



The Economics of Cryptocurrencies – Finance in Digital Era

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ABSTRACT:

Global economic markets are encountering apprehensions and susceptibilities because of rise in global pandemic of COVID-19. Investment patterns are becoming restrained because of uncertain global scenarios and reduced GDP world-wide. World economies are moving towards digital era and investors are becoming more open towards newest forms of investments. During these troubled times of pandemic investors are looking forward for some lucrative forms of investments and Cryptocurrencies are the ray of hope for global investors. Since its inception from last decade, many investors, researchers and financial analyst are trying to explore this digital form of investment. Technology has become an integral part of investment these days, and during the times of pandemic cryptocurrencies can be one of the alluring form of investments. The present study is an attempt to explore the changing dynamics of cryptocurrencies with global crisis.

Keywords: Cryptocurrency, volatility, GARCH

Introduction:

The global outburst, COVID-19 which has been labelled a pandemic by the World Health Organisation (WHO) has significantly impacted economy of the world (Yarovaya et al., 2020). Sales of products declined, consumer behaviour changed, production reduced, organisations had financial burdens and there was increase in the unemployment rate worldwide (Lahmiri and Bekiros, 2020). Amid these circumstances, the financial market undoubtedly responded.

The revolutionary utopia that the technology growth promises seems to come closer at an astounding pace, yet unexpected challenges have come up during COVID-19 crisis. This pandemic has destabilized the entire world in the past few months, not only putting lives in danger but has also plundered the economic well-being of deep-rooted global businesses and subsequently the world's financial structure.

The world wasn't prepared for this global pandemic, not even back in 1918-1920 during the Spanish flu. But the difference between then and now lies in the fact the world has been more technologically sound, people can work remotely, shop online, have tele-consultations with doctor through video calling and also buy digital currencies. Even before the onset of COVID-19, digital assets were maturing gradually. During last decade, evolution of a new currency called "Cryptocurrency" was seen.

In the past few years, Cryptocurrency Market has attracted the attention of various investors, researchers and government (Makarov and Schoar, 2020; Nasir et al., 2019). The philosophy behind cryptocurrency lies in the famous quote by Richard Kovacevich, "banking is necessary, banks are not" (Baur et al., 2015). Cryptocurrencies are an unruly payment mechanism which do not require any intermediation from the banks. They can be used by business organisations that use blockchain technologies for production and circulation of cryptocurrencies. Therefore, cryptocurrencies are not measured by any central bank or government and they are not a part of the real economy (Bohme et al., 2015).

There has been a rapid increase in the size of cryptocurrency market. The reasons behind this increase can be (Yousaf and Ali, 2020):

- a. Declining community belief in the dominant banking arrangement post the worldwide economic crises (Weber 2016).
- b. Industrial revolution 4.0 and the usage of various smart technologies
- c. Acknowledgment of cryptocurrency legally in diverse republics
- d. Acknowledgment of cryptocurrency from famous corporations alike Microsoft, Tesla, Facebook, JP Morgan and Shopify (<https://www.businessinsider.com/top-cryptocurrencies>)

Now, financial sphere is more digitized and virtualized because of the technological advancements, it is important that we are able to overcome the problem of dynamically predicating the cryptocurrency market. The tools used for predicting and modelling the cryptocurrency market need proper improvisation so that the distrust of public for cryptocurrency as a pioneering financial asset can be duly managed (Danylchuk et al., 2020).

Cryptocurrency market is considered as a volatile market, also a substantial portion of purchase of cryptocurrency are considered as speculations (Fry & Cheah, 2016). With the rising number of cryptocurrencies and increase in market capitalisation of the cryptocurrency market (Ji et al., 2019) many studies have been conducted to understand the cryptocurrency markets in terms of its volatility (Liu, 2019; Corbet et al., 2018; Liu & Tsyvinski, 2018). Previous studies have shown the cross-market volatilities between cryptocurrency market and other markets (Gajardo et al., 2018; Bouri et al., 2017).

Thus far, from an investment point of view, it is vital to comprehend the altering aspects of the digital currency marketplace specially how the cryptocurrency market's efficiency has been affected by COVID-19. It is significant to study the impact of one cryptocurrency on another cryptocurrency.

LITERATURE REVIEW

Many studies have been conducted to inspect the profits and instability transmission amongst various cryptocurrencies. Yi et al. (2018) studied the instability interconnection among fifty-two cryptocurrencies for estimating the high-dimensional VARs by making use of the LASSO-VAR approach. They found that the 52 cryptocurrencies were strongly interconnected and also analysed the volatility spillover from bitcoin to the supplementary cryptocurrencies.

Koutmos (2018) measured the volatility and return broadcast amongst eighteen foremost cryptocurrencies. He revealed that Bitcoin was the main contributor of volatility spillovers amongst the 18 cryptocurrencies. He also explained that the return and volatility spillovers had increased with time and also there can be spikes in the spillovers whenever there is any major news regarding cryptocurrencies.

Katsiampa (2019) employed the diagonal BEKK model and investigated the instability among Bitcoin and Ethereum. They found that cryptocurrencies in the cryptocurrency market were interdependent on each other and their volatility and correlation was responsive to any major news event. They analysed that Ethereum could be a tough hedge in counter to Bitcoin.

Ji et al. (2019) studied the profits and unpredictability amongst six cryptocurrencies (Bitcoin, Ethereum, Ripple, Litecoin, Stellar, and Dash) by applying the measures developed by Diebold and Yilmaz (2012) and found out that Bitcoin followed by Litecoin were the net spreaders of Profits and instability to additional cryptocurrencies. Also, Ripple and Ethereum, were the net receivers of the spillovers.

Katsiampa et al. (2019a) analysed the shockwave and instability spillover amongst three cryptocurrencies (Bitcoin, Litecoin and Ethereum) using the BEKKMGARCH model and found that there was bi-directional shock spill-over amongst Bitcoin and Ethereum, Bitcoin and Litecoin. Also, bi-directional volatility spill-over was pragmatic amongst Bitcoin and Ethereum, Bitcoin and Litecoin, Litecoin and Ethereum pairs.

Canh et al. (2019) investigated the unpredictability undercurrents in seven foremost cryptocurrencies Bitcoin, Stellar, Dash, Litecoin, Ripple, Monero and Bytecoin by using the DCC-MGARCH model and found that there was noteworthy volatility transmission between all seven cryptocurrencies. They also observed that structural breaks were present in all these cryptocurrencies and the shift in market capitalisation spreads from smaller to larger cryptocurrencies.

Liu and Serletis (2019) in their study examined the shockwave and instability transmission across three foremost cryptocurrencies, namely, Bitcoin, Litecoin and Ethereum. They used the GARCH in mean model to conduct their study and found that there was substantial shock and volatility spillover amongst the three of them.

Beneki et al. (2019) applied the BEKK-GARCH modelling procedure to explore the instability transmission among Bitcoin and Ethereum. They found a one directional instability transmission from Ethereum to Bitcoin.

MOTIVATION OF THE STUDY AND RESEARCH GAP

In times of pandemic of COVID-19, investors world-wide are in state of confusion and dilemmas about investment decisions. As the future looks very gloomy and investors are losing confidence in stocks of even renowned and well-established companies, cryptocurrencies can be a ray of hope for investors to bag profits. At present times, investors are looking for a safer and more profitable form of investments where they feel more secure and confident. In such uncertain financial and economic scenarios, this study is an attempt to understand the role of cryptocurrency as potential investment avenue. The study is majorly focusing on the performance and predictability of cryptocurrency with the help of GARCH model. The researchers have tried to explore the changes in volatility patterns pre and during COVID times. Such shifts in volatility will also contribute in assessing the behavioral shifts of investors.

On the basis of the literature review, it could be observed that not a single researcher had studied the spill-overs amongst the cryptocurrencies throughout a phase of crisis. Numerous researchers have observed the instability spill-over amongst various assets like bond, equity and commodity during a crisis period (Bekaert et al. 2014; Aloui et al. 2011; Diebold and Yilmaz 2009) but the cryptocurrencies have still not been investigated. Therefore, this literature gap will be addressed by our study.

RESEARCH METHODOLOGY

The contemporary research has discovered the behavior of volatility of selected five cryptocurrencies namely, Bitcoin, Ethereum, XRP, chainlink and bitcoin cash with the help of GARCH (p,q) model. The study is considering the present scenario of pre and during COVID-19. As per WHO's report the first case of COVID-19 was detected in December 2019. So, the data prior to December 2019 is considered to be pre-COVID and data after December 2019 is considered to be during-COVID. The study is an attempt to understand the shift in the volatility behaviour of the selected cryptocurrencies because of pandemic. The two-year daily cryptocurrency prices are taken from coinmarketcap.com ranging from 1st December 2018 – 30th November 2019 (Pre-COVID) and 1st December 2019 – 30th November 2020 (During-COVID).

OBJECTIVES OF THE STUDY

- To recognize the transformation in the conditional variance of the cryptocurrencies due to global pandemic of COVID-19.
- To understand the transition in investor behaviour due to change in global investment markets due to pandemic of COVID-19.

The market prices are changed into returns with the support of the subsequent formulary:

$$R_t = \ln(P_t/P_{t-1}) * 100 \quad (1)$$

Here, R_t designates revenues at period t , whereas, P_t and P_{t-1} are the prices of the cryptocurrencies at period t and $t-1$. The stability of the data has been weighed by employing Augmented Dickey Fuller Test. The Null Hypothesis of ADF test conditions that "Return has Unit Root". This hypothesis has been forbidden during all the regimes selected for all the currencies.

MODEL ADVANCEMENT FOR CRYPTOCURRENCY RETURN VOLATILITY (DEGREE OF MODIFICATION IN THE CONSTRUCTION OF CONDITIONAL VOLATILITY)

GARCH (1,1) MODEL

The architype of GARCH (p,q) model is originated by Bollerslev (1986) who acclaims that conditional variance of the revenues generated by any stock or currency is directly related to its previous conditional variance and squared values of its previous error terms. Conditional mean equation of GARCH (1,1) prototype is detailed as following:

$$R_t = C + \alpha R_{t-1} + \varepsilon_t \quad (2)$$

Conditional Volatility prototype is demonstrated as following :

$$h_t = \omega_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \quad (3)$$

In equation (2), R_t is the revenue derived by the prices of cryptocurrencies. Here, α can be defined as the influence of previous logged revenues on present revenues. In the present prototype, ε_t is independently and identically distributed (i.i.d). Which again states that the error terms have stable variance and zero mean. Equation (3) explains the conditional variance, and h_t is the conditional variance of ε_t . Here the value of ε_t demonstrate a constant fluctuation throughout the selected time frame. α_1 demonstrates the impact of recent news on today's revenues. This phenomenon is also acknowledged as "news coefficient" and popularly identified as ARCH effect in financial history. Another constant identified as β_1 in the prototype also significantly influence the performance of the currency. This is prevalently acknowledged as "persistent coefficient" or the "GARCH effect". This outcome explore the influence the older information on the cryptocurrency. The GARCH (p,q) prototype, explores both ARCH (p) and GARCH (q) effect.

In this contemporary research, Generalised Autoregressive Heteroscedastic model (GARCH) is implied to inspect the movement of instability or the consequences of volatility spillover amongst the cryptocurrencies in pre-COVID and during-COVID regimes. To extract the results, the residual series of the cryptocurrencies is derived and furthermore it is squared. The series is squared with the purpose of eradicating the negative influence. The residual of the cryptocurrency data which squared afterwards is positioned as shockwave instigator in the volatility prototype as a regressor. The coefficients of these shockwave instigators which are significant as well validate spillover effect transmitting among the cryptocurrencies.

GARCH (1,1) model to validate spillover effect is having subsequent stipulations:

$$h_t(\text{returns}) = \omega_0 + \alpha_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 + \psi(\text{sqresid}_{\text{returns}}) \quad (4)$$

The prototype mentioned above, recognizes h_t which symbolizes conditional variance of the cryptocurrency. This h_t is regressed and also a function of mean identified as ω_0 . Here, α_1 is the function of "news coefficient" and β_1 is the function of "persistence coefficient". Furthermore, ψ signifies the residual of cryptocurrency. This residual series of cryptocurrency is placed in variance equation as shockwave instigator.

The typical GARCH (1,1) archetypal takes up a symmetrical reply of instability in the direction of "good" and "bad" newscast.

ANALYSIS

The contemporary segment of the research debates on the outcomes of the tests run on the pre and during COVID phases/regimes.

Table-1

RESULTS OF UNIT ROOT TEST
PRE-COVID – 1ST DECEMBER 2018 – 30TH NOVEMBER 2019
DURING-COVID- 1ST DECEMBER 2019 – 30TH NOVEMBER 2020

	During-COVID	Pre-COVID
Bitcoin	22.156 (0.000)	-19.709 (0.000)
Ethereum	-21.932 (0.000)	-20.200 (0.000)
XRP	-9.401 (0.000)	-19.447 (0.000)
Chain Link	-20.678 (0.000)	-19.370 (0.000)
Bitcoin Cash	-22.321 (0.000)	-16.682 (0.000)

Table-1 depicts the outcomes of unit root test on the returns of five selected cryptocurrencies, namely, Bitcoin, Ethereum, XRP, Chain Link and Bitcoin Cash. The data has been selected in two phases, pre-COVID and during COVID. Pre-COVID period ranges from 1st December 2018 – 30th November 2019 and during-COVID period ranges from 1st December 2019 – 30 November 2020. The data has been reported stationary on observing the results of unit root test on selected five cryptocurrencies in two phases.

Table-2
VOLATILITY SPILLOVER OF CRYPTOCURRENCIES IN PRE-COVID
(FROM 1ST DECEMBER 2018 – 30TH NOVEMBER 2019)

	Bitcoin	Ethereum	XRP	Chain-link	Bitcoin Cash
C	0.000 (0.000)	0.000 (0.000)	0.0002 (0.000)	0.000 (0.018)	0.000 (0.000)
ARCH	0.086 (0.051)	0.004 (0.564)	0.104 (0.0001)	-0.005 (0.022)	0.138 (0.000)
GARCH	-0.008 (0.710)	-0.039 (0.008)	-0.019 (0.4751)	1.003 (0.000)	-0.028 (0.263)
SQRESBitcoin	-	0.519 (0.002)	-0.005 (0.873)	-0.043 (0.001)	0.075 (0.609)
SQRESEthereum	0.648 (0.000)	-	0.561 (0.000)	-0.080 (0.000)	1.067 (0.000)
SQRESXRP	0.083 (0.033)	0.679 (0.000)	-	0.135 (0.000)	0.154 (0.214)
SQRESChainlink	0.004 (0.281)	0.005 (0.210)	-0.001 (0.362)	-	0.0006 (0.901)
SQRESBitcoincash	-0.009 (0.965)	0.1004 (0.075)	0.054 (0.056)	0.011 (0.0003)	-

Table-2 demonstrates the result of volatility spillover in pre-COVID period ranging from 1st December 2018 - 30th November 2019. The study has considered five cryptocurrencies namely, Bitcoin, Ethereum, XRP, Chain link and Bitcoin cash. For each cryptocurrency, the volatility spillover from rest of the four cryptocurrencies has been assessed. On observing the outcome, Bitcoin returns have been influenced by the volatility of Ethereum (0.648) and XRP (0.033). Ethereum's returns have been affected by Bitcoin (0.519), XRP (0.679) and Bitcoin cash (0.1004 at 10% level of significance) respectively. XRP's returns have been affected by Ethereum (0.561) and Bitcoin cash (0.054). Chain link's returns are influenced by Bitcoin (-0.043), Ethereum (-0.080), XRP (0.135) and Bitcoin cash (0.011). Bitcoin cash's returns are influenced by Ethereum (1.067) only. ARCH effect has been observed on all the cryptocurrencies except Ethereum, whereas, GARCH effect has been reported on Ethereum (-0.039) and Chain link (1.003). The results report that recent news affects the returns of all the currencies except Ethereum whereas persistency effect is only visible on two cryptocurrencies. Chain link is one of the most vulnerable currency which is getting influenced by all the other cryptocurrency and demonstrate both ARCH and GARCH effect. Bitcoin, XRP and Bitcoin cash are least vulnerable and do not get affected by maximum number of cryptocurrencies. For investors, Ethereum can be one of the good investments as it is not as much vulnerable as chain link and not as much indifferent as Bitcoin, XRP and Bitcoin cash. Most of the significant spillovers are directly impacting the returns of respective cryptocurrencies except Ethereum (-0.080) on Chain Link and GARCH (-0.039) effect on Ethereum.

Table-3
VOLATILITY SPILLOVER OF CRYPTOCURRENCIES IN DURING-COVID
(FROM 1ST DECEMBER 2019 – 30TH NOVEMBER 2020)

	Bitcoin	Ethereum	XRP	Chain-link	Bitcoin Cash
C	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.176)	0.000 (0.189)
ARCH	0.129 (0.042)	-0.012 (0.074)	0.031 (0.177)	-0.017 (0.692)	-0.051 (0.000)
GARCH	0.549 (0.000)	-0.008 (0.158)	0.027 (0.448)	0.019 (0.702)	0.202 (0.006)
SQRESBitcoin	-	0.332 (0.116)	0.010 (0.917)	0.010 (0.808)	0.117 (0.145)
SQRESEthereum	0.0002 (0.409)	-	0.175 (0.035)	0.013 (0.736)	0.106 (0.044)
SQRESXRP	0.0003 (0.340)	0.654 (0.000)	-	0.905 (0.002)	0.244 (0.000)
SQRESChainlink	-0.0002 (0.000)	0.033 (0.103)	-0.007 (0.000)	-	-0.0009 (0.002)
SQRESBitcoincash	0.002 (0.000)	0.184 (0.028)	0.365 (0.000)	-0.0008 (0.906)	-

Table-3 demonstrates the outcomes of spillover effect among the designated five cryptocurrencies during the time frame ranging from 1st December 2019 to 30th November 2020. This regime has been identified as During-COVID period. On observing the outcome, it is identified that Bitcoin is affected by

Chain Link (-0.0002) and Bitcoin cash (0.002), although the impact is very minimum. Ethereum is influenced by XRP (0.654) and Bitcoin cash (0.184), XRP is affected by Ethereum (0.175), Chain Link (-0.007) and Bitcoin Cash (0.365). On observing the results of Chain link, it has been reported that only XRP (0.905) could influence its returns. Ethereum (0.106), XRP (0.244) and Chain Link (-0.0009) have significantly influenced the returns of Bitcoin Cash. ARCH effect also known as new effect has been observed on Bitcoin (0.129), Ethereum (-0.012) and Bitcoin cash (-0.051). GARCH effect also known as persistency effect is observed on Bitcoin (0.549) and Bitcoin Cash (0.202).

It has been discovered that Chain Link is one of the cryptocurrencies which is getting volatility spillover only from XRP but affecting the returns of all the cryptocurrencies except Bitcoin. Hence, Chain Link's volatility can be employed to predict the reruns of other cryptocurrencies. Bitcoin cash is one of the most vulnerable cryptocurrencies among all the five as it is getting volatility spillover from Ethereum, XRP and Chain link and also reporting ARCH and GARCH effect. Bitcoin can be a good investment opportunity as it is not as vulnerable as Bitcoin cash but can also be predictable in comparison to others.

FINDINGS OF THE STUDY

The present study is an attempt to explore the impact of pandemic on the cryptocurrencies. In recent times it has been observed that investor's focus has been shifted to digital currencies instead of traditional forms of investment. The study has identified a shift in the behavior of investors due to pandemic where the impact of recent information has been reduced and investors are a little less sensitive to recent piece of information, whereas, older news were not that significant in pre-COVID times also. Bitcoin is one of the most popular form of cryptocurrencies in the history of cryptocurrencies. One of the major findings of the study states that earlier investors were exploring other forms of cryptocurrencies eg. Ethereum and Chain link as these cryptocurrencies were receiving volatility spillover from maximum number of cryptocurrencies. But the scenario has been completely transformed due to COVID. During-COVID Bitcoin Cash, XRP and Bitcoin is receiving volatility spillover from maximum number of cryptocurrencies. A major shift has been observed in Chain link as in pre-COVID times it received volatility spillover from rest of the four cryptocurrencies and during-COVID times it received volatility spillover only from XRP. The study confirmed that pandemic has made the investors more cautious about their investments and they do not want to invest their money into less reliable form of investments.

IMPLICATION OF THE STUDY

On Comparing the Pre and During COVID results, ARCH effect has been reduced from four to three Cryptocurrencies. Ethereum has been demonstrating ARCH effect During-COVID times, whereas, earlier it was not showing any impact of the recent news. GARCH effect has been observed on two currencies earlier while it is still visible on two cryptocurrencies only, whereas, in pre-COVID times it was observed on Ethereum and Chain link and During-COVID times it is observed on Bitcoin and Bitcoin cash. It can be seen that during COVID times investors have switched to the most famous cryptocurrency rather than putting their money in other forms of investments. This investor behavior shows that investors want to play safe in the market by just investing in renowned investment avenues. The study also contributes in understanding the role of investor sentiments while selecting any form of investments. The present scenario has forced the investors to go for most reliable form of cryptocurrencies while earlier investors were more open for newer forms of investments. The present scenario has made them more vulnerable and cautious.

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REFERENCES:

1. Aloui, R., Aïssa, M. S. B., & Nguyen, D. K. (2011). Global financial crisis, extreme interdependences, and contagion effects: The role of economic structure? *Journal of Banking & Finance*, 35(1), 130-141.
2. Baur, D. G., & Dimpfl, T. (2018). Asymmetric volatility in cryptocurrencies. *Economics Letters*, 173, 148-151.
3. Bekaert, G., Ehrmann, M., Fratzscher, M., & Mehli, A. (2014). The global crisis and equity market contagion. *The Journal of Finance*, 69(6), 2597-2649.
4. Beneki, C., Koulis, A., Kyriazis, N. A., & Papadamou, S. (2019). Investigating volatility transmission and hedging properties between Bitcoin and Ethereum. *Research in International Business and Finance*, 48, 219-227.
5. Böhme, R., Christin, N., Edelman, B., & Moore, T. (2015). Bitcoin: Economics, technology, and governance. *Journal of economic Perspectives*, 29(2), 213-38.
6. Bollerslev, T. (1986). Generalized Autoregressive Conditional Heteroskedasticity. *Journal of Econometrics*. 33. 307-327.

7. Bouri, E., Jalkh, N., Molnár, P., & Roubaud, D. (2017). Bitcoin for energy commodities before and after the December 2013 crash: Diversifier, hedge or safe haven? *Applied Economics*, 49(50), 5063–5073.
8. Canh, N. P., Wongchoti, U., Thanh, S. D., & Thong, N. T. (2019). Systematic risk in cryptocurrency market: Evidence from DCC-MGARCH model. *Finance Research Letters*, 29, 90-100.
9. Corbet, S., Meegan, A., Larkin, C., Lucey, B., & Yarovaya, L. (2018). Exploring the dynamic relationships between cryptocurrencies and other financial assets. *Economics Letters*, 165, 28–34.
10. Danylchuk, H., Kovtun, O., Kibalnyk, L., & Sysoiev, O. (2020). Monitoring and modelling of cryptocurrency trend resistance by recurrent and R/S-analysis. In *E3S Web of Conferences* (Vol. 166, p. 13030). EDP Sciences.
11. Diebold, F. X., & Yilmaz, K. (2009). Measuring financial asset return and volatility spillovers, with application to global equity markets. *The Economic Journal*, 119(534), 158-171.
12. Diebold, F. X., & Yilmaz, K. (2012). Better to give than to receive: Predictive directional measurement of volatility spillovers. *International Journal of Forecasting*, 28(1), 57-66.
13. Fry, J., & Cheah, E.-T. (2016). Negative bubbles and shocks in cryptocurrency markets. *International Review of Financial Analysis*, 47, 343–352.
14. Gajardo, G., Kristjanpoller, W. D., & Minutolo, M. (2018). Does Bitcoin exhibit the same asymmetric multifractal cross-correlations with crude oil, gold and DJIA as the Euro, Great British Pound and Yen? *Chaos, Solitons & Fractals*, 109, 195–205.
15. Ji, Q., Bouri, E., Lau, C. K. M., & Roubaud, D. (2019). Dynamic connectedness and integration in cryptocurrency markets. *International Review of Financial Analysis*, 63, 257–272.
16. Katsiampa, P. (2019). Volatility co-movement between Bitcoin and Ether. *Finance Research Letters*, 30, 221-227.
17. Katsiampa, P., Corbet, S., & Lucey, B. (2019a). Volatility spillover effects in leading cryptocurrencies: A BEKK-MGARCH analysis. *Finance Research Letters*, 29, 68-74.
18. Koutmos, D. (2018). Return and volatility spillovers among cryptocurrencies. *Economics Letters*, 173, 122-127.
19. Lahmiri, S., & Bekiros, S. (2020). The impact of COVID-19 pandemic upon stability and sequential irregularity of equity and cryptocurrency markets. *Chaos, Solitons & Fractals*, 109936.
20. Liu, J., & Serletis, A. (2019). Volatility in the cryptocurrency market. *Open Economies Review*, 30(4), 779-811.
21. Liu, W. (2019). Portfolio diversification across cryptocurrencies. *Finance Research Letters*, 29, 200–205.
22. Liu, Y., & Tsyvinski, A. (2018). Risks and returns of cryptocurrency (Nr. 0898–2937). National Bureau of Economic Research.
23. Makarov, I., & Schoar, A. (2020). Trading and arbitrage in cryptocurrency markets. *Journal of Financial Economics*, 135(2), 293-319.
24. Nasir, M. A., Huynh, T. L. D., Nguyen, S. P., & Duong, D. (2019). Forecasting cryptocurrency returns and volume using search engines. *Financial Innovation*, 5(1), 2.
25. Weber, B. (2016). Bitcoin and the legitimacy crisis of money. *Cambridge Journal of Economics*, 40(1), 17-41.
26. Yarovaya, L., Brzeszczyński, J., Goodell, J. W., Lucey, B. M., and Lau, C. K. (2020). Rethinking financial contagion: Information transmission mechanism during the covid-19 pandemic. Available at SSRN 3602973.
27. Yi, S., Xu, Z., & Wang, G. J. (2018). Volatility connectedness in the cryptocurrency market: Is Bitcoin a dominant cryptocurrency? *International Review of Financial Analysis*, 60, 98-114.
28. Yousaf, I., & Ali, S. (2020). Discovering interlinkages between major cryptocurrencies using high-frequency data: new evidence from COVID-19 pandemic. *Financial Innovation*, 6(1), 1-18.