: Springer, pp. 399–414.

Baur, Dirk G., and Thomas Dimpfl. 2018. Asymmetric volatility in cryptocurrencies. *Economics Letters* 173: 148–51. [CrossRef]

Beck, Thorsten. 2020. Finance in the times of coronavirus. In *Economics in the Time of COVID-19*. London: CEPR Press, vol. 73, pp. 73–76.

Boone, L. 2020. Tackling the fallout from COVID-19. In *Economics in the Time of COVID-19*. Edited by Richard Baldwin and B. Weder Di Mauro. London: CEPR Press.

Borgards, Oliver, and Robert L. Czudaj. 2020. The prevalence of price overreactions in the cryptocurrency market. *Journal of International Financial Markets, Institutions and Money* 65: 101194. [CrossRef]

Bouoiyour, Jamal, and Refk Selmi. 2020. Coronavirus Spreads and Bitcoin's 2020 Rally: Is There a Link? Available online: https://www.researchgate.net/publication/339537158_Coronavirus_Spreads_and_Bitcoin\T1\textquoterights_2020_Rally_Is_There_a_Link (accessed on 14 March 2023).

Bouri, Elie, Mahamitra Das, Rangan Gupta, and David Roubaud. 2018. Spillovers between Bitcoin and other assets during bear and bull markets. *Applied Economics* 50: 5935–49. [CrossRef]

Bouri, Elie, Rangan Gupta, Aviral Kumar Tiwari, and David Roubaud. 2017. Does Bitcoin hedge global uncertainty? Evidence from wavelet-based quantile-in-quantile regressions. *Finance Research Letters* 23: 87–95. [CrossRef]

Briere, Marie, Kim Oosterlinck, and Ariane Szafarz. 2015. Virtual currency, tangible return: Portfolio diversification with bitcoin. *Journal of Asset Management* 16: 365–73. [CrossRef]

Cavus, Nadire, Yakubu Bala Mohammed, and Mohammed Nasiru Yakubu. 2021. Determinants of learning management systems during COVID-19 pandemic for sustainable education. *Sustainability* 13: 5189. [CrossRef]

Cochrane, John H. 2020. 12 Coronavirus monetary policy. In *Economics in the Time of COVID-19*. London: CEPR Press, p. 105.

Conlon, Thomas, and Richard McGee. 2020. Safe haven or risky hazard? Bitcoin during the COVID-19 bear market. *Finance Research Letters* 35: 101607. [CrossRef]

Corbet, Shaen, Yang Greg Hou, Yang Hu, Charles Larkin, Brian Lucey, and Les Oxley. 2022. Cryptocurrency liquidity and volatility interrelationships during the COVID-19 pandemic. *Finance Research Letters* 45: 102137. [CrossRef]

Dardouri, Nesrine, Abdelkader Aguir, Ramzi Farhani, and Mounir Smida. 2023. Revisiting the Determinants of Investment-The Case of Tunisia. *Estudios de Economía Aplicada* 41. [CrossRef]

Demir, Ender, Mehmet Huseyin Bilgin, Gokhan Karabulut, and Asli Cansin Doker. 2020. The relationship between cryptocurrencies and COVID-19 pandemic. *Eurasian Economic Review* 10: 349–60. [CrossRef]

Dwyer, Gerald P. 2015. The economics of Bitcoin and similar private digital currencies. *Journal of Financial Stability* 17: 81–91. [CrossRef]

Engle, Robert F., and Clive W. J. Granger. 1987. Co-integration and error correction: Representation, estimation, and testing. *Econometrica: Journal of the Econometric Society* 55: 251–76. [CrossRef]

Feridun, Mete, and Muhammad Shahbaz. 2010. Fighting terrorism: Are military measures effective? Empirical evidence from Turkey. *Defence and Peace Economics* 21: 193–205. [CrossRef]

Giudici, Paolo, and Paolo Pagnottoni. 2019. High frequency price change spillovers in bitcoin markets. *Risks* 7: 111. [CrossRef]

Gujarati, Damodar N. 2022. *Basic Econometrics*, 4th ed. Hoboken: Prentice Hall.

IMF. 2020. World Economics Outlook, a Long and Difficult Ascent. Available online: https://www.imf.org/en/Publications/WEO/Issues/2020/09/30/world-economic-outlook-october-2020 (accessed on 14 March 2023).

Iqbal, Najaf, Zeeshan Fareed, Guangcai Wan, and Farrukh Shahzad. 2021. Asymmetric nexus between COVID-19 outbreak in the world and cryptocurrency market. *International Review of Financial Analysis* 73: 101613. [CrossRef]

Jakub, Bartos. 2015. Does Bitcoin follow the hypothesis of efficient market. *International Journal of Economic Sciences* 4: 10–23.

Johansen, Søren. 1988. Statistical analysis of cointegration vectors. *Journal of Economic Dynamics and Control* 12: 231–54. [CrossRef]

Johansen, Soren, and Katarina Juselius. 1990. Maximum Likelihood Estimation and Inference on Cointegration—With Applications to the Demand for Money. *Oxford Bulletin of Economics and Statistics* 52: 169–210. [CrossRef]

Katsiampa, Paraskevi, Shaen Corbet, and Brian Lucey. 2019. High frequency volatility co-movements in cryptocurrency markets. *Journal of International Financial Markets, Institutions and Money* 62: 35–52. [CrossRef]

Khan, Maaz, Umar Nawaz Kayani, Mrestyal Khan, Khurrum Shahzad Mughal, and Mohammad Haseeb. 2023. COVID-19 Pandemic & Financial Market Volatility; Evidence from GARCH Models. *Journal of Risk and Financial Management* 16: 50.

Kristoufek, Ladislav. 2020. Bitcoin and its mining on the equilibrium path. *Energy Economics* 85: 104588. [CrossRef]

Lahmiri, Salim, and Stelios Bekiros. 2020. The impact of COVID-19 pandemic upon stability and sequential irregularity of equity and cryptocurrency markets. *Chaos, Solitons & Fractals* 138: 109936.

Liu, Yukun, and Aleh Tsyvinski. 2018. *Risks and Returns of Cryptocurrency (No. w24877)*. Cambridge, MA: National Bureau of Economic Research.

López-Cabarcos, M. Ángeles, Ada M. Pérez-Pico, Juan Piñeiro-Chousa, and Aleksandar Šević. 2021. Bitcoin volatility, stock market and investor sentiment. Are they connected? *Finance Research Letters* 38: 101399. [CrossRef]

MacKinnon, James G. 1996. Numerical distribution functions for unit root and cointegration tests. *Journal of Applied Econometrics* 11: 601–18. [CrossRef]

Matkovskyy, Roman, and Akanksha Jalan. 2019. From financial markets to Bitcoin markets: A fresh look at the contagion effect. *Finance Research Letters* 31: 93–97. [CrossRef]

McKibbin, Warwick, and Roshen Fernando. 2021. The global macroeconomic impacts of COVID-19: Seven scenarios. *Asian Economic Papers* 20: 1–30. [CrossRef]

Naeem, Muhammad Abubakr, Elie Bouri, Zhe Peng, Syed Jawad Hussain Shahzad, and Xuan Vinh Vo. 2021. Asymmetric efficiency of cryptocurrencies during COVID19. *Physica A: Statistical Mechanics and Its Applications* 565: 125562. [CrossRef] [PubMed]

Nakamoto, Satoshi. 2008. Bitcoin: A peer-to-peer electronic cash system. *Decentralized Business Review*. Available online: https://bitcoin.org/bitcoin.pdf (accessed on 14 March 2023).

Ofori, Daniel, George Asumadu, Isaac Mensah, and Bright Amponsem. 2021. Coronavirus Disease 2019 (COVID-19): Its Ramifications on the Economy and Future Perspectives—A Review. *Modern Economy* 12: 944–59. [CrossRef]

Pesaran, M. Hashem, Yongcheol Shin, and Richard J. Smith. 2001. Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics* 16: 289–326. [CrossRef]

Pesaran, M. Hashem, Yongcheol Shin, and Ron P. Smith. 1999. Pooled mean group estimation of dynamic heterogeneous panels. *Journal of the American Statistical Association* 94: 621–34. [CrossRef]

Rognone, Lavinia, Stuart Hyde, and S. Sarah Zhang. 2020. News sentiment in the cryptocurrency market: An empirical comparison with Forex. *International Review of Financial Analysis* 69: 101462. [CrossRef]

Sarkodie, Samuel Asumadu, and Phebe Asantewaa Owusu. 2021. Global assessment of environment, health and economic impact of the novel coronavirus (COVID-19). *Environment, Development and Sustainability* 23: 5005–15. [CrossRef]

Wang, Xinxin, Zeshui Xu, and Marinko Škare. 2020. A bibliometric analysis of Economic Research-Ekonomska Istra zivanja (2007–2019). *Economic Research-Ekonomska Istraživanja* 33: 865–86. [CrossRef]

World Bank. 2020. Annual Report. Available online: https://www.worldbank.org/en/about/annual-report (accessed on 14 March 2023).

Zaremba, Adam, Renatas Kizys, David Y. Aharon, and Ender Demir. 2020. Infected markets: Novel coronavirus, government interventions, and stock return volatility around the globe. *Finance Research Letters* 35: 101597. [CrossRef] [PubMed]