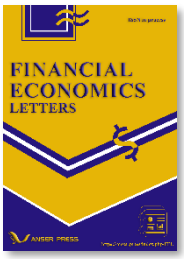
Financial Economics Letters

Homepage: https://anser.press/index.php/FEL



Time-frequency dependency between stock market volatility, and Islamic gold-backed and conventional cryptocurrencies

Md. Mamunur Rashid [a, *], Md. Ruhul Amin [a]

[a] *Department of Finance and Banking, Islamic University, Kushtia-7003, Bangladesh*

ABSTRACT

We extend the Shariah-compliant digital assets and Islamic Fintech literature through exploring the time-frequency associations between the volatility index (VIX) and cryptocurrencies (both Islamic and traditional). Employing wavelet-based technique, we find that Islamic cryptocurrencies demonstrate low or no coherency with stock market volatility compared to traditional cryptocurrencies (except Tether) during the whole time and frequency bands, highlighting the hedging capabilities of Islamic cryptocurrencies. Tether also serves the same against VIX, as there is a low or favorable link between these variables. Finally, our findings would be prolific to digital currency traders and investors in designing the portfolio strategies.

KEYWORDS

Stock market volatility; Islamic gold-backed cryptocurrencies; Conventional cryptocurrencies; Time-frequency dependency

* Corresponding author: Md. Mamunur Rashid
E-mail address: mamunur1621027@gmail.com

ISSN 2972-3426
doi: 10.58567/fel02010001

Received 1 January 2023; Accepted 25 March 2023; Available online 3 April 2023

1. Introduction

Cryptocurrencies, especially Bitcoin, have recently drawn a great deal of attention from investors, policymakers, consumers, and economists owing to the potentials and difficulties of cryptocurrency markets (Jiang et al., 2018). Since then, hundreds of alternative cryptocurrencies have emerged, topping a market capitalization of US $1.09 trillion by early 2023.[1] However, among the traditional cryptocurrencies, the new Islamic cryptocurrencies that are baked mainly on gold have been introduced in providing Shariah-based traders access to an innovative digital token that complies the rules of Sharia. The foundation of the Shariah-compliant cryptocurrency is gold, which is one of the six "rabawi" commodities (e.g., gold, silver, wheat, barley, salt, and dates) that Shariah-based traders are permitted to exchange (Aloui et al., 2021).

Islamic finance industry is growing rapidly in the global financial markets because of its stable features amid the financial crisis held in 2008 (Akhtar & Jahromi, 2017), resulting in reach the market capitalization of Islamic finance industry to around US $4 trillion.[2] In the recent years, Islamic cryptocurrencies add a new dimension in the Islamic finance industry. Although this market is not big enough, it has a huge growth potential (Yousaf & Yarovaya, 2022). However, apart from Shariah-based stocks and bonds, Islamic cryptocurrencies, such as OneGram and X8X, can be an alternative investible instrument to the Muslim investors across the world. These gold-backed cryptocurrencies have been referred to as new potential safe-haven assets (e.g., Aloui et al., 2021; Baur and Hoang, 2021). In this vein, a few researches, which are discussed in the literature, have been carried out recently considering several aspects of Islamic cryptocurrency, and they found varied results regarding the hedging behavior of Islamic cryptocurrency against the Islamic equity markets.

However, the earlier literature lacks in considering the stock market volatility in the global financial markets. It is well noted that increasing the stock market volatility will increase the uncertainty in the investor's portfolio decision making. In this perspective, investors often look for alternative assets that are uncorrelated or negatively correlated with the traditional investments of their primary interest during times of stock market stress (Ali et al., 2022). Additionally, the recent COVID-19 crisis has further deepened the uncertainty in the stock markets (Hasan et al., 2021), which increases the volatility of investors' portfolios that require to offset through alternative investment instruments, particularly Islamic cryptocurrency. In this strand, it crucial to inspect the hedging and safe-haven potential of Islamic cryptocurrencies compared to traditional cryptocurrencies against the stock market volatility (proxies by volatility index (VIX)[3]).

Against this backdrop, we examine the dependence structure between VIX and cryptocurrencies (both Islamic and traditional) to explore their comparative hedge and safe-haven properties against VIX. Using wavelet-based models for the period from December 12, 2018 to January 17, 2023, we find that Islamic cryptocurrencies outperform conventional cryptocurrencies (except Tether) in terms of hedging abilities against the VIX shocks. This pattern also varies with the changes of time and investment horizons. This finding would be useful for investors and policymakers in making effective portfolio and policy decisions.

This empirical research adds contributions to the growing Islamic Fintech literature through several ways. Firstly, unlike the previous studies which focus on the safe haven potential of Islamic cryptocurrency against Islamic equity markets, this is the first attempt to study the lead/lag interdependence between stock market volatility, and Islamic and traditional cryptocurrency to scrutiny the comparative hedging opportunities against the VIX shocks. Secondly, from the methodological point of view, we utilize the wavelet-based methods, allowing to capture lead and lag connectedness during both the time and frequency domains, which will shed light on the effective decision making for investors and regulators. Finally, our findings suggest that Islamic gold-backed cryptocurrency has a

[1] The market capitalization trend of cryptocurrency is available at: https://www.coingecko.com/en/global-charts
[2] https://www.statista.com/topics/6345/islamic-financial-sector/#topicOverview
[3] The details of these variables are discussed in the data description section.

greater hedging benefits against VIX, compared to conventional cryptocurrencies (excluding Tether).

The remainder article is arranged as follows: Section 2 highlights the related literature. The description of data and methodology is highlighted in Section 3. Section 4 delineates the empirical results. Conclusion is in Section 5.

2. Review of Related Literature

There are several schools of thought in the cryptocurrency markets, and literature on cryptocurrency is extensive. For instance, the earlier school of thoughts explain the Bitcoin's medium of exchange (Baur et al., 2018) and its efficiency (Urquhart, 2016; Nadarajah & Chu, 2017) and found mixed results. Recently, a considerable number of studies (e.g., Conlon & McGee, 2020; Hasan et al., 2021; Shahzad et al., 2022; Mo et al., 2022; Hasan et al., 2023; inter alia) have focused on the cryptocurrency markets, especially Bitcoin, in terms of diversification, hedging, and safe-haven opportunities of cryptocurrency against the stock markets, several uncertainties, and other financial assets, such as commodities. No consensus has been made by the findings of the abovementioned studies. However, another new digital asset, which is based on the Shariah principles, called Islamic gold-backed cryptocurrency, has been introduced in the recent years. This Islamic gold-backed cryptocurrency offers investors and portfolio managers as an alternative investable asset, which may convey diversification and hedging opportunities in their portfolio (Aloui et al., 2021). Despite having the alternative investment features of Islamic cryptocurrency, little research has been conducted to this market to explore the hedge and safe-haven abilities. In this strand, we will highlight some recent studies that have focused on the Islamic gold-backed cryptocurrency.

Aloui et al. (2021) examine whether the Islamic cryptocurrency is different asset classes or not compared to conventional cryptocurrency. They utilize the DCC-GJR-GARCH model and find that Islamic gold-backed cryptocurrency reacts differently compared to conventional cryptocurrency in terms of geopolitical risk. Similarly, using VAR-BEKK-AGARCH approach, Yousaf and Yarovaya (2022) uncover the perspective of return as well as volatility dependency between Shariah-based cryptocurrencies and equity markets. Their findings show that by including Islamic cryptocurrencies in the portfolio, investors can lower the Islamic equity portfolio risks. They further assert that as comparison to the pre-pandemic level, the hedging costs for all combinations have actually risen throughout the COVID-19 period.

Furthermore, Ali et al. (2022) have examined the safe-haven function of two Islamic cryptocurrencies backed by gold for 15 Islamic equities indexes. They employ the value at risk (VaR), cross-quantilogram, and dynamic conditional correlation-based hedging, and safe-haven methods. Their findings demonstrate that Onegram acts as a strong safe-haven for various Islamic equity markets, especially during the COVID-19 crisis. Mnif et al. (2022) examine and compare the herding behavior of the gold-backed, conventional cryptocurrency, and gold markets through utilizing the Multifractal Detrended Fluctuation Analysis (MFDFA) technique. They observe that the gold-backed cryptocurrency (X8X) is the most efficient market in the long-run, while the Bitcoin market is the most efficient on the short-run investment horizon. They further witness that on large sizes, the gold-backed cryptocurrencies exhibit less herding behavior than conventional cryptocurrencies.

Overall, from the literature mentioned above, a few characteristics stand out. To begin with, prior research mainly focuses on the efficiency, herding behavior of Islamic cryptocurrency, and whether this behavior differs from conventional ones. Moreover, very few studies (e.g., Ali et al., 2022; Yousaf & Yarovaya, 2022) have analyzed the hedging and safe-haven behavior of Islamic cryptocurrency, and the hedging capability is mainly analyzed against the Islamic equity markets. The previous research, nevertheless, lacks whether the Islamic gold-backed cryptocurrency offer more hedging opportunity compared to conventional ones against the stock market volatility, since the stock market volatility is the crucial factor when investors make investment decision.

Furthermore, from the methodological point of view, the methodologies (e.g., DCC-GARCH, VAR-BEKK-GARCH, VaR, etc.) they applied in their studies capture some particular aspects, such as static or dynamic relationship,

ignoring both the time and frequency associations, as well as lead/lag connectedness altogether. Exploring the time-frequency and lead/lag connectedness altogether between the variables is crucial for investors and policymakers, as the earlier research suggests that the returns and volatility of financial markets differ with changes of time and investment horizons (e.g., short, medium, and long run), which will allow them to make effective portfolio and policy decisions. To address the existing literature lacuna mentioned above, this study explores time-frequency lead/lag interconnectedness between the stock market volatility (proxies by VIX) and cryptocurrencies (both Islamic and traditional). This study further examines whether Islamic cryptocurrency conveys higher hedging benefits compared to traditional cryptocurrency against VIX.

3. Data and methodological frameworks

3.1. Data description and descriptive statistics

To explore the time frequency association between stock market volatility and cryptocurrencies (both Islamic and traditional), we utilize the daily closing price of the variables. We choose two Shariah-based gold-backed cryptocurrencies, such as Onegram coin and X8X token, and three traditional cryptocurrencies[4], such as Bitcoin, Ethereum, and Tether. Conversely, the CBOE Volatility Index (VIX)—also called fear index—is employed as stock market volatility indicator. This index measures the inferred volatility of a variety of options, which are based on the S&P 500 index and is regarded the world's most leading forecaster of financial volatility. The data period spans from December 12, 2018 to January 17, 2023 and is selected on the basis of data availability. Finally, we use the natural logarithm returns for all variables as a first difference between two consecutive prices (i.e., $R_t = ln\left(\frac{P_t}{P_{t-1}}\right) \times 100$). The data for X8X and Onegram tokens are sourced from https://coinmarketcap.com/ and https://coincodex.com/, respectively. Additionally, the data for VIX, Bitcoin, Ethereum, Tether are amassed from investing.com. The price dynamics for all variables are illustrated in Figure 1.

Table 1 exhibits the summary and stationarity test statistics (Panel A) and unconditional correlation coefficient (Panel B). We observe that Ethereum witnesses the maximum average returns, and Onegram reveals the lowest and negative average returns with strongest volatility. The heavy tails or outliers are represented by high kurtosis values. The variables' return distributions are non-normal, which is further proved by the Jarque-Bera test statistic. Finally, the Augmented Dickey-Fuller (ADF) and Phillips Perron (PP) unit root test outcomes indicate that our datasets have no stationarity issues. The correlation matrix (Panel B) suggests that cryptocurrencies are significantly negatively associated with the changes of VIX shocks.

3.2. Wavelet-based method

This study uncovers the time and frequency-based lead/lag associations between stock market volatility indicators and both Islamic gold-backed and traditional cryptocurrencies. In doing so, we care about the selection of appropriate and sophisticated methodology. However, among the several methodologies used in the field of econometrics and finance literature to analyze the interrelationship between the variables, we have chosen the wavelet-based techniques—continuous wavelet transforms (CWT), and wavelet coherence (WC)—for several grounds. Firstly, the wavelet approaches can make outcomes in the form of time-frequency coherence and time differences between the studied variables' pairs (Umar et al., 2021). The CWT enables us to see how each analyzed variable varies or changes as time passes and frequency bands. Secondly, the WC method provide insights into the

[4] We have selected these three cryptocurrencies based on the market capitalization at the time of the writing this paper and collecting data.

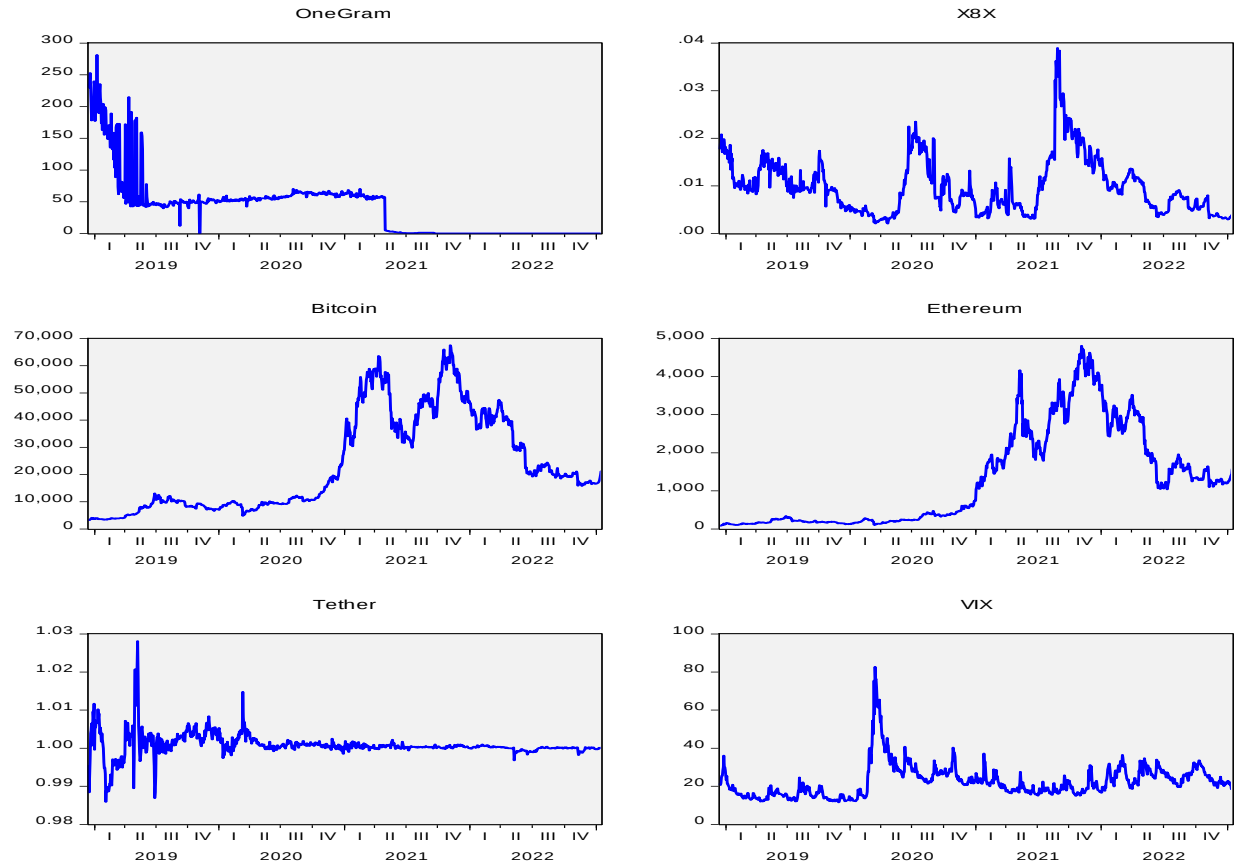


Figure 1. Time-trends for all variables.

Table 1. Summary statistics and Pearson correlation.

Panel A: Summary statistics and unit root test						
Variables	Onegram	X8X	Bitcoin	Ethereum	Tether	VIX
Mean	-1.1585	-0.1411	0.173	0.2737	0.0005	-0.0099
Std. Dev.	35.8588	12.7896	4.6086	6.0933	0.1658	8.0046
Skewness	-0.7929	0.2622	-1.3577	-0.9217	-0.1802	1.1756
Kurtosis	175.8398	11.503	18.3413	14.8994	34.8163	7.3255
Jarque-Bera	1300855.00***	3160.11***	10568.83***	6313.22***	44081.73***	1055.35***
ADF	-22.42***	-38.15***	-34.04***	-35.15***	-28.29***	-36.11***
PP	-47.19***	-39.01***	-34.00***	-35.05***	-38.44***	-36.53***
Panel B: Unconditional correlation						
Onegram	1					
X8X	0.0001	1				
Bitcoin	-0.0051	0.2804***	1			
Ethereum	0.0196	0.3355***	0.8258***	1		
Tether	0.0715**	0.0144	-0.0765**	-0.0168	1	
VIX	-0.0339	-0.1031***	-0.2511***	-0.2613***	0.0279	1

*Notes: The table lists all of the variables' descriptive statistics, unit root test, and unconditional correlation. The standard deviation is denoted by Std. Dev. The ADF and PP symbolize the Augmented Dickey-Fuller, and Phillips-Perron test, respectively. The statistical significance is indicated by ***, **, and * at the 1%, 5%, and 10% levels, respectively.*

joint behavior of variables not only in the single dimension of time, but also across multiple investment time-scales, allowing us to investigate distinct patterns of stock market volatility and selected financial assets' return movements and co-movements. Thirdly, the WC captures the lead/lag associations not only in the single time dimension, but also across several investment time-scales between the variables, letting us to make accurate choice

based on the leading/lagging behavior of the variables. Finally, we are also inspired to employ these methods based on some recent studies (e.g., Al-Yahyaee et al., 2020; Bouri et al., 2020; Hasan et al., 2022; Hassan et al., 2022; inter alia), as these studies apply the wavelet-based methods to capture the same. The details of the wavelet-based techniques are explained in the sections below.

3.2.1. The continuous wavelet transforms (CWT)

The CWT $R_a(x,y)$ shows the valuation of a wavelet ψ (.) against the time sequence $a\,(t) \in K^2(\underline{R})$, i.e.,

$$R_a(X,Y) = \int_{-\infty}^{\infty} a(t)\frac{1}{\sqrt{y}}\psi\left(\frac{\sqrt{t-p}}{s}\right)dt \quad (1)$$

The CWT is capable to decompose and restructure the series in time a (t) ∈ $K^2(\underline{R})$ into the first converse CWT:

$$a(t) = \frac{1}{C_\psi}\int_0^{\infty}\left[\int_{-\infty}^{\infty} R_a\,(x,y)\psi_{x,y}(t)du\right]\frac{dq}{S^2}, S > 0 \quad (2)$$

Additionally, the CWT conserves the experimented time sequence power, which is stated below:

$$\|a\| = \frac{1}{C_\psi}\int_0^{\infty}\left[\int_{-\infty}^{\infty}|R_a(x,y)|^2\,dp\right]\frac{dq}{S^2} \quad (3)$$

These features are used to demonstrate WC, which illustrates the association between variables.

3.2.2. The wavelet coherence (WC)

It is crucial to define the cross-wavelet power and cross-wavelet transform before describing the WC technique. The cross-wavelet transform can be justified by the multiple time sequences, a (t) and b (t) (Torrence and Compo, 1998):

$$R_{ab}(x,y) = R_a(x,y)R_b^*(x,y) \quad (4)$$

where $a\,(t)$ and $b\,(t)$ are signified two continuous transforms via $R_a(x,y)$ and $R_b(x,y)$, respectively, where the index's location, measure, and composite conjugate are indicated by x, y, and (*), respectively. The cross-wavelet transform is utilized to estimate $|R_a(x,y)|$. Conversely, the cross-wavelet power spectra segregate the domain pertinent to the data's timeframe. The time-frequency co-movement shapes are uncovered using the WC examination. Torrence and Webster (1998) disclose the WC modified specification below:

$$N^2(x,y) = \frac{|S(S^{-1}R_{ab}(x,y)|^2}{S(S^{-1}|R_a(x,y)|^2)S(S^{-1}|R_b(x,y)|^2)} \quad (5)$$

where S symbolizes the smoothing mechanism. The squared WC series coefficients are spotted by $0 \leq N^2(x,y) \leq 1$. The magnitudes closest to unity and zero or close to zero indicate a strong connection and an absence of correlation, respectively. The Monte Carlo approach is employed to scrutinize the hypothetical WC allocation.

4. Analysis of empirical results

Figure 2 shows the continuous wavelet transform (CWT) plots. The CWT gauges the movement or variation of the variables through the time and frequency bands. The CWT results reveal that Onegram and X8X have a significant volatility in the very short-run scale during the year of 2019. Accordingly, X8X returns exhibit the significant volatility during the late 2020 to early 2021 at the short and medium-run frequency bands (0-64 scale). We find low or no volatility during the long-run frequency bands for Onegram and X8X tokens for whole sample period. Accordingly, Bitcoin and Ethereum show almost identical volatility for whole sample period during the short and medium-term scales. However, the significant volatility is only found up to 3rd quarter of 2019 at the short and medium-run domains for Tether returns. The VIX has a mixed volatility during the short-run scales up to the 2nd quarter of 2022, whereas the volatility is increased up to the middle-run frequency bands during the 1st and 2nd quarters of 2020. The reason for this increased volatility is caused by the COVID-19 pandemic crisis that adversely

hits the global economic and financial systems (Hasan et al., 2022).

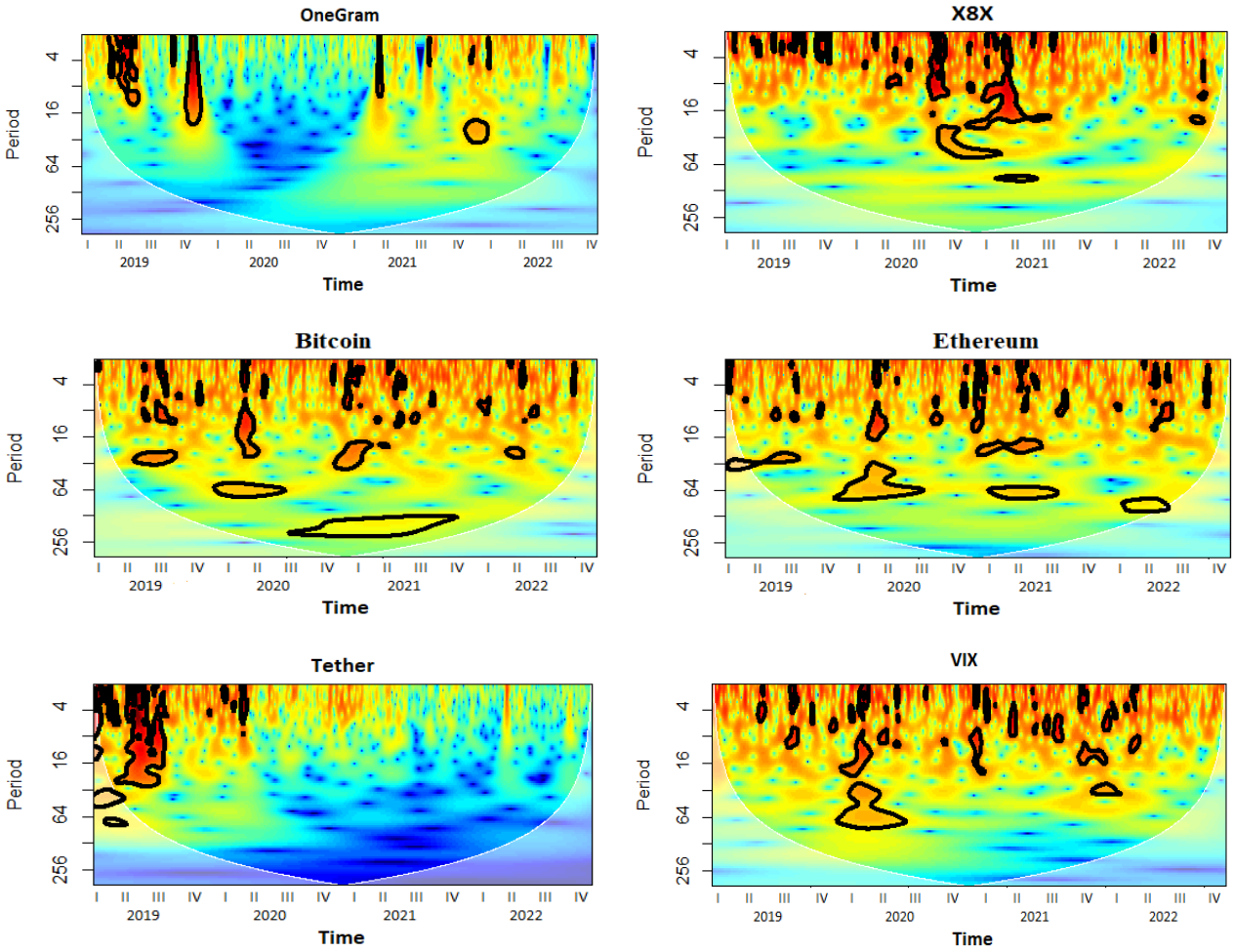


Figure 2. CWT plots.

Notes: The figure depicts the CWT plots for all the variables. The horizontal axis shows the time periods, while the vertical axis shows the duration in days. The thick black contour against the red color represents the 5% significant level.

The plots of wavelet coherence (WC) between the selected variables are displayed in Figure 3. The WC provides key insights into how these the variables interact throughout the analyzed time and frequency domains with lead/lag associations. We witness that there is little or no lead/lag dependence between VIX and Islamic cryptocurrencies across the whole time and frequency domains. This notion contends that Onegram and X8X can be utilized as the hedging instruments owing to their risk absorbing capacity against stock market volatility. However, only a very few islands display a significant connection between the abovementioned variables at the short and medium-run scales.

Alternatively, the coherency between VIX and traditional cryptocurrencies (e.g., Bitcoin, Ethereum, and Tether) is mixed and varies over time and frequency bands. For instance, the returns of Bitcoin and Ethereum react identically with the vicissitudes of VIX across the entire time periods. Some arrows of Bitcoin and Ethereum returns against the alterations of VIX represent an out-phase association having anti-cyclic effects during the short and medium-run bands from 2nd quarter of 2021 to sample period, reflecting the negative co-movement between aforementioned couples of pairs. Surprisingly, during the middle-run scales from the 4th quarter of 2019 to the 4th quarter of 2020[5], the abovementioned two pairs of variables co-move adversely, as the arrows are pointing to the

[5] According to earlier literature, these periods are regarded the peak crisis moment of COVID-19 pandemic, where

left-side down with consistent leading effect by VIX. This result implies that stock market volatility has a significant adverse influence on Bitcoin and Ethereum returns, suggesting no hedging or safe-haven benefits of Bitcoin and Ethereum during the extreme COVID-19 turbulence time. This finding is further corroborated by the studies of Conlon and McGee (2020), as well as Hasan et al. (2021). However, there is a low and little co-movement between VIX and Tether across whole time and frequency domains. Accordingly, Tether and VIX follow a significant positive co-movement during the extreme COVID-19 crisis at the medium-long run scales, suggesting there is strong hedge and safe-haven ability of Tether against the changes of VIX, which is in line with Hasan et al. (2021).

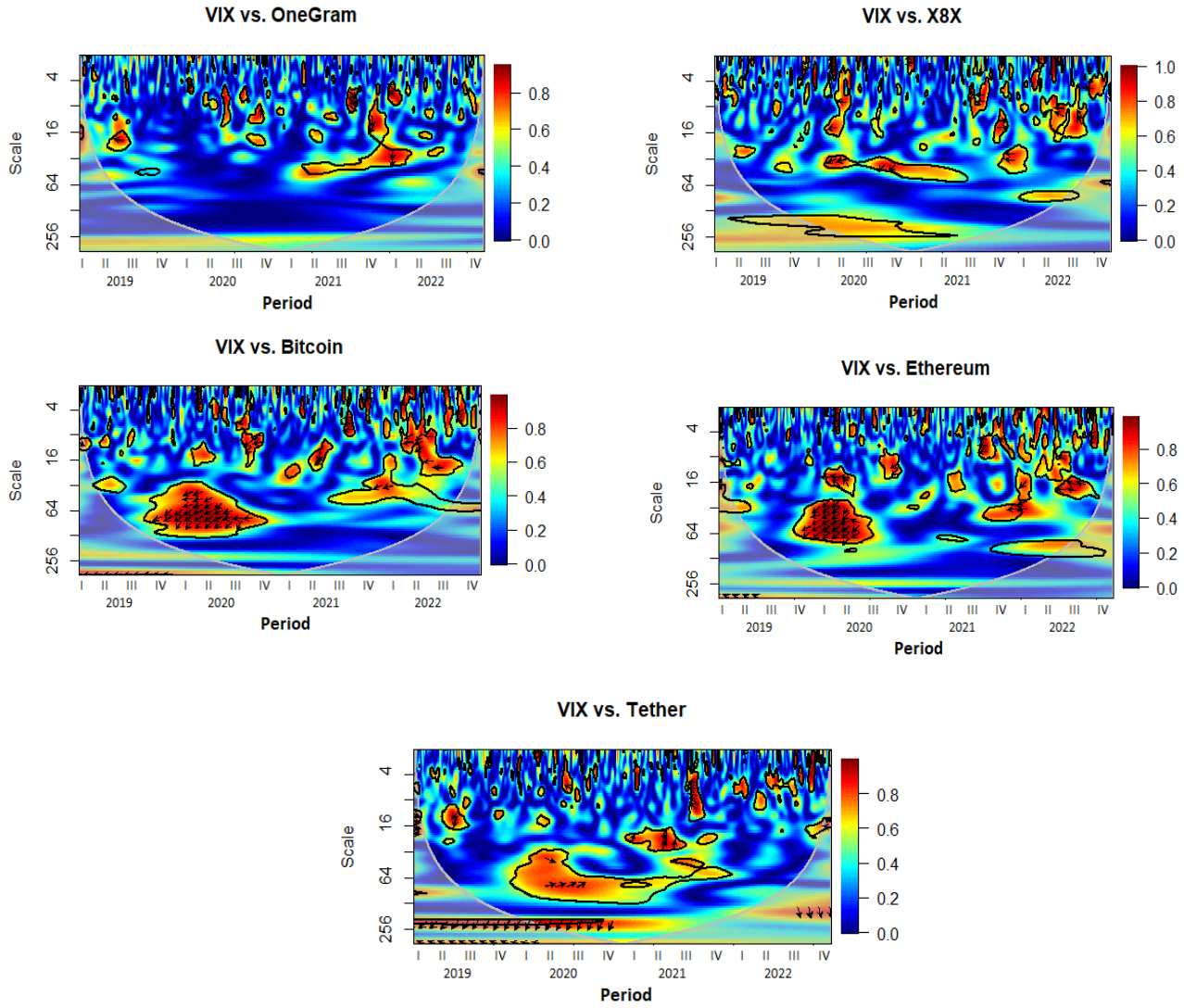


Figure 3. WC plots.

Notes: The figure illustrates the WC plots for whole study period. Each plot's right side displays the power range, which spans from blue (low) to red (high). The phase differences between the variables are shown by the arrows. The two series are in phase, as indicated by the arrows on the right (left) side (anti-phase). The cyclical (anti-cyclical) influence is shown by the in-phase (out-phase) association between variables. The arrows pointing up (right side) and down (left side) symbolizes that the VIX (cryptocurrencies) is leading.

there was a devastating effect on the financial markets.

5. Conclusions and policy implications

This study examines the time-frequency interconnectedness between stock market volatility (proxies by VIX) and cryptocurrencies (both Islamic gold-backed and traditional) to discover the comparative hedging and safe-haven potential of cryptocurrencies for the stock market volatility. Applying the wavelet-based approach, we find that Islamic gold-baked cryptocurrency has a low or no interdependency with VIX, highlighting their hedging and safe-haven status against stock market volatility. Conversely, the dependence structure is somewhat negative and significant, particularly during the extreme COVID-19 crisis at medium-run scale, between VIX and traditional cryptocurrencies (excluding Tether). This notion demarcates the hedging and safe-haven roles of Bitcoin and Ethereum against VIX. However, Tether has a low or positive coherence with VIX across the whole time and frequency domains, reflecting safe-haven ability of Tether.

The findings of this research are crucial to portfolio managers, digital asset traders, and Shariah-based investors who are looking for alternative Sharia-compliant instruments to lower the risk of stock markets. Particularly, they should utilize the Islamic cryptocurrency and Tether as the hedge and safe-haven instruments against the volatility of stock market. Therefore, more Shariah-compliant digital assets should be introduced by Islamic Fintech firms and entrepreneurs to offer greater options to the investors. Future research should compare Islamic gold-backed cryptocurrency with other financial asset classes in terms of several macroeconomic uncertainty factors.

Funding Statement

This research received no external funding.

Declaration of Competing Interest

The author claims that the manuscript is completely original. The author also declares no conflict of interest.

References

Akhtar, S., & Jahromi, M. (2017). Impact of the global financial crisis on Islamic and conventional stocks and bonds. Accounting & Finance, 57(3), 623-655. https://doi.org/10.1111/acfi.12136

Ali, F., Bouri, E., Naifar, N., Shahzad, S. J. H., & AlAhmad, M. (2022). An examination of whether gold-backed Islamic cryptocurrencies are safe havens for international Islamic equity markets. Research in International Business and Finance, 63, 101768. https://doi.org/10.1016/j.ribaf.2022.101768

Aloui, C., ben Hamida, H., & Yarovaya, L. (2021). Are Islamic gold-backed cryptocurrencies different? Finance Research Letters, 39, 101615. https://doi.org/10.1016/j.frl.2020.101615

Al-Yahyaee, K. H., Mensi, W., Rehman, M. U., Vo, X. V., & Kang, S. H. (2020). Do Islamic stocks outperform conventional stock sectors during normal and crisis periods? Extreme co-movements and portfolio management analysis. Pacific-Basin Finance Journal, 62, 101385. https://doi.org/10.1016/j.pacfin.2020.101385

Baur, D. G., & Hoang, L. T. (2021). A crypto safe haven against Bitcoin. Finance Research Letters, 38, 101431. https://doi.org/10.1016/j.frl.2020.101431

Baur, D. G., Hong, K., & Lee, A. D. (2018). Bitcoin: Medium of exchange or speculative assets? Journal of International Financial Markets, Institutions and Money, 54, 177–189. https://doi.org/10.1016/j.intfin.2017.12.004

Bouri, E., Shahzad, S. J. H., Roubaud, D., Kristoufek, L., & Lucey, B. (2020). Bitcoin, gold, and commodities as safe havens for stocks: New insight through wavelet analysis. The Quarterly Review of Economics and Finance, 77, 156-164. https://doi.org/10.1016/j.qref.2020.03.004

Conlon, T., & McGee, R. (2020). Safe haven or risky hazard? Bitcoin during the COVID-19 bear market. Finance Research Letters, 35, 101607. https://doi.org/10.1016/j.frl.2020.101607

Hasan, M. B., Hassan, M. K., Gider, Z., Rafia, H. T., & Rashid, M. (2023). Searching Hedging Instruments Against Diverse Global Risks and Uncertainties. The North American Journal of Economics and Finance 66, 101893. https://doi.org/10.1016/j.najef.2023.101893

Hasan, M. B., Hassan, M. K., Rashid, M. M., & Alhenawi, Y. (2021). Are safe haven assets really safe during the 2008 global financial crisis and COVID-19 pandemic? Global Finance Journal, 50, 100668. https://doi.org/10.1016/j.gfj.2021.100668

Hasan, M. B., Rashid, M. M., Shafiullah, M., & Sarker, T. (2022). How resilient are Islamic financial markets during the COVID-19 pandemic? Pacific-Basin Finance Journal, 74, 101817. https://doi.org/10.1016/j.pacfin.2022.101817

Hassan, M. K., Hasan, M. B., Halim, Z. A., Maroney, N., & Rashid, M. M. (2022). Exploring the dynamic spillover of cryptocurrency environmental attention across the commodities, green bonds, and environment-related stocks. The North American Journal of Economics and Finance, 61, 101700. https://doi.org/10.1016/j.najef.2022.101700

Jiang, Y., Nie, H., & Ruan, W. (2018). Time-varying long-term memory in Bitcoin market. Finance Research Letters, 25, 280-284. https://doi.org/10.1016/j.frl.2017.12.009

Mnif, E., Salhi, B., Trabelsi, L., & Jarboui, A. (2022). Efficiency and herding analysis in gold-backed cryptocurrencies. Heliyon, 8(12), e11982. https://doi.org/10.1016/j.heliyon.2022.e11982

Mo, B., Meng, J., & Zheng, L. (2022). Time and frequency dynamics of connectedness between cryptocurrencies and commodity markets. Resources Policy, 77, 102731. https://doi.org/10.1016/j.resourpol.2022.102731

Nadarajah, S., & Chu, J. (2017). On the inefficiency of Bitcoin. Economics Letters, 150, 6–9. https://doi.org/10.1016/j.econlet.2016.09.019

Shahzad, S. J. H., Bouri, E., Ahmad, T., & Naeem, M. A. (2022). Extreme tail network analysis of cryptocurrencies and trading strategies. Finance Research Letters, 44, 102106. https://doi.org/10.1016/j.frl.2021.102106

Torrence, C., & Compo, G. P. (1998). A practical guide to wavelet analysis. Bulletin of the American Meteorological Society, 79(1), 61-78. https://doi.org/10.1175/1520-0477(1998)079<0061:APGTWA>2.0.CO;2

Torrence, C., & Webster, P. J. (1998). The annual cycle of persistence in the El Nino/Southern Oscillation. Quarterly Journal of the Royal Meteorological Society, 124(550), 1985-2004. https://doi.org/10.1002/qj.49712455010

Umar, Z., Gubareva, M., & Teplova, T. (2021). The impact of Covid-19 on commodity markets volatility: Analyzing time-frequency relations between commodity prices and coronavirus panic levels. Resources Policy, 73, 102164. https://doi.org/10.1016/j.resourpol.2021.102164

Urquhart, A. (2016). The inefficiency of Bitcoin. Economics Letters, 148, 80–82. https://doi.org/10.1016/j.econlet.2016.09.019

Yousaf, I., & Yarovaya, L. (2022). Spillovers between the Islamic gold-backed cryptocurrencies and equity markets during the COVID-19: A sectorial analysis. Pacific-Basin Finance Journal, 71, 101705. https://doi.org/10.1016/j.pacfin.2021.101705