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Can Bitcoin Become a Hedge, Diversifier, or Safe-Haven for Emerging and Frontier Stock Markets?

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Abstract: The popularity of Bitcoin increases with time and investors take it as an alternative investment due to continuous financial instability and uncertainty throughout the world. It can be an alternative not only for developed markets but also for emerging and frontier markets. Prior to now, researchers focused solely on developed markets. For this purpose, the present paper has explored the answer to the question of whether Bitcoin enables a hedge or diversifier or safe-haven against emerging and frontier stock market indices. Instead of previous analyses, here we have examined constancy relationships as well as time-varying relationships between Bitcoin with four stock indices of emerging and frontier stock markets of four different countries. We have applied the GJR-GARCH method to find the answer to the question, and we have also applied the Threshold Autoregressive (TAR) model for cross-validation of the findings. Our empirical results have shown that Bitcoin has safe-haven abilities are in normal and turmoil market situations for emerging and frontier stock markets. Also, we have found evidence of hedging and diversification properties.

Keywords: Bitcoin, Diversifier, Emerging and frontier stock markets, Hedge, Quantile, Safe-haven

1. Introduction

In this recent era, all financial markets, such as stock markets, digital currency markets, energy markets, precious metal markets, and different financial instruments, have rapidly grown in number, value, and volume. This rapid progression has simultaneously elevated risks and uncertainty in the financial procedure and potentially generate the essentiality of a safe-haven characteristic for the investors. Even though Bitcoin has connected every so often with the safe-haven properties, in most cases, researchers are not mindful of any research investigating this proposition. From the definition of [1], there is an apparent discrepancy between a hedge, a diversifier, and a safe-haven property. Therefore, it is necessary to test whether Bitcoin acts as the mentioned features. Due to the recent popularity and acceptance as well as searching for alternative investment places, the choice of Bitcoin is not exorbitant at all. The theoretical explanations from any econometrical model are limited or not at all referring to the mentioned features of Bitcoin. Maybe one major reason or explanation is that it can be served like money and can be used to hedge against inflation and financial instability. Another reason, Bitcoin is uncorrelated or has very little correlation with other kinds of assets, which is a key attribute in this epoch of globalization, where correlations amplified intensely amongst most of the assets. These postulates could be impacted significantly by the function of Bitcoin.

After the introduction of Bitcoin by [2], the new era of virtual currency was started as a new monetary resource that operates a peer-to-peer automated cash system allowing online transactions directly to transfer one person to another without involving any financial institutions. For that reason, there is no need for any associate authority for Bitcoin like most of the financial assets and thus no necessity for tangible representatives. The most attractive uses of Bitcoin are very low transaction costs, peer-to-peer technology, strong security, and globalization, and free of centralized control. However, the acceptability of Bitcoin reduces due to lack of computer knowledge, lack of conviction about the Bitcoin transaction system of its users, very high Bitcoin volatility compared to other financial assets, and limited area of acceptable financial institutions to take Bitcoin as an alternative currency. Nonetheless, Bitcoin's popularity increases significantly because of frequently addressing by media (both in print and electronic), investors, policy-makers, financial institutions, politicians, researchers, and government. From the inauguration of Bitcoin to 19th May 2017, the prices stayed below USD2000. However, its price rose over USD19000 on 16th December 2017 due to the frenzied market exhibiting the highest volatility (as seen in Fig. 1) [3] [4] and this increasing figure is another

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proof of the acceptability of Bitcoin. The questions arise with Bitcoin's climbing popularity, how Bitcoin's price is correlated with monetary assets (such as stock prices, energy prices, precious metal prices, and bond prices) is the topmost concern of comprehending for the investors, researchers, regulators of the governing body, policymakers, and government of a country. Another question, is Bitcoin valuable like other assets, or is it comparable with other assets to include in the portfolio? We have tried to explore the answer to this question of how it can be utilized as an alternative risk management counter to financial markets.

Bitcoin is a growing e-cash in the virtual markets and the largest both in volume and market capitalization. It occupied 89% of the market share from the total share of whole digital currency markets as of [5] and is considered the leading valuable and acceptable cryptocurrency. Bitcoin price volatility increases substantially over time compared to the regular currency. Reference [6] has observed that Bitcoin volatility became double counter to the 51 conventional currencies average volatility from the period between July 2010 and June 2014. To see the driving forces of Bitcoin prices researchers got mixed findings. Reference [6] has concluded that Bitcoin returns were uncorrelated to speculative trading, whereas [7] has shown that Bitcoin value exposes speculative bubbles and has no fundamental value. Reference [8] has tried to find the answer to whether Bitcoin acts as currency or as a commodity and concludes that Bitcoin returns pointed positive response to the US dollar and US Federal Funds rate. He also found risk management abilities of Bitcoin against exchange rates of dollar-euro and dollar-pound, almost similar findings found in the case of gold by [9]. Thus, [8] suggested that Bitcoin could be categorized as not the same as gold and US dollar, something in between them, and could be used as a portfolio management tool. In the [10] study, they found gold has a significant impact on the financial markets, especially when the markets are in turmoil, whereas Bitcoin performs precisely in the opposite way and is strongly correlated with downstream markets. They also observed that there is no evidence of hedging abilities.

Reference [11] has assessed gold price with yen-dollar and sterling-dollar exchange rates and found gold's hedging abilities against exchange rates, but this relationship moved across time and depended on political situations. An in-depth investigation of safe-haven and hedging features of gold has been done by [1]. Their studies found evidence of safe-haven and hedge properties of gold only on stocks, but there is no such effect on bonds. However, they also found that gold performs as safe-haven only for 15 days after markets fall. By applying wavelet analysis, [12] has shown that gold provides safe-haven benefits for a maximum of one year, whereas [13] has found that the safe-haven abilities of gold are not stable, suggesting that the hedging ability of gold is stable, but safe-haven ability oscillates over time. [14] have testified that from 2000 onwards, gold can work as a safe-haven for the UK pound and US dollar. Thus, the literature is enriched by assessing the safe-haven and hedging characteristics of gold, but there are scarcities of a detailed Bitcoin investigation.

In recent years, the researchers have gotten attention to enrich the literature of the association amongst Bitcoin with other monetary assets, which resolves the question of whether Bitcoin performed as a safe-haven, hedge, or diversifier counter to the other monetary assets. An approach of quantile regression to investigate the correlation between global uncertainty and gold, [15] has shown that Bitcoin only serves as a hedge counter to global uncertainty in a short run horizon and in the time of bull markets. Applying the dynamic conditional correlation (DCC) model in their analysis, [16] have shown that there is inadequate evidence of safe-haven and hedging capabilities of Bitcoin, although they found strong evidence of efficient diversifier. [17] added that Bitcoin has its risks, which are challenging to hedge against, but still, it can play an essential role in the investor's portfolio. However, Bitcoin could act as a safe-haven shown by [18], while its time-varying function varies across markets. Very recent work of [19] has shown in their studies that if investors include cryptocurrencies into their stock-bond-commodity portfolios, which radically enhances portfolio performance through extremely high risk-adjusted returns. Similar findings are obtained by [20] in their studies. Hence, there is some evidence of Bitcoin hedging and diversification abilities, but a detailed examination is essential in the case of Bitcoin to fill up the lacks in the literature. Reference [21]'s robustness metrics, which include risk ratios and diversification advantages, show that when coupled with Bitcoin in a portfolio, the Islamic equities market has hedging potential. Reference [22] found that Bitcoin has the potential to serve as a safe-haven for investors in four key asset classes. However, Bitcoin hedging capability is found in the case of commodities from metals, agriculture, and energy [23]. In recent studies, researchers found evidence of Bitcoin hedging and diversification ability against various sectors [24][25].

Our econometric model consists of regression analysis where Bitcoin returns regressed on returns of the stock index with two interaction terms. This model assesses whether Bitcoin acts as a hedge or diversifier or safe-haven when the stock market is in turmoil or exhibit excessive negative returns. In this analysis, we have used two different categories of stock markets with four major indices of four different countries. These markets are categorized by the MSCI index, one is emerging markets, two indices from which are Malaysia stock index (FBMKLCI index) and India stock index (Nifty50 index), and another is frontier markets, two indices from which are Bangladesh stock index (DSEX index) and Nigeria stock index (NGSE index). The research pertinent to this subject is comparatively meager. Only a few papers [8], [16], [20], [26], [27], [28], [29] have investigated the function of Bitcoin as a hedge or diversifier. All those studies are related to Bitcoin with currencies or stock indices of developed markets. This

is due to the fact that the developed markets seem like tranquil markets and less volatile counter to the emerging and frontier markets.

Based on our knowledge, there is no paper related to Bitcoin as a hedge or safe-haven or diversifier for emerging and frontier markets. Notably, the study of frontier markets always falls into the blind side of the research; one of the reasons is unstable markets; that is, most of the time, this type of market exhibits high volatility. Moreover, there is no paper related to cross-validation through two different techniques. This study also offered flight-to-quality literature; in other words, this study has explored the answer to the question of whether the stakeholders run away from stock markets to Bitcoin when stocks unveil severe losses. Here we have followed [1], where they used three quantiles, namely 5%, 2.5%, and 1% quantile in the regressor to investigate safe-haven capabilities during the extreme market conditions. Here the $q\%$ lower quantile, such as 5%, 2.5%, and 1% means that if the return is higher than the $q\%$ quantile, then the value of $r_{Stock,t(q)}$ is 0 (zero). Also, following [27] and [30] techniques for cross-validation purposes, we have applied the TAR model considering the break in the data.

The other parts of this paper are structured as explanations of data types, their returns procedure, and their detailed analysis of characteristics are presented in the data source. After that, the methodology section has visualized the method used in this paper. In contrast, a detailed analysis of results and their critical investigations are presented in the results and discussion section. Finally, the overall discussions are in the conclusion section, followed by references.

2. Data Source

Based on MSCI indexing, two emerging markets, namely, Malaysia stock index (FBMKLCI index) and India stock index (Nifty50 index) and two frontier markets, Bangladesh stock index (DSEX index) and Nigeria stock index (NGSE index), together with Bitcoin are considered for our analysis. The daily data of DSEX was collected from dsebd.org, and the rest of the data were collected from investing.com in the time interval 29^{th} January 2013 to 25^{th} March 2020, a total of 2613 observations in each variable. Bitcoin is trading 24 hours and 7 days a week, but stock markets are trading 5 days a week and off trading during special occasions. For that reason, we already interpolated missing values taken as mid-point. Since Bitcoin traded 24 hours and stock markets traded few hours in a day, therefore, to overcome this issue, we have taken closing price and closing indices. The sample data is not stationary. To remove such nonstationary status, we have taken the logarithmic return. Let r_t represent logarithmic return, p_t is the stock index at time t and p_{t-1} is the stock index at time t-1. Then the logarithmic return for Bitcoin and stock index are as follows:

$$r_t = 100 * \log\left(p_t / p_{t-1}\right)$$

Fig. 1 shows a time-series graph of the sample data and the return data. Three stock indices DSEX, FBMKLCI, and Nifty50 have a similar trend in the entire sample, and NGSE rises around January 2014, then decreases become lowest around January 2016, again peak around January 2018, then falls. BTC was bear market from the beginning up to 2017 in the entire sample period, then rises become peak around January 2018, but the trend is not obvious. The variables dBTC, dDSEX, dFBMKLCI, dNGSE, and dNifty50 are represented as returns of BTC, DSEX, FBMKLCI, NGSE, and Nifty50, respectively. Summary statistics of returns are presented in Table I, where Bitcoin's average return is over 18 times bigger than all indices' average return, and NGSE has the lowest average return. Only Bitcoin and Nifty50 returns are positive, where others have negative returns. Bitcoin is over 33 times more volatile than the stock indices, and FBMKLCI is the least volatile among them. DSEX and NGSE returns are positively skewed, others are negatively skewed, and all variables possess leptokurtic distribution, which means all variables experience tail disturbances. From Table I, the p-value of the Jarque-Bera test showed that the returns are not normally distributed. According to the p-value of the ADF test (in Table I), all sample data are nonstationary, but after the first difference of logarithm, returns are stationary. Fig. 1 also confirms that the return data graphs are stationary. The correlation matrix of Bitcoin with stock index and their 5%, 2.5%, and 1% quantile are reported in Table II, where the correlation between index returns and Bitcoin is positive, and few are negative but very weak relation.

3. Methodology

Following [1], we have used an econometric model in this paper to examine whether Bitcoin is a hedge or diversifier, or safe-haven. Thus, our primary regression model can be written as follows:

$$r_{dBTC,\,t} = a + b_1 r_{Stock,\,t} + b_2 r_{Stock,t(q)} + \phi_1 r_{dBTC,\,t-1} + \theta_1 \varepsilon_{t-1} + \varepsilon_t \quad (1)$$

where $r_{dBTC,\,t}$ and $r_{Stock,\,t}$ are Bitcoin return and stock index return at time t, respectively, ε_t is error term at time t and a is constant. ϕ_1 and θ_1 are coefficient of AR and MA terms, respectively. The additional term $r_{Stock,t(q)}$ is consider for asymmetry of positive shocks and negative shocks to observe falling stock markets. Particularly we want to observe Bitcoin's role in times of extreme stock markets condition; for that purpose, we include in the regressors $q\%$ below quantile of stock returns, such as 5%, 2.5%, and 1% quantile (all three quantiles represent extreme condition). The return $r_{Stock,t(q)}$is considered zero when higher than $q\%$ quantile. If the coefficient b_1 is zero (0) or negative, it means that Bitcoin can hedge for stock index although they are uncorrelated or negatively correlated. Whether Bitcoin become a safe-haven for the stock index is examine via the coefficient b_2. If the sum of the coefficient b_1 and b_2, i.e., total impact in extremely tumbling stock index is

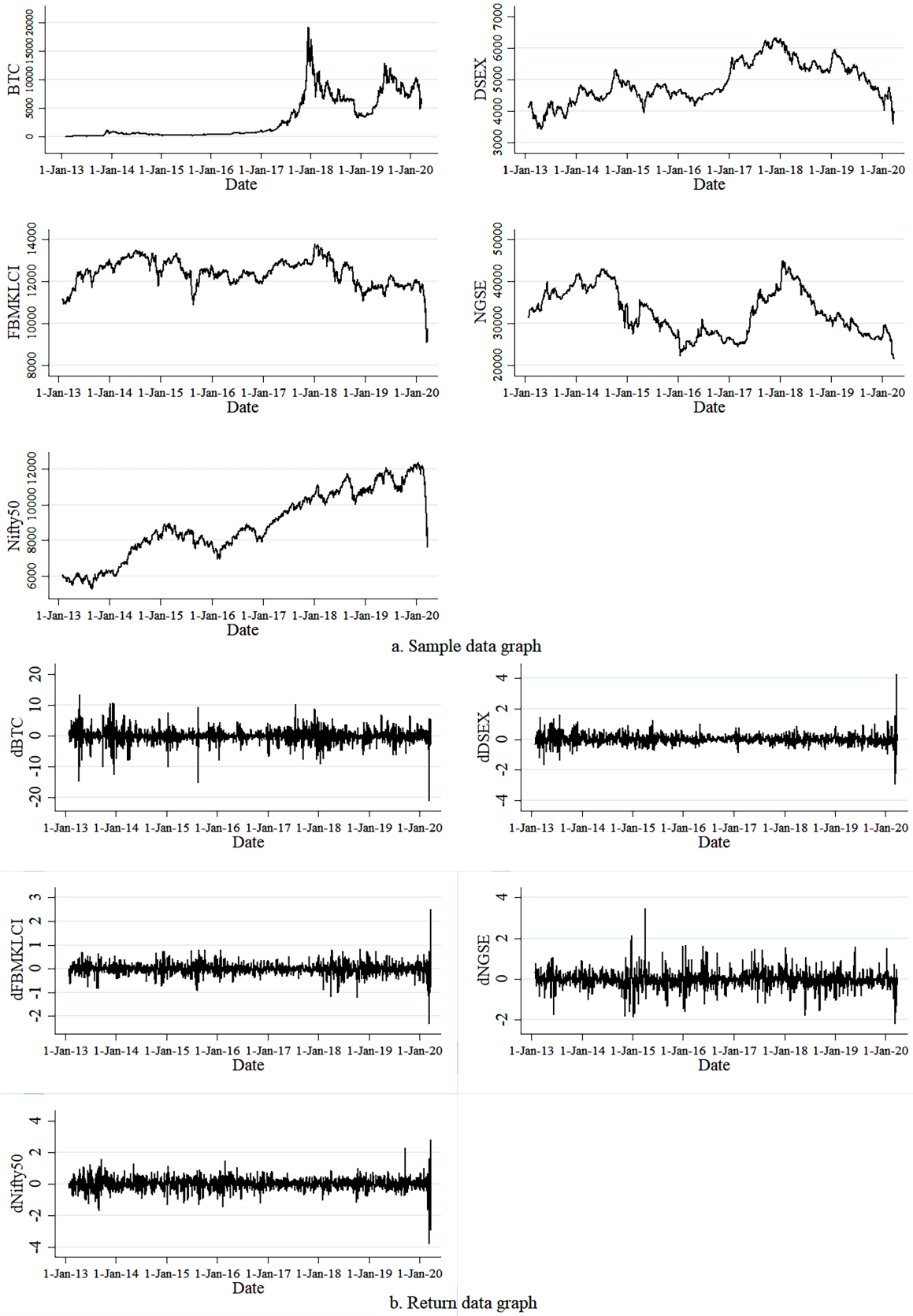

Figure 1. The five time-series graphs in a. sample data graph and b. return data graph from 29th January 2013 to 25th March 2020

TABLE I. Summary statistics of Bitcoin and four stock indices returns

Variables	Mean	Variance	Standard deviation	Skewness	Kurtosis	JB	ADF
dBTC	0.09704	4.07778	2.01935	-0.76910	14.70647	0.0000	0.0000
dDSEX	-0.00060	0.07860	0.28036	1.04655	32.12315	0.0000	0.0000
dFBMKLCI	-0.00227	0.04294	0.20722	-0.04886	21.18760	0.0000	0.0000
dNGSE	-0.00621	0.12031	0.34686	0.35057	13.66265	0.0000	0.0000
dNIFTY50	0.00529	0.10768	0.32814	-0.81223	19.74581	0.0000	0.0000

TABLE II. Correlation of Bitcoin with stock indices and their 5%, 2.5%, and 1% quantile

Variables	dBTC	Variables	dBTC	Variables	dBTC	Variables	dBTC
dDSEX	0.0220	dFBMKLCI	0.0041	dNGSE	0.0163	dNIFTY50	0.0143
dDSEX(5%)	0.0135	dFBMKLCI(5%)	0.0233	dNGSE(5%)	0.0657**	dNIFTY50(5%)	-0.0781**
dDSEX(2.5%)	-0.0047	dFBMKLCI(2.5%)	0.0188	dNGSE(2.5%)	0.0778**	dNIFTY50(2.5%)	-0.0799**
dDSEX(1%)	-0.0246	dFBMKLCI(1%)	0.0129	dNGSE(1%)	0.1002**	dNIFTY50(1%)	-0.0313

** represent 5% significance level

non-positive, then Bitcoin becomes a safe-haven for stock index although their correlation is zero (sum of coefficients is zero) or correlation is negative (sum of coefficients is negative). When the correlation of Bitcoin and stock index is negative during extreme market situations, Bitcoin price will rise in such situations, thus recompensing stockholders for losses experienced in stock investment.

Since there exist ARCH effect and heteroskedasticity (which confirm by the ARCH test (χ^2 = 227.718, degree of freedom, df = 5, and p-value = 0.0000) and white noise test (χ^2 = 499.50, df = 14 and p-value = 0.0000) after the OLS regression), therefore, the necessity of the GARCH family model, similar to [11] and [8], we have used in this paper asymmetric GARCH model to classify volatility correlations. Asymmetric models can describe the significance of dynamic relationships amidst the variables, therefore vital to estimate the models. If the return increases, the volatility of the time series tends to decline, but if the return decreases, it has a tendency to rise, which is known as leverage effects that make asymmetry vital in time series modeling [31]. Therefore, we have used a GJR-GARCH model proposed by [32] with a normal distribution. Additionally, we have identified an ARMA(1,1) process in the mean equation on bitcoin return, which will improve the accuracy of estimation, similarly to [11] and [8], where they added AR(1) process in their models. Then the GJR-GARCH(1,1) specification is

$$\sigma_t^2 = \omega + \alpha_1 \varepsilon_{t-1}^2 + \gamma I \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \tag{2}$$

where I is indicator function equal to 1 if $\varepsilon_{t-1} < 0$ otherwise 0. σ_t^2 is variance return, ω is constant, α_1 and β_1 is ARCH and GARCH terms, respectively, and γ is the asymmetric term (or leverage effects).

For cross-validation, we have applied the TAR model like [27] and [30] to observe hedge, diversification, or safe-haven characteristics of Bitcoin on index returns. Here we have applied OLS with Heteroskedasticity and Autocorrelation Consistent (HAC) standard errors for our estimation of

$$r_{dBTC,\ t} = a_{0,1} + b_{1,1} dIndex_t + b_{2,1} r_{dBTC,\ t-1} + \varepsilon_t \tag{3}$$

where $dIndex_t$ are indices return at time t and $a_{0,1}$ is constant. The model from equation (3) allows further investigation of the hedging abilities of Bitcoin throughout the whole sample of our data. By extending the equation (3) to find the answer to whether Bitcoin displays safe-haven benefits, here we have applied the [33] threshold testing technique. This test classifies index returns from a positive return to a negative return then identifies a single unknown breakpoint. However, there is a possibility of multiple thresholds in index returns, so augment Hansen's (2000) technique by employing [34], [35] multiple structural change analysis to classify the returns. This method seeks a maximum number of thresholds within the returns to find overall probable combinations of unknown breakpoints. Therefore, the extended model can be presented as

$$\begin{aligned}
r_{dBTC,\ t} &= a_{0,1} + b_{1,1} dIndex_t + b_{2,1} r_{dBTC,\ t-1} + \varepsilon_{1,t} \ if \ q_t \le \lambda_1 \\
&\vdots \\
r_{dBTC,\ t} &= a_{0,j} + b_{1,j} dIndex_t + b_{2,j} r_{dBTC,\ t-1} + \varepsilon_{j,t} \ if \ \lambda_{j-1} < q_t \le \lambda_j \\
&\vdots \\
r_{dBTC,\ t} &= a_{0,m} + b_{1,m} dIndex_t + b_{2,m} r_{dBTC,\ t-1} + \varepsilon_{m,t} \ if \ \lambda_m < q_t
\end{aligned} \tag{4}$$

where $a_{0,i}$ is constant, $\varepsilon_{i,t}$ is an error term, λ_i is the threshold value for $i = 1, \cdots, j, \cdots, m$ and q_t is the threshold

variable at time t. When the threshold variable is less than or equal to the threshold value, then we will consider a single regime model. When the threshold variable is between the $j-1^{th}$ and j^{th} threshold values, then we will consider the j-regime model. The threshold value is evaluated by taking the lowest value of sum-of-squared residuals, which is created for all possible thresholds. We included an additional lag term of the dependent variable in the explanatory variables to confirm potential serial correlations in errors. As it has concluded, adding only the first lag that is one lag of the dependent variable, is enough to guarantee serial-correlation-free errors [27]. This permits us endogenously to detect stock index thresholds where Bitcoin characteristic changes over time and, in doing so, examine whether Bitcoin turns as safe-haven in the extreme conditions for index returns.

4. Results and Discussion

Estimated results of equations (1) and (2) are presented in Table III. Since our primary concern is to analyze hedge, diversification, and safe-haven properties, for this reason, we discarded constant terms from Table III. Because these terms have no influence on the analysis. Here we are not going to scrutinize the output since the wide-ranging purposes of the ARMA(1,1)-GJR-GARCH(1,1) model is to study the characteristics of Bitcoin over the stock index. However, in the mean-equation ARMA(1,1) terms are significant, GARCH coefficients together with asymmetry terms (γ) are most significant, and thus we can claim that the models are well-defined corresponding to specification errors. The presence of a significant negative asymmetric term implies that a negative shock (or bad news) raises the debt-equity ratio. That means negative leverage is referred to as a negative return on equity as a result of higher interest on debt than investment return. Furthermore, negative leverage will also refer to the debt-equity ratio arising from a firm (or a company) having a negative net worth. The estimated coefficient shows the average impact of the stock index on Bitcoin is -0.528 for DSEX, -0.0993 for FBMKLCI, -0.120 for NGSE, and 0.0742 for NIFTY50. The only coefficient of DSEX return is significant at a 1% level; others are insignificant. The sign together with the value of coefficients b_1 from equation(1) decide whether Bitcoin becomes a hedge or diversifier. From the explanations of [1], negative correlation (or uncorrelated) indicates a robust hedging relationship; the positive correlation (but not perfectly) suggests a diversifier, and when the market is in turmoil, negative correlation (or uncorrelated) indicates safe-haven relationship. When correlation is positive, and less than one can be considered as a weak hedge. It is essential to reduce risk in a real-world application; therefore, robust hedging capabilities are of utmost desire because the practical application is less complex to minimize risks. We have seen that DSEX, FBMKLCI, and NGSE return are negatively correlated with Bitcoin return; therefore, an indication of the hedging relationship; NIFTY50 is positively correlated with Bitcoin return which suggests that Bitcoin can play diversifier or a weak hedge. Since DSEX return is significantly negatively correlated and the value is very high; therefore, an indication of a strong hedging relationship. These findings of Bitcoin's weak hedging ability are analogous to [26] and [8]. Therefore, investors from Bangladesh can get strong hedging benefits compared to the other countries.

In the case of extremely negative stock index returns, coefficients b_2 for 5% quantile are negative for NGSE and NIFTY50 returns and positive for DSEX and FBMKLCI returns, for 1% quantile all returns are positive, and 2.5% quantile all returns are negative except NIFTY50 return. The sum of all estimated coefficients will give total effects for a quantile. For example, total effects of 1% quantile are -1.0705 for DSEX return, 4.1607 for FBMKLCI return, 2.426 for NGSE return, and -0.6726 for NIFTY50 return, which implies that during stock index return reveal extremely negative that is in 1% quantile, Bitcoin price sharply increases against DSEX return and slightly against NIFTY50 return.

We have taken one lag for all markets except for NIFTY50 because optimal lag length carries a significant specification. No lags for NIFTY50 return because this lag has no impact on it. Thus, it is necessary to include lagged effects on total contemporaneous effects in index returns. The total effects (including lagged effects) are -1.8085 for DSEX, -0.0153 for FBMKLCI, and 1.765 for NGSE returns are stronger (since the total effect including lagged effect is lower than the total effect without lagged effect) than corresponding contemporaneous effects of -1.0705, 4.1607, and 2.426, respectively.

For safe-haven proposition, the sum of coefficients ($-0.12-0.191=-0.311$ and $0.0742-2.051=-1.9768$) is negative for 5% quantile in NGSE and NIFTY50 returns, for 2.5% quantile become negative except FBMKLCI returns and for 1% quantile become positive in all the stock indices returns except DSEX and NIFTY50 returns, which suggests that Bitcoin serves as a safe-haven at 2.5% quantile except FBMKLCI returns and 5% quantile only for NGSE and NIFTY50 returns. However, during more extreme situations (that is in 1% quantile), the safe-haven proposition is rejected. Only DSEX and NIFTY50 returns get benefits from safe-haven features in more extreme situations. More precisely, Bitcoin price increases when index returns fall at 5% quantile (NGSE and NIFTY50 returns), 2.5% quantile (DSEX, NGSE, and NIFTY50 returns), and 1% quantile (DSEX and NIFTY50 returns). While Bitcoin price co-movement with index returns if index returns fall at 5% quantile (DSEX and FBMKLCI returns), 2.5% quantile (FBMKLCI returns), and 1% quantile (FBMKLCI and NGSE return). Similar results were found by [1] in the case of bond returns, where gold and bonds show co-movement during extreme markets condition.

The notion that Bitcoin is a safe-haven for stock indices indicates that investors who retain Bitcoin in normal

TABLE III. Estimated results of ARMA(1,1)-GJR-GARCH(1,1) model for DSEX, FBMKLCI, NGSE, and NIFTY50 returns

For DSEX return									
$r_{dBTC,\ t}$	b_1	$b_2(5\%)$	$b_2(2.5\%)$	$b_2(1\%)$	ϕ_1	θ_1	α_1	γ	β_1
Coeff.	-0.528***	1.067*	-1.659	0.0495	-0.939***	0.92***	0.216***	-0.075***	0.776***
	(0.0765)	(0.646)	(1.138)	(1.157)	(0.0451)	(0.0532)	(0.0188)	(0.0186)	(0.013)
1 lag									
Coeff.	0.132	0.231	-1.213	0.112					
	(0.127)	(0.345)	(1.142)	(1.223)					
For FBMKLCI return									
Coeff.	-0.0993	4.123***	-2.31	2.447*	0.975***	-0.964***	0.199***	0.013	0.757***
	(0.16)	(0.699)	(1.553)	(1.452)	(0.0248)	(0.0298)	(0.0174)	(0.0212)	(0.0112)
1 lag									
Coeff.	0.108	5.803***	-6.032***	-4.055**					
	(0.155)	(0.549)	(1.975)	(1.995)					
For NGSE return									
Coeff.	-0.12	-0.191	-0.698	3.435***	-0.938***	0.918***	0.184***	-0.018	0.766***
	(0.0928)	(0.803)	(0.937)	(0.585)	(0.0481)	(0.057)	(0.0177)	(0.0187)	(0.0129)
1 lag									
Coeff.	0.077	-0.525	1.917***	-2.13***					
	(0.0977)	(0.484)	(0.619)	(0.641)					
For NIFTY50 return									
Coeff.	0.0742	-2.05***	1.25	0.0542	-0.937***	0.916***	0.211***	-0.068***	0.783***
	(0.0923)	(0.176)	(1.127)	(1.173)	(0.0453)	(0.0533)	(0.0158)	(0.0148)	(0.0132)

and stressful times are compensated for losses caused by negative stock returns through positive Bitcoin returns. Nevertheless, what will happen if an investor invests in Bitcoin purchases after extreme shocks happened in the stock market? The lagged value (1 lag of coefficient b_1) of index return is positive in all markets, and a total of the lagged value of index return in extreme condition, negative for DSEX and FBMKLCI returns at 2.5% and 1% quantile, and for NGSE return at 5% and 1% quantile which implies that for negative index returns at time t compensate positive Bitcoin returns at time $t+1$. For the NIFTY50 return, we have not found any such effect. Similar findings were also obtained by [1]; in their results, the United States shows such effect, but Germany and the United Kingdom did not. So, from the above results, we can conclude that the investors who purchase Bitcoin after extreme shocks yielding a positive Bitcoin return, which is also a function of safe-haven. Therefore, our empirical results confirm that Bitcoin possesses both hedging and safe-haven properties for index returns and, in some cases, weak hedge or evidence of diversification feature. These findings are similar to [36] and [37], where Bitcoin offered as a hedge for the developing countries but worked as a diversifier only for developed countries.

Table IV is estimated results of equation (3) where we have reported a positive relationship amongst Bitcoin and indices returns (coefficient $b_{1,1}$) implies that Bitcoin can be used as a diversifier. Thus, these findings support further proof of the probable repayments of Bitcoin to stock index investors. Since the adjusted R-squared is low, it implies that the extra input variable is not providing value to the model. Therefore, it suggests that we need to estimate equation (4).

To inspect whether the connection amid Bitcoin and stock index divergences when the devaluation of the stock index goes beyond a certain level, Table V gives details of multiple-thresholds regression outcomes of equation (4). Panel A shows null hypothesis test results of no break contrary to the alternative hypothesis of 4 breaks (based on [34], [35] test), i.e., there are 4 thresholds (5 regimes). Table V panel A also shows that the returns value corresponding to 4 breakpoints found in the samples and the sum-squared-residuals (SSR) are reported. These results validate the presence of non-linearity correlations amongst Bitcoin and stock indices, which was possibly unexplored in OLS regression estimations in Table IV. In panel B, constants, index returns, and lagged terms of Bitcoin returns with five situations such as very low, low, medium, high, and extreme are reported. From panel B, when the market is in extreme situations (the high and extreme levels considered as extreme situations according to [27]), the coefficients in different levels for index returns indicate that Bitcoin becomes a safe-haven for FBMKLCI, NGSE and NIFTY50 returns. In these cases, there are negative correlations between Bitcoin and index in extreme market conditions means that when stock indices are in unstable conditions, the Bitcoin value increases over time. Our estimated results show that Bitcoin does not offer safe-haven properties in times of extreme market conditions for DSEX indices, which suggests that when returns are positive, Bitcoin cannot confirm safe-haven properties for the investors. Thus, our findings confirm the safe-haven

TABLE IV. Estimated results of equation (3) where $b_{1,1}$ is index returns and $b_{2,1}$ is lagged term of Bitcoin returns

	dDSEX	dFBMKLCI	dNGSE	dNIFTY50
$a_{0,1}$	0.116334**	0.115762**	0.078484**	0.11524**
	(0.051217)	(0.050975)	(0.033977)	(0.051473)
$b_{1,1}$	0.201168	0.023639	0.118917	0.113844
	(0.234116)	(0.212438)	(0.153196)	(0.353141)
$b_{2,1}$	-0.20604**	-0.20065**	0.193497***	-0.2024**
	(0.080973)	(0.08219)	(0.070195)	(0.081194)
AdjR^2	0.001189	0.000435	0.000925	0.00077

benefits of Bitcoin for FBMKLCI, NGSE and NIFTY50 indices but not for DSEX. Therefore, the estimated results of equations (3) and (4) are analogous with our above findings and also with [27] and [30], where some currencies showed hedging and safe-haven status, but some are not.

5. Conclusion

This paper solely examines hedge, diversification, and safe-haven characteristics between emerging and frontier stock markets and Bitcoin. A safe-haven attribute is easily differentiated from hedging and also diversifier attribute, which afford safe-haven aids typically but not certainly when most desirable, i.e., during the turmoil market. The key features of this study are (i) to classify the behavior of Bitcoin on emerging and frontier stock markets, (ii) to apply quantile concepts within the model to observe extreme market conditions, and (iii) finally, to employ two different models separately for the cross-validation purposes. From two different analyses, it is evident that Bitcoin serves as a hedge against the stock index and thus can be applied to minimize or eradicate market risks. The analyses from Table III, DSEX has got strong hedging benefits from Bitcoin compared to the other indices. We have found evidence of diversification benefits from Bitcoin, i.e., Bitcoin can be used as a diversifier. From the first analysis when the markets are in turmoil conditions (that is in extreme situations), we have seen Bitcoin assures safe-haven benefits against all stock indices except the FBMKLCI index.

Nevertheless, only DSEX and NIFTY50 secure safe-haven facilities from Bitcoin when the markets are in more extreme conditions. We have also observed that after extreme market situations, Bitcoin gives advantages to safe-haven assets for DSEX, FBMKLCI, and NGSE indices. From the second analysis, we have seen that FBMKLCI, NGSE and NIFTY50 obtain safe-haven facilities from Bitcoin. Therefore, we conclude that investors who purchase Bitcoin during turmoil markets will compensate for positive Bitcoin returns. Overall, our findings have valuable insights for emerging and frontier markets, especially for frontier markets. From these categories of markets, investors can think about Bitcoin as an alternative investment in the case of market turmoil, and governments from those countries can rethink Bitcoin (not only Bitcoin but also all digital currencies) and implement some policies for the investors.

References

[1] D. G. Baur and B. M. Lucey, "Is gold a hedge or a safe haven? an analysis of stocks, bonds and gold," *Financial Review*, vol. 45, no. 2, pp. 217–229, 2010.

[2] S. Nakamoto, "Bitcoin: A peer-to-peer electronic cash system," *Decentralized Business Review*, p. 21260, 2008.

[3] Y.-J. Zhang, E. Bouri, R. Gupta, and S.-J. Ma, "Risk spillover between bitcoin and conventional financial markets: An expectile-based approach," *The North American Journal of Economics and Finance*, vol. 55, p. 101296, 2021.

[4] M. J. Hossain, M. T. Ismail *et al.*, "Is there any influence of other cryptocurrencies on bitcoin?" *Asian Academy of Management Journal of Accounting & Finance*, vol. 17, no. 1, 2021.

[5] A. F. Bariviera, "The inefficiency of bitcoin revisited: A dynamic approach," *Economics Letters*, vol. 161, pp. 1–4, 2017.

[6] B. M. Blau, "Price dynamics and speculative trading in bitcoin," *Research in International Business and Finance*, vol. 41, pp. 493–499, 2017.

[7] E.-T. Cheah and J. Fry, "Speculative bubbles in bitcoin markets? an empirical investigation into the fundamental value of bitcoin," *Economics letters*, vol. 130, pp. 32–36, 2015.

[8] A. H. Dyhrberg, "Hedging capabilities of bitcoin. is it the virtual gold?" *Finance Research Letters*, vol. 16, pp. 139–144, 2016.

[9] E. Tully and B. M. Lucey, "A power garch examination of the gold market," *Research in International Business and Finance*, vol. 21, no. 2, pp. 316–325, 2007.

[10] T. Klein, H. P. Thu, and T. Walther, "Bitcoin is not the new gold–a comparison of volatility, correlation, and portfolio performance," *International Review of Financial Analysis*, vol. 59, pp. 105–116, 2018.

[11] F. Capie, T. C. Mills, and G. Wood, "Gold as a hedge against the dollar," *Journal of International Financial Markets, Institutions and Money*, vol. 15, no. 4, pp. 343–352, 2005.

[12] D. Bredin, T. Conlon, and V. Potì, "Does gold glitter in the long-run? gold as a hedge and safe haven across time and investment horizon," *International Review of Financial Analysis*, vol. 41, pp. 320–328, 2015.

[13] B. M. Lucey and S. Li, "What precious metals act as safe havens, and when? some us evidence," *Applied Economics Letters*, vol. 22, no. 1, pp. 35–45, 2015.

TABLE V. Estimated results of TAR model for multiple breaks where there exist four breaks and five regimes

	dDSEX	dFBMKLCI	dNGSE	dNIFTY50
Panel A: Thresholds				
1	1.549482	1.549482	1.549482	1.549482
2	0.5104063	0.5486548	0.5329758	0.5885885
3	-0.3257242	-0.2362533	-0.3155055	-0.171705
4	-1.229584	-1.229584	-1.229584	-1.229584
SSR	2967.475	2966.381	2959.296	2941.956
Panel B: Coefficients				
$a_{0,1}$(very low)	3.050035***	3.050756***	3.052262***	3.051817***
	(0.106663)	(0.106718)	(0.106549)	(0.10621)
$a_{0,2}$(low)	0.942332***	0.972445***	0.958414***	1.000808***
	(0.014138)	(0.014521)	(0.014457)	(0.014449)
$a_{0,3}$(medium)	0.077818***	0.135178***	0.093341***	0.179502***
	(0.00762)	(0.007417)	(0.007828)	(0.00762)
$a_{0,4}$(high)	-0.695981***	-0.627145***	-0.68564***	-0.579055***
	(0.011835)	(0.011726)	(0.011842)	(0.011867)
$a_{0,5}$(extreme)	-2.941137***	-2.934591***	-2.938358***	-2.934699***
	(0.128974)	(0.127415)	(0.127715)	(0.127611)
$b_{1,1}$(very low)	0.320012	-0.231527	0.014988	-0.136467
	(0.225991)	(0.35206)	(0.259901)	(0.2692)
$b_{1,2}$(low)	0.070802	-0.098189	0.083898*	-0.018525
	(0.052688)	(0.077073)	(0.044666)	(0.044261)
$b_{1,3}$(medium)	-0.023398	0.029852	0.011058	-0.023087
	(0.034299)	(0.035119)	(0.027081)	(0.022614)
$b_{1,4}$(high)	0.008358	-0.123199**	-0.013007	-0.103316***
	(0.03262)	(0.053495)	(0.034625)	(0.035845)
$b_{1,5}$(extreme)	0.360174	0.63695	0.527776	0.782851
	(0.669568)	(0.766969)	(0.563279)	(1.030631)
$b_{2,1}$(very low)	-0.0771*	-0.072726*	-0.075381*	-0.076159*
	(0.040576)	(0.042089)	(0.041138)	(0.040812)
$b_{2,2}$(low)	0.002056	-0.005598	-0.004355	-0.005722
	(0.007894)	(0.008293)	(0.008017)	(0.008114)
$b_{2,3}$(medium)	-0.003592	-0.015898***	-0.010396*	-0.010445*
	(0.005714)	(0.005433)	(0.005573)	(0.0054)
$b_{2,4}$(high)	-0.000311	-0.010004	-0.003218	-0.004652
	(0.008101)	(0.008323)	(0.008069)	(0.008637)
$b_{2,5}$(extreme)	0.070875*	0.074393*	0.07437*	0.066786
	(0.041663)	(0.040818)	(0.040936)	(0.043584)

[14] C. Ciner, C. Gurdgiev, and B. M. Lucey, "Hedges and safe havens: An examination of stocks, bonds, gold, oil and exchange rates," *International Review of Financial Analysis*, vol. 29, pp. 202–211, 2013.

[15] E. Bouri, R. Gupta, A. K. Tiwari, and D. Roubaud, "Does bitcoin hedge global uncertainty? evidence from wavelet-based quantile-in-quantile regressions," *Finance Research Letters*, vol. 23, pp. 87–95, 2017.

[16] E. Bouri, P. Molnár, G. Azzi, D. Roubaud, and L. I. Hagfors, "On the hedge and safe haven properties of bitcoin: Is it really more than a diversifier?" *Finance Research Letters*, vol. 20, pp. 192–198, 2017.

[17] S. Corbet, B. Lucey, and L. Yarovaya, "Datestamping the bitcoin and ethereum bubbles," *Finance Research Letters*, vol. 26, pp. 81–88, 2018.

[18] S. J. H. Shahzad, E. Bouri, D. Roubaud, L. Kristoufek, and B. Lucey, "Is bitcoin a better safe-haven investment than gold and commodities?" *International Review of Financial Analysis*, vol. 63, pp. 322–330, 2019.

[19] E. Platanakis and A. Urquhart, "Should investors include bitcoin in their portfolios? a portfolio theory approach," *The British Accounting Review*, vol. 52, no. 4, p. 100837, 2020.

[20] A. Kajtazi and A. Moro, "The role of bitcoin in well diversified portfolios: A comparative global study," *International Review of Financial Analysis*, vol. 61, pp. 143–157, 2019.

[21] M. U. Rehman, N. Asghar, and S. H. Kang, "Do islamic indices provide diversification to bitcoin? a time-varying copulas and value at risk application," *Pacific-Basin Finance Journal*, vol. 61, p. 101326, 2020.

[22] S. H. Kang, S.-M. Yoon, S. Bekiros, and G. S. Uddin, "Bitcoin as hedge or safe haven: evidence from stock, currency, bond and derivatives markets," *Computational Economics*, vol. 56, no. 2, pp. 529–545, 2020.

[23] M. A. Naeem, S. Farid, F. Balli, and S. J. Hussain Shahzad, "Hedging the downside risk of commodities through cryptocurrencies," *Applied Economics Letters*, vol. 28, no. 2, pp. 153–160, 2021.

[24] J. Chu, S. Chan, and Y. Zhang, "Bitcoin versus high-performance technology stocks in diversifying against global stock market indices," *Physica A: Statistical Mechanics and its Applications*, p. 126161, 2021.

[25] M. Fakhfekh, A. Jeribi, A. Ghorbel, and N. Hachicha, "Hedging stock market prices with wti, gold, vix and cryptocurrencies: a comparison between dcc, adcc and go-garch models," *International Journal of Emerging Markets*, 2021.

[26] W. H. Chan, M. Le, and Y. W. Wu, "Holding bitcoin longer: The dynamic hedging abilities of bitcoin," *The Quarterly Review of Economics and Finance*, vol. 71, pp. 107–113, 2019.

[27] A. Urquhart and H. Zhang, "Is bitcoin a hedge or safe haven for currencies? an intraday analysis," *International Review of Financial Analysis*, vol. 63, pp. 49–57, 2019.

[28] M. Briere, K. Oosterlinck, and A. Szafarz, "Virtual currency, tangible return: Portfolio diversification with bitcoin," *Journal of Asset Management*, vol. 16, no. 6, pp. 365–373, 2015.

[29] M. J. Hossain, M. T. Ismail, S. Akter, and M. R. Hossain, "Which will serve better as a hedge or diversifier gold or bitcoin?" in *2020 International Conference on Decision Aid Sciences and Application (DASA)*. IEEE, 2020, pp. 1052–1055.

[30] R. Fatum and Y. Yamamoto, "Intra-safe haven currency behavior during the global financial crisis," *Journal of International Money and Finance*, vol. 66, pp. 49–64, 2016.

[31] M. J. Hossain, S. Akter, and M. T. Ismail, "Performance analysis of garch family models in three time-frames," *Jurnal Ekonomi Malaysia*, vol. 55, no. 2, pp. 15–28, 2021.

[32] L. R. Glosten, R. Jagannathan, and D. E. Runkle, "On the relation between the expected value and the volatility of the nominal excess return on stocks," *The journal of finance*, vol. 48, no. 5, pp. 1779–1801, 1993.

[33] B. E. Hansen, "Sample splitting and threshold estimation," *Econometrica*, vol. 68, no. 3, pp. 575–603, 2000.

[34] J. Bai and P. Perron, "Estimating and testing linear models with multiple structural changes," *Econometrica*, pp. 47–78, 1998.

[35] J. Bai and P. Perron, "Computation and analysis of multiple structural change models," *Journal of applied econometrics*, vol. 18, no. 1, pp. 1–22, 2003.

[36] A. Stensås, M. F. Nygaard, K. Kyaw, and S. Treepongkaruna, "Can bitcoin be a diversifier, hedge or safe haven tool?" *Cogent Economics & Finance*, vol. 7, no. 1, p. 1593072, 2019.

[37] J. Mizerka, A. Stróżyńska-Szajek, and P. Mizerka, "The role of bitcoin on developed and emerging markets–on the basis of a bitcoin users graph analysis," *Finance Research Letters*, vol. 35, p. 101489, 2020.

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