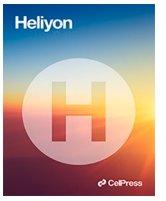
Heliyon 9 (2023) e16502

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon



Research article

How media coverage news and global uncertainties drive forecast of cryptocurrencies returns?☆

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ARTICLE INFO

Keywords:
Cryptocurrency
COVID-19 pandemic
QQA
Investor sentiment
Global uncertainty

ABSTRACT

This paper aims to investigate the impact of global financial, economic, and gold price uncertainty indices (VIX, EPU, and GVZ) and investor sentiment based on media coverage news on the returns of Bitcoin and Ethereum during the COVID-19 pandemic. We adopt an asymmetric framework based on the Quantile-on-Quantile approach, which examines the quantiles of the cryptocurrency returns, investor sentiment, and the various uncertainties indicators. The empirical findings suggest that the COVID-19 pandemic has significantly impacted cryptocurrency returns. Specifically, **(i)** the results demonstrate the predictive power of Economic Policy Uncertainty (EPU) during this period, as evidenced by a strong negative association between EPU and cryptocurrency returns across all quantiles; (**ii**) the correlation between cryptocurrency returns and the VIX index was negative but weak, across various quantile combinations of Ethereum and Bitcoin returns; (**iii**) an increase in COVID-19 news negatively affected Bitcoin returns across all quantiles; (**iv**) Bitcoin and Ethereum cannot be relied upon as effective hedging tools against global financial and economic uncertainty during the COVID-19 pandemic. Studying the behavior of cryptocurrency during uncertainty like pandemics is extremely important because it provides investors with insights on diversifying their portfolios and hedging their risks.

1. Introduction

Since their emergence, cryptocurrencies have received an exceeding interest due to the opinion that they may be considered a new investment category. The market for cryptocurrencies has experienced substantial growth since its inception. Bitcoin, introduced in early 2009, started trading at $0.50 in December 2010. Its value has since soared, reaching $40,040 in January 2021 and exceeding $50,000 in February 2021. Specifically, on the 19th of the same month, Bitcoin's market cap reached $ 1 trillion for the first time. The global cryptocurrency market cap in February 2022 exceeded $1.7 Trillion. Bitcoin represents the largest cryptocurrency by market cap, followed by Ethereum. Ethereum was introduced in 2015 at less than $3; by November 9, 2021, its price had reached a record of $4815. The recent COVID-19 pandemic has affected economies and increased global economic and financial uncertainties.

Numerous studies have focused on classifying cryptocurrencies as an asset class and questioned their resemblance to a currency or a

☆ This article is a part of the "The impact of uncertainty and risk on financial markets".

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https://doi.org/10.1016/j.heliyon.2023.e16502
Received 18 January 2023; Received in revised form 13 May 2023; Accepted 18 May 2023
Available online 26 May 2023
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commodity [59]. examined whether cryptocurrencies could function as a currency due to their complicated nature. According to the findings of [43], the primary use of bitcoins is as a means of storing value rather than being utilized as a medium of exchange. This indicates that their potential as a currency is somewhat restricted. According to Ref. [27] research, bitcoins exhibit characteristics that are akin to commodities, such as the ability to hedge against risks and respond in a symmetrical manner to news events.

Recent studies have explored the interrelationships and unique characteristics between markets for cryptocurrencies. Such investigations include assessments of efficiency ([53,62]); diversification benefits ([16,32]); bubble behavior ([23]). In addition [39], suggested strong interdependencies and volatility spillovers between cryptocurrencies.

The main question that motivated this research paper is to understand why certain cryptocurrencies are more speculative than others. We think that the difficulty and subjectivity involved in determining their fair values is a crucial trait. In other words, opinions regarding potential cash flows and investment risks affect the valuation process, and then investors in cryptocurrencies are subject to sentiment.

As defined by Ref. [11], the concept of investor sentiment refers to assumptions about future cash flows and investment risks that are not supported by existing facts. Existing literature has established the significance of investor sentiment in financial markets [28]. showed theoretically that stock prices might deviate from their intrinsic values due to changes in noise traders and limits to arbitrage, leading to excessive market volatility [10]. proved theoretically that investor sentiment significantly affects stock return. They argued that sentiment does not affect all prices equally when the two distinct channels (sentiment-based demands or arbitrage constraints) vary across stocks, leading the most sensitive stocks to speculative demand, which usually has highly subjective valuations and increases risk more affected by shifts in investor sentiment. By analyzing monthly data from January 1963 to December 2000 [18], find that investor sentiment affects asset valuation, with sentiment predicting market returns over the next 1–3 years.

According to Ref. [58], investor sentiment has been demonstrated to possess considerable explanatory capability for a range of asset pricing models [47]. investigated how investor sentiment affects yield spreads on corporate bonds. Empirical findings show that sentiment and bond yield spreads are correlated. According to Ref. [57], there is evidence that momentum is influenced by sentiment, which highlights the importance of gaining a deeper comprehension of sentiment's role in financial asset pricing [5]. argue that investors' cognitive dissonance is one of the ways in which sentiment impacts momentum. Similarly [38], have shown a positive correlation between sentiment and return expectations [54]. showed that investor sentiment has a causal impact on the variance of commodities and their returns [42]. state that investment sentiments help predict cryptocurrency volatility and returns.

Examining the relationship between investor sentiment and cryptocurrency returns is appealing for several reasons. Firstly, sentiment is expected to have predictive power for the dynamics of cryptocurrency returns. So, investor sentiment, proxied by media coverage news and global uncertainty factors, can help investors to make assumptions about future cash flows and investment risks. Secondly, understanding this relationship can provide insight into asset valuation by identifying new variables related to cryptocurrency valuation. Lastly, it can assist investors to optimize their portfolios by offering additional hedging and diversification options during normal crisis periods.

This paper aims to tackle several unresolved inquiries. One such inquiry pertains to the possible correlation between Bitcoin and Ethereum returns and investor sentiment during the COVID-19 pandemic. Another unresolved issue relates to the impact of indices reflecting global financial, economic, and gold price uncertainty on returns for Bitcoin and Ethereum. Furthermore, we investigate whether the dependence structure between the two cryptocurrencies changes across different market conditions and quantiles. Finally, we examine whether Bitcoin and Ethereum represent viable alternatives for investors seeking to optimize their portfolios during the COVID-19 pandemic.

The current paper aims to extend the existing literature by investigating the impact of a range of global uncertainty factors and investor sentiment on the prediction of returns for Bitcoin and Ethereum during the COVID-19 pandemic. Our approach is based on an asymmetric framework that utilizes quantile methods, which covers all four waves of the Coronavirus. We employ the Quantile-on-Quantile approach developed by Ref. [56] to investigate how various quantiles of investor sentiment and global uncertainties affect the conditional quantiles of cryptocurrency returns. This technique allows us to explore the dependence structure between changes in uncertainty levels and cryptocurrency returns under different conditions while considering the nuances of uncertainty levels. Our study analyzes the entire dependence structure of the quantiles and provides insights into the average dependence and upper and lower tail dependence based on the level of uncertainty. Consequently, this research contributes valuable insights into the relationship between global uncertainty, investor sentiment, and cryptocurrency returns during the pandemic.

The structure of this paper is as follows: In Section 2, the literature review is presented. Then, in Section 3, the research methodology is explained. Next, Section 4 outlines the data and preliminary statistics. Afterward, in Section 5, the empirical results are presented and discussed. Section 6 then demonstrates the robustness check. Lastly, the paper concludes in Section 7 with some investment implications.

2. Literature review

According to Ref. [37], the existence of uncertainty in economic policy has significant implications for the overall economy. Economic policy is made up of monetary, fiscal, and regulatory policies, as noted by Refs. [2,50]. [33] found that economic policy uncertainty can impact commodity returns through various channels, including consumption and investment, while [71] found that it can affect financing and production expenditures. Additionally [49], noted that economic policy uncertainty could affect interest rates, inflation, and expected risk premiums. Theoretical research conducted by Refs. [40,68] has highlighted that the term structure, hedging pressure, and risk factors are key factors influencing commodity returns. Additionally, studies conducted by Ref. [64] have shown that sentiment analysis can be useful in forecasting future price movements. More recent research by Refs. [51,70] have

revealed a strong correlation between economic policy uncertainty and commodity returns, indicating that macroeconomic factors reflecting economic policy uncertainty can predict the volatility of the commodity market.

A strand of literature analyzes how global uncertainties factors impact cryptocurrencies, including spillover effects from international economic policy uncertainty ([22]); a herd behavior exists in the cryptocurrency market ([17]; and [63]); the ability of geopolitical risks to predict Bitcoin returns and the price volatility [7]; a positive effect of economic policy uncertainty on the price volatility of Bitcoin ([30]).

However, it is essential to consider the return behavior at different uncertainties' quantiles. Other markets are observed to be correlated during turmoil due to "flight to quality," As a result, the degree of interdependence between these markets can fluctuate based on their individual performance. Thus, the level of dependence between assets could be distributed (i.e., quantile). According to Ref. [15], economic policy uncertainty has a negative impact on cryptocurrency return as per their Ordinary Least Squares estimations. However, their study did not explore the price behavior across different quantiles. On the other hand, the results obtained from the Quantile estimations suggest a positive effect of cryptocurrency [29]. also discovered that economic policy uncertainty positively influences cryptocurrency return at extreme quantiles. Additionally [7], demonstrated that geopolitical risks positively impact Bitcoin returns and price volatility at the upper quantiles using Quantile-on-Quantile estimations. According to Ref. [34], there were notable alterations in the Bitcoin returns and trade policy uncertainty regimes. The study discovered that Bitcoin returns were adversely impacted by trade policy uncertainty during regime change periods. In a related study [20], identified a non-linear impact of media on the lowest and middle stock market return quantiles during the COVID-19 pandemic. These findings suggest that the relationship between cryptocurrencies and uncertainty varies across quantiles, particularly in extreme periods. Therefore, the application of Quantile-on-Quantile estimations is necessary.

One of the contributions of this research is the exploration of investor sentiment, which was assessed through news coverage. Previous studies have suggested that social media can impact investor sentiment ([41]). Researchers have utilized various proxies from news and social media to measure investor sentiments, such as the sentiment of newsletter writers [21], Wall Street strategists, newsletter writers, and individual investors ([31]). Other studies have used media pessimism extracted from the Wall Street Journal column content and negative views expressed in the news and social media to forecast firms' earnings and stock returns ([60]). Text messages downloaded from Yahoo! Finance have also been used to measure investor sentiment ([6,26]).

[19] research presents an overview of academic investigations into the correlation between social media, investors' sentiment, and capital markets. The study concludes that mass media positively influences the development of the transmission mechanism between mass media and financial markets.

[25] conducted a study to analyze the relationship between news coverage and Bitcoin returns. To achieve this, they developed a sentiment index that was based on factors such as GDP, Consumer Price Index, unemployment, and durable goods. The findings of the study indicate that the increase in positive news following announcements about the unemployment rate and durable goods leads to a decrease in Bitcoin returns. Conversely, an increase in negative news coverage of these announcements is linked to a rise in Bitcoin returns [65]. research explores the volatility spillover connectedness between NFTs' attention and financial markets. Utilizing a TVP-VAR spillover connectedness model, the empirical outcomes reveal that cryptocurrency, DeFi, equity, bond, commodity, FX, and gold markets have a higher impact on NFT markets.

[42] created new cryptocurrency uncertainty indices (UCRY Policy and UCRY Price), which can capture policy uncertainty and price uncertainty in the cryptocurrency market beyond price volatility [66]. introduced the cryptocurrency environmental attention index (ICEA) for 2014–2021, which aims to capture the relative extent of media discussions about the environmental impact of cryptocurrencies. Empirical results demonstrate that ICEA significantly impacts the bitcoin price. Finally [67], investigated how cryptocurrency market uncertainty can help to explain and forecast volatilities in precious metal markets. They used the new cryptocurrency uncertainty indices developed by Ref. [42]. Empirical results show that uncertainty measures can capture different types of long-term fluctuations in precious metal prices.

Covid-19 provoked fluctuations and caused investors to fear, potentially affecting investment activities, like short-term investors selling their stocks due to pessimism ([52]), increasing equity returns volatility ([35]), using cryptocurrencies as a safe haven ([3,14,24]) [8,9]). On the other hand [61], research shows a strong correlation between major cryptocurrencies and the COVID-19 Panic Index. In addition [1], study presents proof that the pandemic has increased the interconnectivity between commodity and financial markets, indicating significant volatility spillovers and risk transmission [44]. examines the influence of diverse COVID-19 media coverage news on Sukuk (Islamic bonds returns and discovers that Sukuk returns experience negative effects from COVID-19 panic news during bearish market conditions. Lastly [45], conducted a study to investigate the impact of COVID-19 media coverage on the returns of Bitcoin. The study analyzed various factors such as the Panic Index and the infodemic index. The results showed that the influence of COVID-19 news on bitcoin returns was not uniform and varied across quantiles, with mostly negative effects.

3. Research methodology

The Quantile-on-Quantile (QQA) introduced by Ref. [56] was used in this paper to analyze the impact of investor sentiment and global uncertainties on conditional quantiles of cryptocurrency returns. QQA employs a combination of non-parametric estimation and traditional quantile regression (QR), providing a wealth of informative data [4]. With QQA, it becomes possible to model cryptocurrency return quantiles as a function of changes in uncertainty and investment sentiment quantiles, allowing for the analysis of the relationship between these time series at different points in their distributions.

$$CCR_t = \beta^{\theta}(UNC_t) + u_t^{\theta} \tag{1}$$

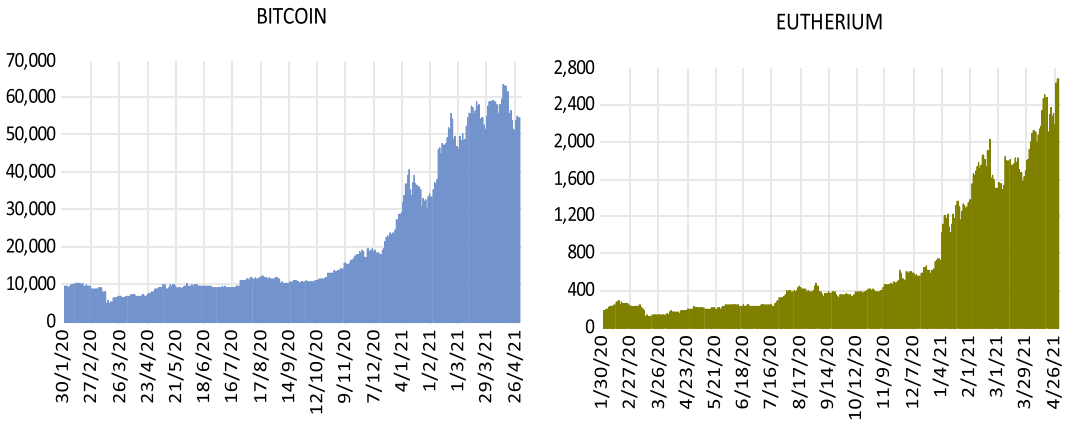

Fig. 1. Time-varying price dynamics of Bitcoin and Ethereum.

From Equation (1), CCR_t represents the cryptocurrency (Bitcoin and Ethereum) returns in time t, UNC_t represents factors related to investor sentiment and global uncertainty on time t, while θ represents a specific quantile (θ^{th}) of the conditional distribution of cryptocurrency returns. u_t^{θ} refers to the quantile error, which is set to zero for the conditional θ^{th} quantile. The $\beta^{\theta}(\bullet)$ is an unknown function that can be approximated through a first-order Taylor expansion around a quantile UNC^{τ}:

$$\beta^{\theta}(UNC_t) \approx \beta^{\theta}(UNC^{\tau}) + \beta^{\theta'}(UNC^{\tau})(UNC_t - UNC^{\tau}) \tag{2}$$

From Equation (2), $\beta^{\theta'}$ is the partial derivative of $\beta^{\theta}(UNC_t)$ with respect to investor sentiment and global uncertainties factors. $\beta^{\theta'}(UNC^{\tau})$ can be renamed as $\beta_0(\theta,\tau)$ and $\beta_1(\theta,\tau)$, respectively (Equation (3)):

$$\beta^{\theta}(UNC_t) \approx \beta_0(\theta,\tau) + \beta_1(\theta,\tau)(UNC_t - UNC^{\tau}) \tag{3}$$

By replacing Equation (3) in Equation (1), we obtain Equation (4):

$$CCR_t = \underbrace{\beta_0(\theta,\tau) + \beta_1(\theta,\tau)(UNC_t - UNC^{\tau})}_{(b)} + u_t^{\theta} \tag{4}$$

In Equation (4), (b) refers to the θ^{th} conditional quantile of returns for cryptocurrencies. To obtain estimates for the parameters b_0 and b_1 through local linear regression, one must solve the subsequent minimization problem:

$$\min_{b_0,b_1} \sum_{i=1}^{n} \rho_{\theta}[CCR_t - b_0 - b_1(\widehat{UNC}_t - \widehat{UNC}^{\tau})]K\left(\frac{F_n(\widehat{UNC}_t) - \tau}{h}\right) \tag{5}$$

From Equation (5), the quantile loss function, $\rho_{\theta}(u)$, can be expressed as $\rho_{\theta}(u) = u(\theta - I(u<0))$, I is an indicator function. The kernel function, $K(\bullet)$, is used in conjunction with the bandwidth parameter, h, and the weights are determined by the distance between the empirical distribution function of $\widehat{UNC}_t$. Specifically, the weights are inversely proportional to this distance, denoted by $F_n(\widehat{UNC}_t) = \frac{1}{n}\sum_{k=1}^{n} I(UNC_k < \widehat{UNC}_t)\Big)$, and the distribution function's value associated with the quantile UNC^{τ}, which is represented by τ.

4. Data description and preliminary statistics

4.1. Data description

To study the impact of global uncertainty factors and investor sentiment based on media coverage news on the returns of cryptocurrencies during the COVID-19 pandemic, we used daily price data of Bitcoin and Ethereum from January 30, 2020, and April 26,2021.[1] We selected Bitcoin and Ethereum because [13,48] showed a co-movement between cryptocurrencies regarding their returns and volatility. Furthermore, they found that Bitcoin and Ethereum currencies seem representative of the whole cryptocurrency market. Fig. 1 depicts the fluctuating patterns of Bitcoin and Ethereum prices over the duration of the analyzed period.

Fig. 1 shows that bitcoin surged above $40,000 for the first time in January 2021. It crossed $17,000 for the first time in November

[1] The time frame we analyzed begins on January 30, 2020, corresponding to the declaration of the outbreak of the novel coronavirus as a Public Health Emergency of International Concern by the World Health Organization (WHO).

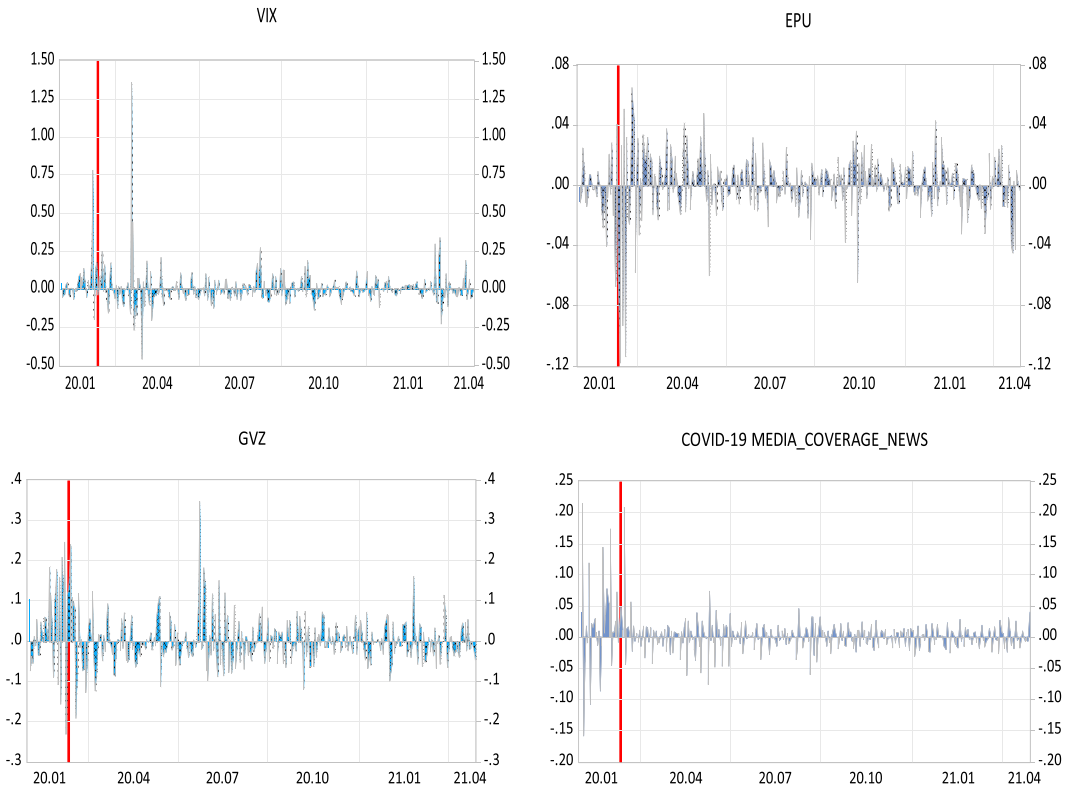

Fig. 2. Time-varying dynamics of uncertainty and investor sentiment returns. **Note**: The declaration of COVID-19 as a pandemic by the World Health Organization (WHO) is marked by the presence of a red line on the chart, indicating the specific date.

Table 1
Descriptive statistics.

	BIT	EUT	VIX	EPU	GVZ	MCI
Mean	0.006650	0.010393	0.005436	−9.96E-05	0.002593	0.002557
Median	0.004336	0.007198	−0.007584	0.001097	−0.005253	0.001422
Maximum	0.211097	0.403775	1.357731	0.064911	0.346731	0.214797
Minimum	−0.371695	−0.321036	−0.463265	−0.118482	−0.233301	−0.158044
Std. Dev.	0.047682	0.063747	0.121296	0.020791	0.064488	0.031835
Skewness	−1.168285	0.502892	5.232173	−1.526856	0.966644	2.030423
Kurtosis	16.62252	10.18380	55.66632	10.21740	6.923212	19.52570
Jarque-Bera	2563.020*	705.9661*	38683.52*	823.9975*	256.6501*	3885.320*
ADF Test	−19.76174*	−18.64533*	−16.90859*	−11.39479*	−18.14403*	−3.00422**

Notes: The sample period used in this study spans from January 30, 2020, to April 26, 2021. The unit root test is based on the Augmented Dickey and Fuller (1979) method, with the ADF value representing the empirical statistics. Results are reported using asterisks (*) and (**) to indicate significance levels of 1% and 5%, respectively, for rejection of the null hypotheses.

2020 and $20,000 in December 2020. In February 2021, Bitcoin's market capitalization reached for the first time US$ 1 trillion, and its price climbed as high as $50,000. Regarding Ethereum, it reached $600 per coin for the first time in November 2020. In February 2021, PayPal announced the intention to accept cryptocurrency payments, and the price of Ethereum exceeded $1600. On April 14, Coinbase was valued more significantly than the British Petroleum Company, and the price of Ethereum exceeded $2500 on April 15, 2021.

In our study, we utilized a metric derived from media coverage to serve as a proxy for investor sentiment. Specifically, we employed the COVID-19 Media Coverage Index (MCI) sourced from Raven Pack Refinitiv. This index quantifies the proportion of news sources reporting on the topic of the novel coronavirus. The scale of this index ranges from 0 to 100, with a score of 60, for instance, indicating that 60% of the sampled news providers are currently featuring news on COVID-19.

We employed various proxies to assess the global financial market, global uncertainty, and gold price volatility. The VIX index was utilized to measure the implied volatility of a diverse array of options based on the S&P 500 index. To evaluate global uncertainty, we opted for the economic policy uncertainty index (EPU) as developed by Ref. [12]. Lastly, The Chicago Board Options Exchange (CBOE) Gold Volatility Index (GVZ) was utilized as a proxy for gold price volatility. Fig. 2 displays the changing patterns of worldwide

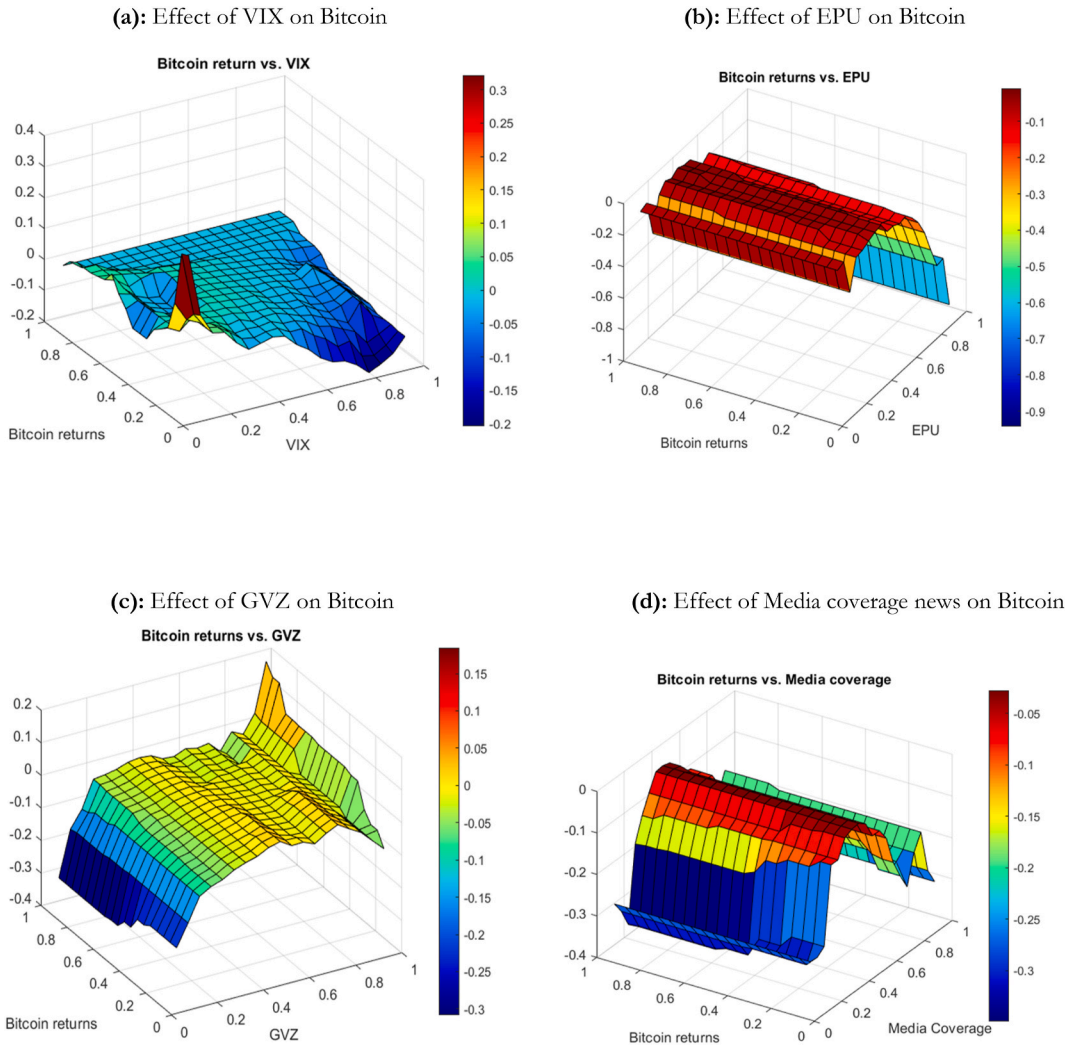

Fig. 3. Measuring the Effect of Global Uncertainty and Sentiment Factors on Bitcoin Returns through Quantile-on-Quantile Estimation. **(a):** Effect of VIX on Bitcoin. **(b):** Effect of EPU on Bitcoin **(c):** Effect of GVZ on Bitcoin. **(d):** Effect of Media coverage news on Bitcoin.

uncertainty factors and investor sentiment throughout the observed timeframe.

4.2. Preliminary statistics

The data in Table 1 presents the summary statistics and initial examinations of the variables for bitcoin prices and COVID-19 news.

Table 1 displays that all variables have kurtosis coefficients greater than three, indicating that their probability distributions satisfy the leptokurtic distribution. The normal distribution of all datasets is rejected by the Jarque-Bera test. Bitcoin and EPU variables exhibit negative skewness values, indicating a left-skewed distribution. Additionally, the variables are shown to be stable by the Augmented Dickey-Fuller (ADF) tests.

4.3. Findings and analysis

4.3.1. Findings on bitcoin

Fig. 3 demonstrates the slope estimates $\beta(\theta,\tau)$, which possess the impact of θ^{th} quantile of global uncertainty and investor sentiment indicators on τ th quantile of bitcoin returns by different values of θ and τ.

Fig. 3(a) depicts the impact of global financial uncertainty, as measured by the VIX, on bitcoin returns. The slope coefficient ranges from −0.20 to 0.3, indicating a moderate positive correlation between middle to lower quantiles of bitcoin returns and lower to lower-middle values of VIX. These findings suggest that bitcoin returns are likely to increase in response to an increase in global financial uncertainty, particularly when the bitcoin market is stable. On the other hand, at a majority of the quantile levels for bitcoin returns,

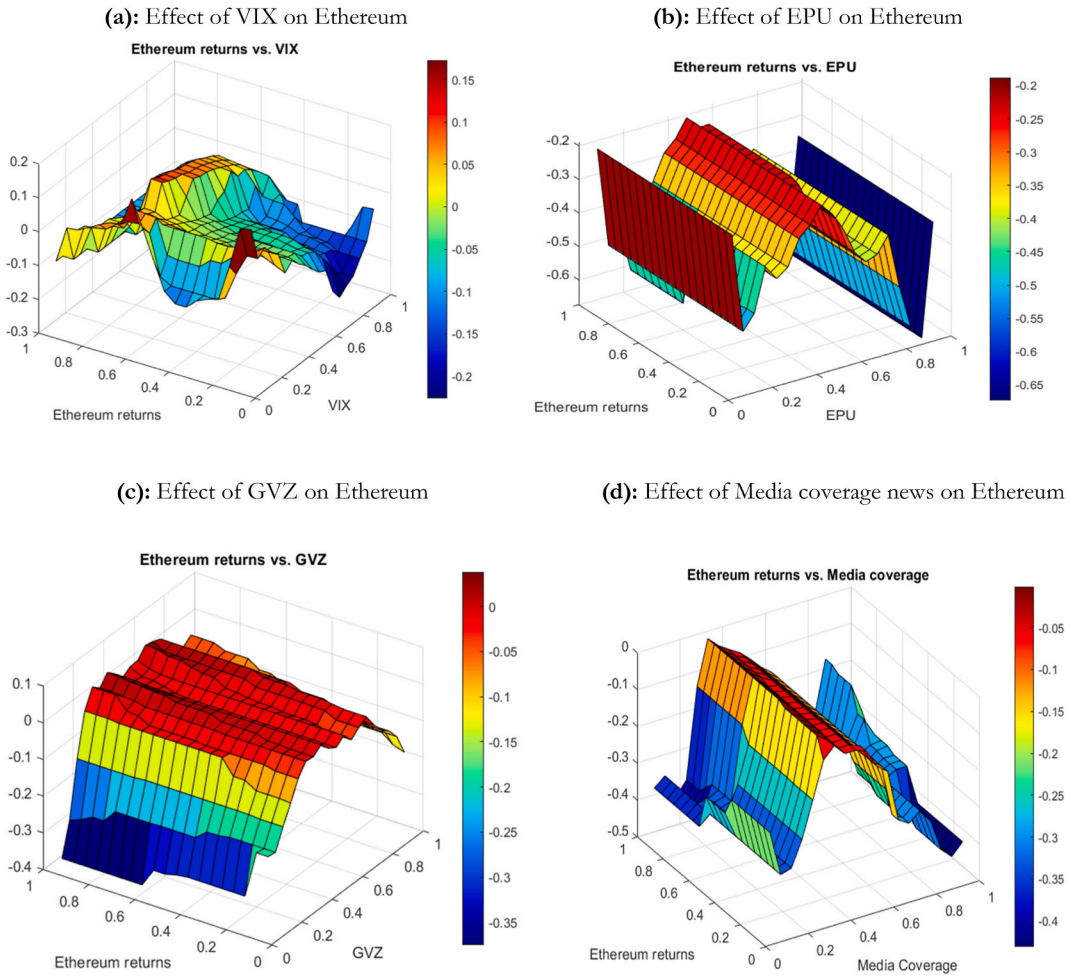

Fig. 4. Measuring the Effect of Global Uncertainty and Sentiment Factors on Bitcoin Returns through Quantile-on-Quantile Estimation. **(a):** Effect of VIX on Ethereum. **(b):** Effect of EPU on Ethereum. **(c):** Effect of GVZ on Ethereum. **(d):** Effect of Media coverage news on Ethereum.

there appears to be a negative and generally weak correlation between VIX and bitcoin return. Furthermore, we observe a stronger negative correlation between the bitcoin market and global financial uncertainty in regions with low bitcoin returns and high VIX levels. This suggests that when there's an increase in global financial uncertainty during a bullish market, the bitcoin market is negatively impacted, especially in the lower quantiles of bitcoin returns. These results partly align with the findings of [15], who discovered a negative association between Bitcoin returns and VIX in the lower quantiles of Bitcoin returns. However, our study reveals different results in the higher quantiles. The figure depicted in Fig. 3(b) showcases the impact of the EPU on bitcoin returns. The slope coefficient ranges from −0.9 to −0.1. Across most quantiles, there is a noteworthy negative correlation found between EPU and bitcoin returns. This negative relationship is particularly prominent in the middle to high quantiles of bitcoin returns (0.50–0.95) when combined with the upper quantiles of EPU (0.75–0.95). Additionally, a moderate negative association exists between the middle to upper-middle quantiles of EPU and the middle-to-upper quantiles of bitcoin returns. These results imply that during the COVID-19 pandemic, the increase in EPU led to a sharp decline in bitcoin returns, particularly during times of increased global economic uncertainty. These findings partially align with previous studies conducted by Refs. [29,36], who have both reported negative associations between EPU and bitcoin returns, albeit at different quantiles.

Fig. 3(c) depicts the gold uncertainty (GVZ) effect on bitcoin returns. The slope coefficient ranges from −0.30 to 0.15. A slight negative association is found mainly in the region which combines the middle to high quantiles of bitcoin returns (0.50–0.95) with the link across the middle to upper quantiles of GVZ (0.50–0.95). When bitcoin is in bearish market conditions, the negative impacts of GVZ are more pronounced. On the other hand, a strong positive association is observed when bitcoin returns and GVZ are both in bullish market conditions. This finding is consistent with the results of [46] who find an a nonlinear relationship between bitcoin-Ethereum and GVZ index. Fig. 3(d) illustrates the correlation between COVID-19 media coverage news and bitcoin returns, serving as a measure of investor sentiment. The slope coefficient ranges from −0.30 to −0.05, indicating a substantial negative association between media coverage news and bitcoin returns across all quantiles. This implies that a greater volume of COVID-19 related news results in lower bitcoin returns in all quantiles. Our results align with prior research conducted by Ref. [45], which

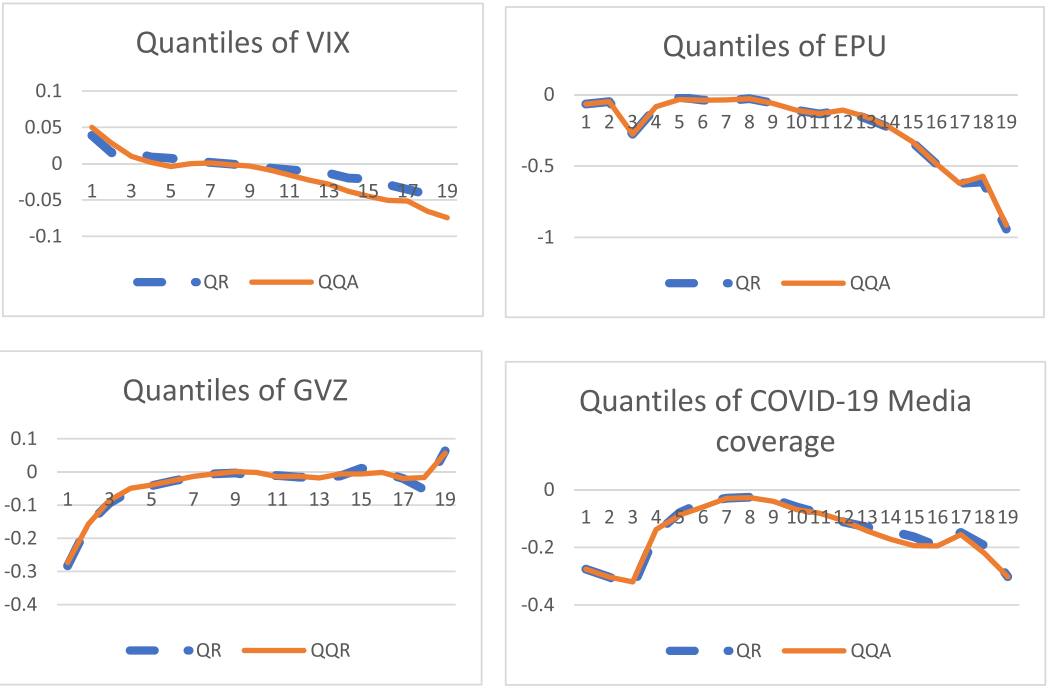

Fig. 5. Examining the differences between the quantile-on-quantile (QQA) methodology and quantile regression (QR) in the case of bitcoin.

also indicate a negative and statistically significant relationship between investor sentiment and bitcoin returns.

4.3.2. Findings on ethereum

Fig. 4 demonstrates the quantile-on-quantile estimates of the impact of global uncertainty and sentiment factors on Ethereum returns.

The impact of the VIX on Ethereum returns is depicted in Fig. 4 (a), where the slope coefficient ranges from −0.20 to +0.15. The negative association is weak in the regions that combine Ethereum's lower and upper quantiles of the VIX, indicating that higher global financial market uncertainty adversely affects Ethereum returns only when the Ethereum market is bearish. Additionally, a slightly negative relationship is observed in the intermediate quantiles of both VIX and Ethereum returns. Conversely, there exists a moderate positive relationship in the region that combines the middle to upper quantiles of Ethereum returns and COVID-19 media coverage news (0.50–0.80). This finding suggests that Ethereum returns tend to increase with higher COVID-19 media coverage news, but only within this specific quantile range. In Fig. 4 (b), the influence of EPU on Ethereum returns is illustrated. The slope coefficient varies between −0.65 to −0.20. The study reveals a significant negative correlation between EPU and Ethereum returns across all quantiles. Furthermore, when all bitcoin returns are combined with the extreme upper quantiles of EPU (0.90–0.95), a negative and substantial effect is detected in the region. The results suggest that increased EPU during the COVID-19 pandemic leads to reduced Ethereum returns for all quantiles. These findings contrast with those of [69], who observed that EPU results in higher returns for Bitcoin, Ethereum, and Ripple.

The impact of GVZ on Ethereum returns is depicted in Fig. 4 (c), with a slope coefficient ranging from −0.35 to 0. The findings indicate a moderate negative impact, as evidenced by the significant numbers of quantiles of Ethereum returns in the lower-middle to middle-upper quantiles (0.30–0.95). Additionally, there is a robust and negative correlation between the upper quantiles of Ethereum returns and the extremely lower quantile of GVZ. These results indicate a negative effect of gold uncertainty on Ethereum returns across all quantiles, with a noticeable negative association that suggests a significant decrease in Ethereum returns during periods of recession, normal, and boom. The impact of COVID-19 media coverage news on Ethereum returns is illustrated in Fig. 4(d), with the slope coefficient varying between −0.40 and −0.05. The results reveal a robust inverse correlation between media coverage news and Ethereum returns, specifically within the middle to high quantiles of Ethereum returns (0.50–0.95) and their association with the upper quantiles of EPU (0.75–0.95). This suggests that an increased volume of COVID-19 news adversely influences Ethereum returns under normal and bullish market conditions.

5. Robustness check

The QQA is considered as a decomposition method for estimating traditional quantile regression (QR) in a way that allows for detailed estimation of different quantiles of the dependent variable (cryptocurrency returns). Due to this decomposition property of the QQA, the QQA estimates can be used to obtain the estimates of the traditional QR approach. Fig. 5 depicts the characteristics of the

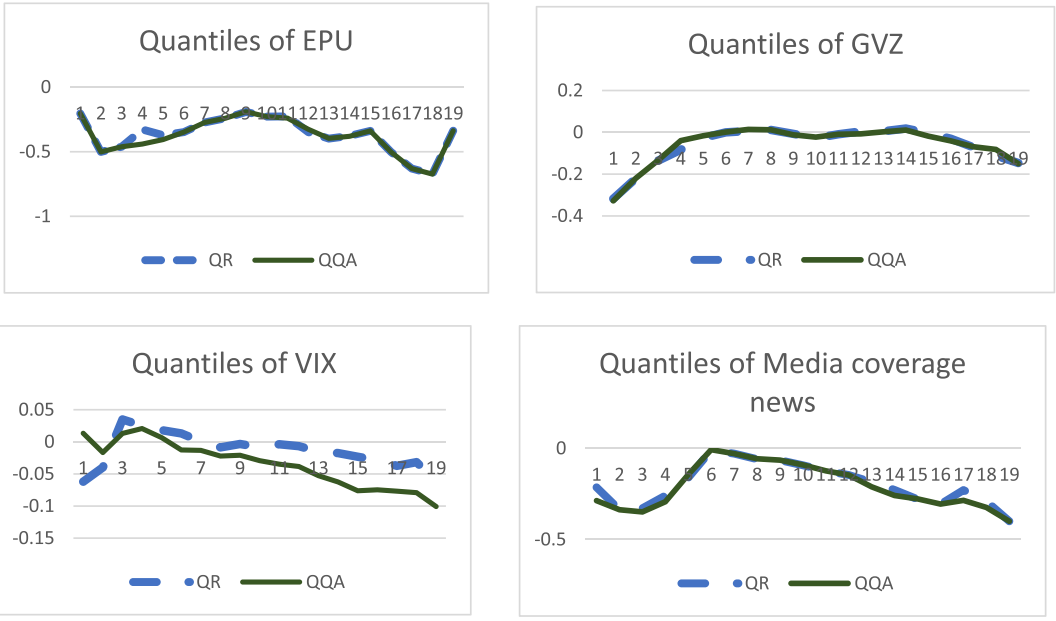

Fig. 6. The comparison between (QQA) and (QR) in the case of Ethereum.

QQA and QR methodologies applied to bitcoin.

The behavior of the slope coefficients' average QQA estimates was analyzed in Fig. 5, which confirmed our earlier findings regarding the QQA. The charts suggest that this behavior is similar to the QR estimates for all variables. The results in Fig. 5 are consistent with our earlier findings presented in Fig. 3. Specifically, we observe that the correlation between bitcoin returns and VIX is positive for intermediate and lower quantiles, while the correlation between trade GVZ and bitcoin returns varies depending on the quantile, being negative for lower quantiles and positive for upper quantiles. Fig. 6 shows the parameters of the QQA and QR approaches in the case of Ethereum.

Fig. 6 confirms our previous findings of the QQA regarding Ethereum. The figure show that the average QQA estimates of the slope coefficients behave similarly to the QA estimates for all variables. Fig. 6 backs up our prior findings, which are shown in Fig. 4.

6. Conclusion

This study provides empirical evidence of the link between cryptocurrency returns and investor sentiment in relation to COVID-19 pandemic-driven media coverage and global uncertainty. We investigated the nonlinear dynamics between Bitcoin and Ethereum returns and various uncertainty indices (EPU, VIX, and GVZ) using an asymmetric framework based on the QQA approach. Empirical results show a mixed relationship. **(i)** A relatively strong negative association between EPU and bitcoin returns across all quantiles **(ii)** a moderate negative relationship between VIX and bitcoin returns **(iii)** a strong positive association is observed when bitcoin returns and GVZ are both in bullish market conditions; **(iv)** the higher level of news related to COVID-19 negatively affects the bitcoin returns in all quantiles.

Studying the behavior of cryptocurrency during uncertainty like pandemics is extremely important because it provides investors with insights on diversifying their portfolios and hedging their risks. The results of this research carry significant implications for cryptocurrency investors who aim to develop effective risk management strategies, as well as for policymakers who are directly involved in shaping regulations in this domain. Our findings suggest several actionable insights. Firstly, the behavior of cryptocurrencies appears to be significantly influenced by global uncertainty factors. Secondly, investor sentiments can provide valuable insights for explaining the return behavior of cryptocurrencies. Thirdly, our results indicate that neither Bitcoin nor Ethereum can be relied upon as a hedge against global financial and economic uncertainty during the COVID-19 pandemic. Finally, our study suggests the possibility of Bitcoin serving as a hedge under specific gold uncertainty conditions.

The scope of the empirical study discussed in this article is limited to Bitcoin and Ethereum. However, expanding the cryptocurrency sample could offer more comprehensive insights into the asymmetric relationship between investor sentiment indicators and cryptocurrency returns. Furthermore, incorporating newly developed cryptocurrency uncertainty indices by Ref. [42] and the cryptocurrency environmental attention index could enhance the accuracy of cryptocurrency return forecasts.

Author contribution statement

Nader Naifar: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the

paper.

Sohale Altamimi; Fatimah Alshahrani: Analyzed and interpreted the data; Wrote the paper.

Mohammed Alhashim: Analyzed and interpreted the data. Editing.

Data availability statement

Data will be made available on request.

Additional information

No additional information is available for this paper.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Acknowledgments

This research project was funded by Princess Nourah bint Abdulrahman University Researchers Supporting Project number (PNURSP2023R358), Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.

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