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COVID-19 pandemic and economic policy uncertainty: The first test on the hedging and safe haven properties of cryptocurrencies

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**ABSTRACT**

This study examines the role of the top-5 cryptocurrencies and gold as a hedge and safe haven against the economic policy uncertainty (EPU) before and during the ongoing COVID-19 crisis. We use the GARCH model for the main analysis and a safe haven index (SHI) for robustness. Our findings show that gold and cryptocurrencies cannot act as a strong hedge or safe haven against EPU before and during the COVID-19 pandemic. However, we find that the SHI exhibits negative returns and increased volatility during the COVID-19 and confirms that cryptocurrencies generally act as weak safe haven. Gold is classified as a weak safe haven asset during the whole period and more likely as a safe asset before the health crisis but loses its safe haven property during the COVID-19 crisis. Our findings provide useful information for investors interested in the cryptocurrency market and safe haven assets when building assets portfolios.

1. Introduction

The ongoing COVID-19 pandemic has caused severe damage to the global economy and increased risk in global financial markets. In this line, many new works questioned whether the traditional safe assets like gold protect against uncertainty caused by the COVID-19 pandemic economic crisis. In fact, gold has traditionally been considered a famous safe haven during several crises (Reboredo, 2013; Bouri et al., 2020a, 2020b). However, the new results are mixed about the gold ability to act as a hedge and a safe haven during the COVID–19 pandemic. For example, Ji et al. (2020) report that gold is a safe haven asset during the COVID–19. Bouri et al. (2020a, 2020b) compared the ability of gold and Bitcoin as a safe haven asset during the COVID–19 pandemic. They provide that gold is not a superior choice as a safe haven asset. However, Cheema and Szulczuk (2020) report that gold has lost its safe haven properties during the COVID–19 pandemic.

While cryptocurrencies are almost isolated from the global financial system and make their valuable and profitable addition to conventional assets portfolios (Corbet et al., 2018; Guesmi et al., 2019; Symitsi and Chalvatzis, 2019), they are linked with the inevitable economic policy uncertainty (EPU). Notably, it is argued in the literature that financial markets are influenced by government policy uncertainty through several channels, including consumption habits, labor supply, and investment choices (Gomes and Kotlikoff, 2012 and Pásstor and Veronesi, 2012, 2013). In fact, increased policy uncertainty can negatively influence investment by...
deterring corporations from taking on new investment ventures and force consumers to be more conservative in their spending habits (Handley and Limao, 2015; Converse, 2017). More specifically, other than the channels mentioned above, cryptocurrencies are linked to uncertainty, regarding economic policies, through their hedging and safe haven properties. In fact, EPU increases conventional assets’ volatility, which pushes investors to increase their holding in cryptocurrencies for a hedging purpose against EPU dynamics.

At this point, the growing popularity of cryptocurrencies has also inspired some studies of their hedging and safe haven properties against uncertainty (Bouri et al., 2018; Wang et al., 2018; Demir et al., 2018; Wu et al., 2019; P. Wang et al., 2020; G.J. Wang et al., 2020; Mokni, 2021). Notably, most previous studies analyzing the cryptocurrencies-EPU nexus focus on periods without accounting for the different events and crises that influence these digital assets’ hedging and safe haven ability against uncertainty. Therefore, these studies would mask any potential effect of crisis that potentially increases the EPU level. Therefore, extending the above literature to consider the last health crisis of the COVID-19 pandemic in our analysis appears important for at least two reasons. First, the outbreak of this pandemic has increased US EPU remarkably, given that the US is the most affected country by this pandemic (Fig. 2). Therefore, investors need the information to protect against this increased EPU and, more specifically, need to know the ability of cryptocurrencies to act as a hedge and safe haven tool against this augmented uncertainty as to the first test on this role during the crisis. Second, a more nuanced analysis that focuses on the COVID-19 period could help investors make inferences regarding portfolio management against increased uncertainty and conventional assets’ volatility. It also helps financial advisors make more suitable decisions regarding risk management and hedging opportunities regarding the ability of cryptocurrencies to hedge versus this augmented EPU.

Therefore, in this study, we analyze the role of the top-5 cryptocurrencies and gold to act as a hedge, safe havens, or as safe assets against economic policy uncertainty by considering the last COVID-19 pandemic crisis in our analysis. In this context, it should be noted that hedging against EPU implies hedging against the high variability of financial assets caused by high uncertainty levels.

Regarding the above discussions, our study contributes to the financial literature in three ways. First, we are the first to compare the hedge and safe haven roles of gold and the top-5 cryptocurrencies against EPU shocks before and during the health crisis of the COVID–19 pandemic. In this context, the previous literature focused only on Bitcoin’s hedging and safe haven properties. Unlike these studies, we use the five most cryptocurrencies in terms of market capitalization. Second, we use the procedure of Baur and McDermott (2010), which is among the most popular approaches that examine the assets’ hedging and safe haven properties. This approach evaluates the cryptocurrencies’ ability to hedge the EPU before and after the COVID-19 pandemic. Third, we apply the new safe haven index (SHI) recently introduced by Baur and Dimpfl (2020). This index has the advantage of combining the information contained in multiple assets into a single time series and reducing the necessary dimensionality of the analysis. Besides, the index is expected to be less noisy, less volatile, and less prone to outliers than an individual benchmark time series (Velliangiri et al., 2019; Baur and Dimpfl, 2020). Our work is helpful for decision-makers and investors searching for hedge or safe-haven assets and distinguishes them from safe assets, especially during crises.

Based on a recent dataset and different approaches of hedging and safe haven testing, the results of this study show generally that neither gold nor cryptocurrencies can act as a strong hedge or safe haven against EPU before and during the COVID-19 pandemic. However, further analysis based on the SHI show again the weakness of these assets in hedging the EPU.

The rest of the paper is structured as follows. Section 2 reviews the literature background, section 3 describes the data and methods. Section 4 presents the results. Section 5 concludes the paper.

2. Concepts and literature review

2.1. Concepts

Baur and Lucey (2010) have introduced simple definitions of the terms hedge, diversifier, and safe haven. In fact, a strong (weak) hedge is defined as an asset that is negatively correlated (uncorrelated) with another asset or portfolio on average. Thus, a hedge does not have the (specific) property of reducing losses in times of market stress or turmoil since the asset could exhibit a positive correlation in such period and a negative correlation in normal times with a negative correlation on average. A diversifier is defined as an asset that is positively (but not perfectly) correlated with another asset or portfolio on average. This means that a diversifier is similar to a hedge as it does not have the (specific) property of reducing losses in adverse market conditions since the correlation property is required to hold on average. A safe haven is defined as an asset that is uncorrelated or negatively correlated with another asset or portfolio in times of market stress or turmoil periods. Moreover, A strong (weak) safe-haven asset is defined as an asset that is negatively correlated (uncorrelated) with other assets or a portfolio on average.

Unlike hedge and a diversifier, a safe haven asset has the specific property of nonpositive correlation with a portfolio during extreme market conditions. This property does not mean that the correlation is positive or negative on average, but it should be zero or negative in specific periods. This implies that if the haven asset is negatively correlated with another asset or portfolio in the period of stress market, it compensates the investor for losses since the haven asset’s price rises when the price of the other asset or portfolio falls.

2.2. Literature background

The recent study extends previous empirical research on whether gold and cryptocurrencies are diversifiers, hedges, or safe haven assets against traditional assets (i.e., stocks, US dollar, energy commodities, and bonds). Gold is often referred to as a store of value and a safe haven asset. A strand of research has focused on whether gold is a hedge, a diversifier or a safe haven. Baur and Lucey (2010) investigate the property of gold by applying a regression equation of gold returns on extreme returns of stocks and bonds. Their
findings show that gold may be considered as a hedge against stocks on average and a safe haven in extreme stock market conditions. However, the safe haven property is short-lived. Since the work of Baur and Lucey (2010), an increasing number of papers have tested the diversifier, safe haven, and hedging properties of gold from different standpoints (Baur and McDermott, 2010; Elder et al., 2012; Van Hoang et al., 2016). Moreover, different econometric approaches (i.e., traditional correlation, copula approach, smooth transitions, wavelet analysis and quantile regression models) were applied to test the hedging and safe haven properties of gold (see, for example, Ciner et al., 2013; Reboreda, 2013a, 2013b, Beckmann et al., 2015; Bekiros et al., 2017; Dar and Maitra, 2017; Wen and Cheng, 2018…). More recently, Trabelsi et al. (2021) investigated the relationship between returns of gold and seven sectoral indices in the Bombay stock exchange (BSE). The paper finds that gold returns are independent of the returns of BSE sectoral indices, which implies that gold may hedge against different BSE equity indices and serves as a robust portfolio diversification tool.

Since the emergence of the first cryptocurrency in early 2009, under the name Bitcoin, the financial press has become attracted by this digital asset, Bouri et al. (2020). Previous studies examined the market efficiency of cryptocurrencies, especially Bitcoin (Zhang et al., 2018; Zargar and Kumar, 2019), the information spillover effects among cryptocurrencies (Yi et al., 2018; Beneke et al., 2019; Sifat et al., 2019) and investor attention to Bitcoin (Shen et al., 2019; Dastgir et al., 2019).

Given that Bitcoin has shown great resilience to crisis periods such as the European debt crisis of 2010–2013 and the Cypriot Banking crisis of 2012–2013, a large body of research discusses the safe haven, hedging, and diversifying properties of Bitcoin. Many studies (Feng et al., 2018; Stenssás et al., 2019; Urquhart and Zhang, 2019) show that Bitcoin may act as a great diversifier for commodities, stocks, and certain currencies, whereas others (Bouri et al., 2017a; Wang et al., 2019b) find that, in a particular situation, cryptocurrencies particularly Bitcoin, can serve as a safe-haven or hedge assets for major stock indices, currencies and commodity indices. Bouri et al. (2017b) examined the safe-haven and hedging properties of Bitcoin for major stock indices using a DCC-GARCH model. Their findings reveal that these two properties are time-varying, and in the majority of cases, Bitcoin acts as a weak hedge. To test the safe-haven property of Bitcoin, gold, and commodities against stocks, Shahzad et al. (2019) applied a bivariate cross-quantiliogram approach and found that each asset can only act as a weak safe haven in some cases. Baur et al. (2018) studied the characteristics of Bitcoin and found that it is mainly used as a speculative investment rather than as a currency or medium of exchange. Bouri et al. (2020) compare the safe-haven property of gold, Bitcoin, and commodity index against a set of international stock indices. Using a wavelet coherence approach, they found that the diversification benefits vary in the time-frequency space, with Bitcoin exhibiting superiority over gold and commodities. More recently, Mensi et al. (2020) examine the co-movement between Bitcoin and Sukuk and the world and regional Islamic stock markets. They found that the benefits of portfolio diversification with Bitcoin and Islamic assets vary across time and frequencies.

Moreover, few works compare the hedging and safe haven roles of gold and Bitcoin during the recent health crisis outbreak and draw different conclusions. For example, Ji et al. (2020) report that gold is a safe haven asset during the COVID–19. Bouri et al. (2020) compared the ability of gold and Bitcoin as a safe haven asset during the COVID–19 pandemic. They provide that gold is not a superior choice as a safe haven asset. However, Cheema and Szulczuk (2020) report that gold has lost its safe haven properties during the COVID–19 pandemic. Conversely, Salisu et al. (2021), in a recent work, find evidence of hedging effectiveness between gold and US sectoral stocks during the COVID-19 pandemic.

Since Bitcoin lost more than half of its market share in the cryptocurrency market, much attention has been paid to the capabilities of other cryptocurrencies against traditional assets (P. Wang et al., 2020; G.J. Wang et al., 2020). In recent research, Bouri et al. (2019) find that other leading cryptocurrencies, including Ethereum and Litecoin, may act as great diversifiers as well as hedges, especially against Asian Pacific and Japanese equities, suggesting that investors can consider alternative cryptocurrencies besides Bitcoin. Wang et al. (2019c) examine the safe-haven and hedging properties of 973 cryptocurrencies against 30 international indices. They find that cryptocurrencies act as a safe haven but not a hedge in general. More recently, Goodell and Goutte (2021a) employ several econometric approaches, including wavelet coherence, copula, principal component, and neural network analysis, to examine the role of COVID-19 on the co-movements of six cryptocurrencies, as well as Bitcoin futures with 14 equity indices and the VIX. They find that co-movement between cryptocurrencies and equity indices increased as COVID-19 progressed. Moreover, most of these co-movements are positively correlated, suggesting that cryptocurrencies do not offer diversification benefits during downturns, except for Bitcoin futures and Tether. In the same context, Colon et al. (2020) and Goodell and Goutte (2021b) test the safe haven properties of several cryptocurrencies (Bitcoin, Ethereum, Litecoin, and Tether) from the perspective of international equity index during the COVID-19 pandemic crisis. Similar results show that Bitcoin, Litecoin, and Ethereum are not safe assets for most examined international equity markets. However, Tether appears to be an important safe haven in pre–COVID and considerably more during the COVID-19 outbreak.

Disli et al. (2021) investigate the role of gold, oil, and cryptocurrencies as safe haven for traditional, sustainable and Islamic investors during the COVID-19 pandemic crisis. Their findings evidence that oil, gold, and Bitcoin do not exhibit safe haven characteristics with the pandemic outbreak. However, by decomposing the time-varying co-movement into different time horizons, results show that investors have diversification opportunities with gold, oil, and Bitcoin at longer horizons.

Gold has been identified as a strong hedge and safe haven during extreme economic and adverse market conditions. Since Bitcoin holds similar safe-haven properties like gold, Bitcoin has been identified as an effective hedging tool against distrust and uncertainty existing in the financial system. In the existing literature, works focusing on the cryptocurrencies hedging ability against uncertainty are relatively scarce. For instance, Bouri et al. (2018) examine the quantile conditional dependence and causality between Bitcoin and the global financial stress index using copula-based techniques. Results provide that Bitcoin can be a safe haven against global financial stress. Based on a multivariate quantile model, Wang et al. (2018) report that Bitcoin is a safe haven under EPU shocks. Also, the risk spillover effect from EPU to Bitcoin is negligible in most conditions. Panagiotidis et al. (2018) consider the drivers of Bitcoin returns using a LASSO approach and show that EPU has a negative impact on Bitcoin returns.

Furthermore, Demir et al. (2018) utilize the wavelet-based quantile-on-quantile method to find that Bitcoin can be used to hedge...
against uncertainty during the times of bull-market. Wu et al. (2019) combined the GARCH model and quantile regression with dummy variables to investigate whether gold or Bitcoin is a safe haven against economic policy uncertainty. They report that gold preserves stability with smaller hedge and safe-haven coefficients and Bitcoin responses more responsive to EPU shocks. Aysan et al. (2019) provide that the global geopolitical risk has predictive power on returns and price volatility of Bitcoin. Also, they report that the Bitcoin returns increase after a negative change in the global geopolitical risk. More recently, Paule-Vianez et al. (2020) argue that Bitcoin can act as a hedge or safe haven against economic uncertainty. P. Wang et al., 2020; G.J. Wang et al., 2020 investigate the impact of EPU on the Bitcoin (BTC) market denominated in local US and UK currencies. They report that the US EPU plays an important role in Bitcoin returns variations. Colon et al. (2020) examine the impact of geopolitical and economic uncertainty on the cryptocurrency market and argue that Bitcoin plays the role of a weak hedge and safe haven against EPU during a bullish market state. Panagiotidis et al. (2020) also indicate that EPU is a key variable for Bitcoin.

3. Data and methodology

3.1. Data

We use daily prices of the top-5 cryptocurrencies in terms of market capitalization (Bitcoin, Ethereum, Tether, XRP, and Bitcoin Cash) and gold price between 01/01/2018 and 07/06/2020. We also use the daily US economic policy index developed by Baker
The sample period is divided into two sub-sample periods: pre-COVID-19 pandemic and COVID-19 period based on 03/11/2020 when the World Health Organization (WHO) announced that COVID-19 is considered a pandemic.

Fig. 1 depicts the evolution of cryptocurrencies and gold prices and the trading volume during the sample period. The evolution paths show that Bitcoin prices have fallen during the first half of the year 2018 and then increased continuously and peaked at 12,000 points at the beginning of 2019. During the new COVID-19 pandemic outbreak at the end of the year 2019, with the announcement of the Chinese government of the first COVID-19 affected cases, Bitcoin prices show a large decline approximated by 6000 points (from 10,000 to 4000). In contrast, the Bitcoin prices recover rapidly during the first quarter of the year 2020, which coincides with the spread of the new coronavirus pandemic around the world. Regarding the Tether, we observe that its price is almost stable during the whole sample period, with a sudden decline during the last quarter of the year 2018 and then a sharp increase in mid-2019. After this date, Tether’s price remained almost stable till the end of the sample period and during the new COVID-19 crisis. For the other cryptocurrencies (Ethereum, XRP, and Bitcoin Cash), prices share similar behavior by falling from the beginning of the period until the end of the year 2018 and remain almost stable for the rest of the sample period.

Regarding the trading volume for each cryptocurrency, we notice that all cryptocurrencies exhibit similar patterns except Bitcoin cash and XRP. The trading volumes for the considered cryptocurrencies are going up from the beginning of the sample period, with a sudden upsurge in the transaction amounts during the outbreak of the coronavirus health crisis. For Bitcoin Cash, we can see that the amount of trading was very low during the overall sample period, but we register an unprecedented increase in the trading amount during the health crisis outbreak, and then it declines in the following period. We notice large increases in cryptocurrency trading volumes during the outbreak of the COVID-19 pandemic that decline slightly in the following months. These patterns indicate that investors increase their trading in the coins markets during the recent pandemic outbreak, reflecting the high liquidity of the cryptocurrency market and indicating that cryptocurrencies behave more like other financial assets than traditional safe-haven assets.

Fig. 2. US economic policy uncertainty index (the shaded area indicates the period of the COVID-19 pandemic).

Table 1
Descriptive statistics and preliminary tests on the data.

| Obs. | Bitcoin | Ethereum | Tether | XRP | Bitcoin Cash | Gold | EPU |
|------|---------|----------|--------|-----|--------------|------|-----|
| Mean | -0.0431 | -0.1319  | 0.0010 | -0.2623 | -0.2515 | -0.0468 | 0.0002 |
| Median| 0.0419  | -0.0111  | 0.0144 | -0.1255 | -0.3003 | -0.0344 | -0.0005 |
| Max  | 16.1042 | 22.5982  | 5.3393 | 32.1040 | 41.7094 | 6.2548  | 3.8922 |
| Min  | -31.5945| -42.3570 | -5.2570| -42.5166| -59.7721| -7.5137 | -3.4839 |
| Std. Dev.| 4.1709 | 5.3071  | 0.8176 | 5.3779 | 6.7992 | 1.2264 | 0.5599 |
| Skewness | -0.8106 | -1.0132 | 0.2811 | -0.3339 | -0.6579 | -0.1268 | 0.0954 |
| Kurtosis  | 9.6546 | 10.5478 | 25.0213 | 12.1840 | 16.1205 | 10.5707 | 10.3966 |
| J-B p-value | 0.0000 | 0.0000  | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| ADF  | -31.3317 | -32.1755 | -12.332 | -31.3054 | -31.5695 | -30.5628 | -25.3454 | -115.2003 |
| PP  | -31.3129 | -32.1453 | -21.332 | -31.5695 | -30.5628 | -25.3454 | -115.2003 |
| ERS  | 0.3451 | 1.2472  | 0.6846 | 0.3596 | 0.3468 | 1.3413 | 0.0228 |
| KPSS  | 0.1305 | 0.0837  | 0.1766 | 0.0745 | 0.0867 | 0.2294 | 0.2294 |
| Q(10) | 11.0450 | 21.366** | 62.967*** | 6.8251 | 23.5500*** | 26.1530*** | 210.780*** |
| Qs(10) | 86.934*** | 70.977*** | 38.689*** | 54.133*** | 17.1400* | 59.311*** | 214.700*** |
| ARCH(10) | 6.2271*** | 5.6645*** | 5.885*** | 4.4183*** | 1.5281 | 7.8451**** | 20.4997*** |

Notes: This table reports the descriptive statistics of the considered cryptocurrencies and gold. J-B is the p-value of the Jarque-Bera normality test statistics. ADF, PP, ERS, and KPSS indicate the unit root tests of Dickey and Fuller (1979); Phillips and Perron (1988); Elliot et al. (1996), and Kwiatkowski et al. (1988), respectively. Q(10) and Qs(10) are the Ljung-Box tests of serial correlations at order 10 for returns and squared returns, respectively. ARCH(10) is the F heteroscedasticity test at order 10. (**), (**), and (*) indicate the statistical significance, respectively, at 1%, 5%, and 10 % levels.

(2016) over the same period. The sample period is divided into two sub-sample periods: pre-COVID-19 pandemic and COVID-19 period based on 03/11/2020 when the World Health Organization (WHO) announced that COVID-19 is considered a pandemic.

The data of cryptocurrencies are downloaded from the website https://coinmarketcap.com/, gold price are obtained from DataStream, and EPU series is obtained from the website https://www.policyuncertainty.com/.

1 The data of cryptocurrencies are downloaded from the website https://coinmarketcap.com/, gold price are obtained from DataStream, and EPU series is obtained from the website https://www.policyuncertainty.com/.
during periods of market turmoil.

Gold prices show a slight decrease during the first semester of the year 2018. After that, prices kept growing up and reached their highest level during the outbreak of the COVID-19 pandemic outbreak. This unprecedented increase in gold prices during the COVID-19 crisis may be explained by the increasing sell-offs of gold by investors to raise cash (Baur and Dimpfl, 2020). Regarding gold’s trading volume, we notice that the amount of transactions on gold was very low during the overall sample period, whereas, with the outbreak of the covid-19 pandemic, we register a sharp increase in the transactions volume on gold at the beginning of the year 2020 which coincides with the announcement of the first infected-cases in china, and then maintain high values during the followed period. The evolution of the volume of transactions on gold implies that, as responses to bad news related to the coronavirus coming from China, investors who want to mitigate expected risks related to stock market downturns are likely to increase their trading in the gold market in the period of adverse market conditions.

Fig. 2 depicts the evolution of the Economic Policy Uncertainty (EPU) index during the sample period. As we can see, the US EPU, as gauged by the news-based EPU index, has shown a jump going from 100 to nearly 900 during the recent COVID-19 health crisis.

Table 1 reports descriptive statistics of the five cryptocurrencies, gold, and the EPU index returns2. Statistics show that the average daily returns of all cryptocurrencies as well as gold are negative, whereas the average return of the EPU index is positive. The Tether cryptocurrency exhibit the largest average returns compared to other cryptocurrencies and gold. Moreover, Bitcoin cash is the riskiest cryptocurrency, followed by XRP and Ethereum, given that they present the highest standard deviations. Based on the standard deviation’s values, the EPU index exhibits the lowest one, followed by gold. All considered time series are skewed to the left as indicated by the significant negative values of the skewness, except Tether and EPU index. Also, all series are characterized by excess kurtosis, suggesting a leptokurtic distribution with fat tails, and the null hypothesis of normality is rejected for all series at the 1% level as indicated by the Jarque-Bera test.

To test for the existence of unit root in the return’s series, we conduct some tests: the augmented dickey-Fuller (ADF) of Dickey and Fuller (1979), PP of Phillips and Perron (1988), and ERS of Elliot et al. (1996). We also use the KPSS test of Kwiatkowski et al. (1992) to conduct a robustness method. Based on the ADF, PP, and ERS, the result shows that the null hypothesis of unit root is rejected for all returns series, indicating that all series are integrated of order zero. Besides, for robustness analysis, the KPSS test shows similar results. The results from the Ljung-Box test on the returns and squared returns show that all series are autocorrelated and exhibit ARCH errors, suggesting that the GARCH process can fit the data.

3.2. Methodology

In this paper, we investigate the hedging and safe haven property of cryptocurrencies and gold against the economic policy uncertainty based on the two different procedures: the GARCH modeling of Baur and McDermott (2010) and the safe haven index (SHI) recently developed by Baur and Dimpfl (2020).

3.2.1. Hedging and safe haven model

To investigate the hedging and safe haven properties of the considered cryptocurrencies and gold, we follow the procedure of Baur and McDermott (2010) by estimating the following model:

\begin{equation}
R_{CR/GD} = a + b_1 \Delta EPU_t + \epsilon_t; \epsilon_t \sim N(0, h^2_t), \tag{1}
\end{equation}

\begin{align}
b_1 &= c_0 + c_1 D(\Delta EPU_t, q_{90}) + c_2 D(\Delta EPU_t, q_{95}) + c_3 D(\Delta EPU_t, q_{99}). \tag{2}
\end{align}

\begin{equation}
h^2_t = \alpha h^2_{t-1} + \beta \epsilon^2_{t-1}, \tag{3}
\end{equation}

where \(R_{CR/GD}\) is the cryptocurrencies’ or gold log-returns at the time \(t\). \(\Delta EPU\) denotes the log-difference of the economic policy index of Baker et al. (2016).

Eq. (1) describes the relationship between the cryptocurrency or gold asset and the changes in the economic policy uncertainty. The parameter \(b_1\) is assumed to be a dynamic process described by Eq. (2). The dummy variables \(D(,)\) in Eq. (2) are created to capture the extreme EPU movements and are equal to one if the EPU changes exceed 90 %, 95 %, and 99 % quantile of the EPU changes’ distribution and zero otherwise.3

The parameters to be estimated in the above model are \(a\) in Eq. (1), and \(c_0, c_1,\) and \(c_2\) in Eq. (2). Eq. (3) models the volatility dynamic described by a GARCH(1,1) process to account for the heteroscedasticity in the cryptocurrencies’ and gold’s returns. Following the estimated parameters of the model above, the hedging and safe haven properties of gold and cryptocurrencies could be verified as follows. If one of the parameters \(c_1, c_2,\) and \(c_3\) is significantly different from zero. There is evidence of a non-linear relationship between gold/cryptocurrency and the EPU index changes. If the parameters in Eq. (2) are non-positive (including \(c_0\)) gold or cryptocurrency acts as a weak safe haven against EPU. However, gold or cryptocurrency assets are a strong safe haven against EPU if these parameters are negative and statistically significant. Gold or cryptocurrency is a hedge for the EPU if the parameter \(c_0\) is zero.

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2 Return series are calculated as the log-difference of the price series.

3 Following Baur and McDermott (2010), investigating the hedging and safe haven properties against economic policy uncertainty is treated by considering higher quantiles. The same procedure is also proceeded by Wu et al. (2019) and Das et al. (2019).
(weak hedge) or negative (strong hedge), and the sum of the parameters \( c_1, c_2, \) and \( c_3 \) are not jointly positive exceeding the value of \( c_0 \).

To examine the ability of gold and the considered cryptocurrencies to act as a safe haven during the COVID-19 pandemic, we also follow Baur and McDermott (2010) and Ranaldo and Söderlind (2007) by replacing Eq. (2) by estimating the following equation:

\[
b_t = c_0 + c_1 D(COVID - 19),
\]

where \( D(.) \) denotes a dummy variable equal to one during the COVID-19 crisis and 0 otherwise. If the parameter \( c_1 \) is zero or negative, gold or a cryptocurrency is a safe haven against EPU during the COVID-19 crisis period. If the parameter is positive, gold or a cryptocurrency could not be considered as a safe haven against EPU during the COVID-19.

3.2.2. Safe haven index (SHI)

To examine whether the considered assets (cryptocurrencies and gold) share common safe haven features against the economic policy uncertainty, we use a so-called “safe haven index” (SHI) developed recently by Baur and Dimpfl (2020). SHI is a performance index, which reflects the average price development of a basket of \( n \) safe haven assets, defined by:

\[
SHI_t = \exp \left[ \ln(SHI_{t-1}) + R^b_t \right],
\]

where \( R^b_t \) denotes the equally weighted return of the basket, defined by:

\[
R^b_t = \frac{1}{n} \sum_{i=1}^{n} R_i.
\]

\( R^b_t \) is the logarithmic return of the \( i \)-th asset in the basket from \( t - 1 \) to \( t \) based on daily closing prices of the \( i \)-th asset. Baur and Dimpfl (2020) use this index as a benchmark to evaluate whether an asset can have safe haven property or not. To this end, they propose to estimate the following regression

\[
R_{i,t} = \mu_i + \theta_i \Delta SHI_t + \epsilon_{i,t},
\]

where \( R_{i,t} \) is the return of the asset \( i \) at time \( t \) and \( \Delta SHI_t \) denotes the log-return of the safe haven index at time \( t \). \( \mu_i \) and \( \theta_i \) are parameters to be estimated for each asset \( i \). Following this model, a typical safe haven asset would yield \( \mu_i = 0 \) and \( \theta_i = 1 \). More precisely, Baur and Dimpfl (2020) define that an asset \( i \) is a strong safe haven if \( \mu_i = 0 \) and \( \theta_i \geq 1 \). An asset is a weak safe haven if \( \mu_i = 0 \) and \( 0 < \theta_i < 1 \). If an asset \( i \) is a safe asset, then \( \mu_i > 0 \) and \( \theta_i = 0 \). In this study, we propose to extend the model expressed by Eq. (6) to a GARCH framework to account for the heteroscedasticity in the assets’ returns. Therefore, we estimate the following GARCH(1,1) process:

\[
R_{i,t} = \mu_i + \theta_i \Delta SHI_t + \epsilon_{i,t} \sim N \left( 0, h_{i,t}^2 \right),
\]

\[
h_{i,t}^2 = \alpha \epsilon_{i,t-1}^2 + \beta h_{i,t-1}^2
\]

where \( h_{i,t} \) denotes the conditional variance of the asset \( i \) at time \( t \).

4. Results and discussions

4.1. Hedging and safe haven properties

This section tests the hedging and safe haven properties of the five considered cryptocurrencies against EPU compared to gold as a traditional safe haven asset. To this aim, we start by implementing the ARCH test of Engle (1982) during the two sub-periods in order to verify if the specified GARCH model fit condonably our data during the two sample periods. The results of this test are presented in Table A1 in the appendix. We find evidence of ARCH effects only before the COVID-19 pandemic. This finding is not surprising since this phenomenon is generally found in long-time series. Moreover, the diagnostic analysis, reported in Table A2 and Table A3, in the appendix show that the model can be accepted and used to analyze the hedging and safe haven properties of cryptocurrencies and gold against EPU. Therefore, the Eq. (3) is removed from the above model during the COVID-19 pandemic, given the absence of ARCH effects during this period.

The estimation results of the considered model during the two sample periods are provided in Table 3. This table contains the estimates of \( c_0 \) and the total effect of the extreme market conditions, thus the sum of \( c_0 \) and \( c_1 \) for the 10% quantile, the sum of \( c_0 \), \( c_1 \), \( c_2 \) and \( c_3 \) for the 5% quantile and the sum of \( c_0 \), \( c_1 \), \( c_2 \) and \( c_3 \) for the 1% quantile. Panel (A) reports the estimation results before the COVID-19 health crisis, while panel B reports the estimates for the period following the health crisis without variance equations, given that there are no ARCH effects in our series during this sub-period.

\[\text{Footnote: A strong or weak safe haven asset cannot be a safe asset. For more details on the definitions of the strong, weak safe haven assets, and safe asset, see Baur and Dimpfl (2020).}\]
Table 2
Hedging and safe haven properties of cryptocurrencies and gold against EPU before and after the COVID-19 pandemic.

|                  | Bitcoin | Ethereum | Tether | XRP         | Bitcoin Cash | Gold                |
|------------------|---------|----------|--------|-------------|--------------|---------------------|
| Panel A: Pre-COVID-19 period: 01/01/2018 – 03/10/2020 |         |          |        |             |               |                     |
| $\alpha$        | −0.0863 | −0.2669  | 0.0071 | −0.2725     | −0.3033      | −0.0398            |
| (0.1478)        | (0.1908) | (0.0205) | (0.1959) | (0.2435) | (0.0480) |
| $\beta$         | −0.6973  | −0.0049  | −0.0012** | 0.3293   | 0.8717      | −0.0109            |
| (0.2757)        | (0.3270) | (0.0006) | (0.4318) | (0.5474) | (0.1644) |
| $\gamma$        | −0.9961  | −3.1054** | 0.0008 | −0.1476     | −2.7673      | −0.0495            |
| (0.9393)        | (1.4137) | (0.0026) | (1.9363) | (2.2473) | (0.9226) |
| $\delta$        | 0.4088   | 2.1668   | 0.0001 | −1.4095     | 1.9960       | −0.1267            |
| (1.8702)        | (2.0157) | (0.0033) | (2.9855) | (3.0546) | (1.0362) |
| $\psi$          | −0.1943  | −9.5473** | 0.0023 | 3.6247      | 2.7001       | −1.6168**          |
| (4.7645)        | (4.2982) | (0.0049) | (4.3783) | (9.0967) | (0.8011) |
| $\omega$        | 0.8096*** | 3.0940*** | 0.0157*** | 0.8620*** | 2.9676***   | 1.4144***          |
| (0.1489)        | (0.7307) | (0.0025) | (0.1409) | (0.5873) | (0.3217) |
| $\epsilon$      | 0.0759*** | 0.1055*** | 0.3255*** | 0.0552*** | 0.0540***   | 0.1771***          |
| (0.0133)        | (0.0208) | (0.0372) | (0.0080) | (0.0104) | (0.0193) |
| $\beta$         | 0.8687*** | 0.7714*** | 0.6643*** | 0.9081*** | 0.8914***   | 0.7825***          |
| (0.0216)        | (0.0445) | (0.0279) | (0.0114) | (0.0231) | (0.0256) |
| Panel B: COVID-19 period: 03/11/2020 – 07/06/2020 |         |          |        |             |               |                     |
| $\alpha$        | 0.4786   | 0.5543   | 0.0393 | −0.0084*** | −0.6955      | −0.0335            |
| (0.6543)        | (0.7943) | (0.1221) | (0.0001) | (0.9903) | (0.0507) |
| $\beta$         | −4.5766  | −5.8619  | −0.0024 | −2.0706*** | 6.8514       | −0.0165            |
| (3.2058)        | (3.7558) | (0.0019) | (0.027)  | (5.0005) | (0.1069) |
| $\gamma$        | 7.7855   | 5.2028   | 0.0022 | −3.3505*** | −4.9705      | 0.4767             |
| (6.6761)        | (6.7033) | (0.0029) | (0.0195) | (3.3046) | (0.3554) |
| $\delta$        | −2.4586  | −7.2704  | −0.0020 | 8.0023      | 4.1660       | −0.6679            |
| (9.1164)        | (36.6081)| (0.0030) | (17.0254) | (6.4040) | (0.4447) |
| $\psi$          | −7.1392  | −6.2582  | 0.0025 | −14.4290    | −10.8344     | −2.1836            |
| (3.3E + 09)     | (5.1E + 10)| (1.5E + 10)| (0.1E - 08)| (3.0E + 08)| (0.4E + 07)|

Notes: This table reports the parameter estimates of the model in Eqs. (1), (2), and (3) before and during the COVID-19 pandemic. Numbers between parentheses are the estimated standard errors. (***), (**) and (*) indicate the parameter significance at 1%, 5%, and 10% level, respectively.

Table 3
Safe haven property of cryptocurrencies and gold against EPU during COVID-19 pandemic.

|                  | Bitcoin | Ethereum | Tether | XRP         | Bitcoin Cash | Gold                |
|------------------|---------|----------|--------|-------------|--------------|---------------------|
| $\alpha$        | −0.0385 | −0.1525  | 0.0034 | −0.2509     | −0.2649      | −0.0406            |
| (0.1445)        | (0.1846) | (0.0183) | (0.1772) | (0.2289) | (0.0473) |
| $\beta$         | −0.1864 | −0.2826  | −0.0008 | 0.2725      | 0.9224       | −0.0471            |
| (0.2837)        | (0.3682) | (0.0005) | (0.4143) | (0.4687) | (0.1119) |
| $\gamma$        | −1.5432 | −2.0220  | −0.0007 | 1.8224      | 1.5786       | 0.0934             |
| (1.0233)        | (1.3211) | (0.0008) | (1.9239) | (2.4110) | (0.3850) |
| $\omega$        | 1.0098*** | 3.3444*** | 0.0339*** | 1.0941*** | 2.6042***   | 1.6121***          |
| (0.1899)        | (0.7515) | (0.0059) | (0.1570) | (0.6591) | (0.3517) |
| $\epsilon$      | 0.0873*** | 0.1219*** | 0.4341*** | 0.0787*** | 0.0657***   | 0.1560***          |
| (0.0156)        | (0.0232) | (0.0533) | (0.0096) | (0.0131) | (0.0196) |
| $\beta$         | 0.8471*** | 0.7464*** | 0.5604*** | 0.8778*** | 0.8726***   | 0.7875***          |
| (0.0253)        | (0.0469) | (0.0485) | (0.0119) | (0.0268) | (0.0272) |

Notes: This table reports the parameter estimates of the model in Eqs. (1), (4), and (3). The estimation is based on the whole period. Numbers between parentheses are the estimated standard errors. (***), (**) and (*) indicate the parameter significance at 1%, 5%, and 10% level, respectively.

Results from panel (A) show that neither gold nor cryptocurrencies can act as a hedge against the economic policy uncertainty (EPU) in the pre-health crisis period, as indicated by the insignificance of the parameter $\alpha$. Moreover, results indicate that Ethereum acts as a weak safe haven against EPU under extreme market conditions (only at the 10% and 1% quantiles), as indicated by the significance of the parameters $c_1$ and $c_2$. Tether exhibits significant but positive coefficients implying no safe haven effect of this cryptocurrency against EPU. We did not register any safe haven property for Bitcoin, Bitcoin Cash, and XRP cryptocurrencies, given the positive or negative but insignificant coefficients. In addition, results reveal that gold is also considered as a weak safe haven against EPU during the pre-health crisis. Our findings are in line with Wu et al. (2019), who find that neither gold nor Bitcoin can serve as a strong hedge or safe-haven for economic policy uncertainty (EPU) at the average condition and contradict those of Demir et al. (2018); Ji et al. (2018) and Wang et al. (2018), who find that Bitcoin serves as a hedging tool against EPU. Moreover, our findings are
consistent with Colon et al. (2020), who show that the cryptocurrency market does not have hedging property against EPU under different market conditions, but it could serve as a weak safe haven against EPU during bull market conditions.

Panel (B) of Table 2 reports the estimates for the same model during the recent health crisis (after the announcement of the COVID-19 as a pandemic). Again, the results show that neither gold nor cryptocurrencies may act as a hedge or safe haven against the increased EPU during this period.

For further robustness, we analyze the hedging and safe haven properties of the considered cryptocurrencies and gold separately during the recent health crisis known as the COVID-19 pandemic. The model specified in Eq. (4) analyzes the COVID-19 pandemic crisis explicitly and not implicitly as the model in Eqs. (1), (2), and (3) do. As indicated previously, the specification of the crisis period is based on the date of the announcement of the WHO that COVID-19 is a pandemic (03/11/2020).

Table 3 reports the parameter’s estimation results of the Eqs. (4) Combined with Eqs. (1) and (3). Results show that the coefficient estimate of the safe haven property during the recent COVID-19 crisis is not statistically significant for the five cryptocurrencies and gold. The results reveal again that neither cryptocurrencies nor gold act as a safe haven asset during the COVID-19 crisis, given that all parameters ($c_0$ and $c_1$) are statistically insignificant. Our results align with Baur and Dimpfl (2020), who find that gold and Bitcoin did not act as safe haven assets against the US stock market during the COVID-19 crisis. Also, our findings support those of Colon et al. (2020) and Goodell and Goutte (2021b), who find that cryptocurrencies are not safe haven assets against equity market risks during the COVID-19 crisis. Our findings also support critical views on Bitcoin as a safe haven asset addressed early by Klein et al. (2018) and Smales (2019) and, more recently, by Conlon and McGee (2020a). A plausible explanation of these findings was given by Fang et al. (2019). Authors show that investors would prefer to invest in well-established assets like stocks and commodities when uncertainty is high, possibly due to these risks being already priced into these assets than Bitcoin, which is a relatively new asset with an immense degree of volatility and likely to increase in risk during periods of heightened global uncertainty, and probably similar explanations hold for other cryptocurrencies.

4.2. Robustness analysis: the Safe haven index (SHI)

To validate our results and verify the ability of the cryptocurrencies and gold in hedging uncertainty before and over the COVID-19 pandemic, we perform a robustness analysis based on the safe haven index developed recently by Baur and Dimpfl (2020).

4.2.1. SHI returns and volatility analysis

In our study, the SHI is composed of the five considered cryptocurrencies and gold. Fig. 3 plots the log-returns and volatility paths of
the safe haven index (SHI) during the considered period. The graphs of daily returns show that the SHI index is very volatile with the onset of the COVID-19 pandemic, returns decreased dramatically, and the volatility jumped from 300 to more than 700, as illustrated by the conditional volatility graph of the SHI. Fig. 3 suggests that in a calm period, the volatility of the SHI is low. In fact, Baur and Dimpfl (2020) provide that when there is no safe haven event, a safe haven asset

| Table 4 |
|---------|
| SHI constituents and their link to SHI returns. |

| Panel A: Full sample period: 01/01/2018 - 07/06/2020 |
|---|---|---|---|---|---|
| Bitcoin | Ethereum | Tether | XRP | Bitcoin Cash | Gold |
| $\mu_i$ | 0.0123 | −0.0576 | 0.0533 | −0.1179 | −0.1561 | 0.0424 |
| (0.0802) | (0.1034) | (0.0400) | (0.1943) | (0.3138) | (0.0421) |
| $\phi_i$ | 0.0093*** | 0.0130*** | −0.0006*** | 0.0146*** | 0.0210*** | 0.0002 |
| (0.0002) | (0.0003) | (0.0001) | (0.0007) | (0.0009) | (0.0001) |
| $w_i$ | 1.3474*** | 3.1071*** | 0.0300*** | 1.3242** | 2.8321 | 0.3945*** |
| (0.2505) | (0.4047) | (0.0136) | (0.7973) | (1.7408) | (0.415) |
| $\alpha_i$ | 0.2633*** | 0.3256*** | 0.3224*** | 0.3799*** | 0.2999*** | 0.2523*** |
| (0.0372) | (0.0475) | (0.1037) | (0.1335) | (0.1235) | (0.0426) |
| $\beta_i$ | 0.6313*** | 0.5103*** | 0.6682*** | 0.5788*** | 0.6118*** | 0.4987*** |
| (0.0457) | (0.0462) | (0.0752) | (0.1460) | (0.1652) | (0.0428) |

| Panel B: preCOVID-19 period: 01/01/2018 - 03/10/2020 |
|---|---|---|---|---|---|
| Bitcoin | Ethereum | Tether | XRP | Bitcoin Cash | Gold |
| $\mu_i$ | −0.0321 | −0.1241 | −0.0003 | −0.1288 | 0.1184 | 0.0555 |
| (0.0882) | (0.1155) | (0.0102) | (0.1134) | (0.1395) | (0.0456) |
| $\phi_i$ | 0.0091*** | 0.0128*** | −0.0001*** | 0.0136*** | 0.0205*** | 0.0003* |
| (0.0003) | (0.0004) | (0.0000) | (0.0003) | (0.0004) | (0.0002) |
| $w_i$ | 1.2122*** | 3.1036*** | 0.0265*** | 2.8513*** | 2.9798*** | 0.4894*** |
| (0.2567) | (0.4874) | (0.0499) | (0.4494) | (0.4982) | (0.0639) |
| $\alpha_i$ | 0.2388*** | 0.2937*** | 0.4161*** | 0.2726*** | 0.2006*** | 0.2208*** |
| (0.0404) | (0.0506) | (0.0523) | (0.0427) | (0.0341) | (0.0424) |
| $\beta_i$ | 0.6583*** | 0.5339*** | 0.5169*** | 0.5573*** | 0.6526*** | 0.4083*** |
| (0.0484) | (0.0536) | (0.0432) | (0.0570) | (0.0465) | (0.0641) |

| Panel C: COVID-19 pandemic period: 03/11/2020 - 07/06/2020 |
|---|---|---|---|---|---|
| Bitcoin | Ethereum | Tether | XRP | Bitcoin Cash | Gold |
| $\mu_i$ | 0.1253 | 0.2027 | 0.0143 | −0.0954 | −0.1159 | −0.1194 |
| (0.2321) | (0.2122) | (0.0553) | (0.2562) | (0.1919) | (0.1170) |
| $\phi_i$ | 0.0136*** | 0.0157*** | 0.0001 | 0.0111*** | 0.0159*** | 0.0008*** |
| (0.0011) | (0.0013) | (0.0003) | (0.0014) | (0.0011) | (0.0000) |

Notes: This table reports the parameter estimates of the model in Eqs. (7) and (8) during all sample periods, before and during the COVID-19 pandemic. Numbers between parenthesis are the estimated standard errors. (***)**, (**), and (*) indicate the parameter significance at 1%, 5%, and 10% level.

The estimates of the parameter $\theta$ are significantly lower than 1, suggesting that these assets have weak safe haven properties against EPU during the sample periods, i.e., the exposure of these assets to the index is weak, and the assets do not rise as much during the safe haven events, but also falls more afterward. Tether exhibits significant but negative estimates of the parameter $\theta$ close to zero, suggesting that this cryptocurrency does not fill the characteristics of a safe haven asset against EPU.

The estimates of the parameter $\theta$ also reveal the risk or volatility of the safe haven assets with the highest values for Bitcoin cash and gold. These two assets are the riskiest. The Bitcoin has the smallest $\theta$ estimate (0.0092), close to zero, which places this cryptocurrency

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5 Following Baur and Dimpfl (2020), we compute the SHI based on initial value $SHI_0 = 100$.  

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Panel (B) and (c) report the estimation results of the safe haven properties of cryptocurrencies and gold before and during the COVID-19 pandemic. Before the recent health crisis, results are very similar to those found for the whole sample period. In fact, gold and all cryptocurrencies exhibit insignificant and non-zero estimated parameter, except for Tether. Also, we observe a significant and less than one estimated parameter. This result places these cryptocurrencies and gold in the group of weak safe haven assets. The estimate of $\theta$ value is very similar to all cryptocurrencies. While for gold, the estimate of the coefficient $\theta$ is smaller than the result found in panel (A), and its value is around zero (0.0005), indicating that gold is probably considered as a safe asset rather than a safe haven asset during the pre–COVID-19 crisis period. During the recent COVID-19 crisis, results show that the safe haven property of cryptocurrencies is similar for the two previous periods (the whole sample period and the post-crisis period) while it is different for gold. In fact, all cryptocurrencies exhibit insignificant and non-zero $\mu$ estimates, while they exhibit significant and less than one $\theta$ estimates (except Tether). These findings suggest that all considered cryptocurrencies, except Tether, are likely to act as a weak safe haven against EPU during the recent COVID-19 crisis. Our results align with Baur and Dimpfl (2020), who find that Bitcoin is very different from typical safe haven assets and suggests that this cryptocurrency is considered as a lucky, safe haven because its prices increased significantly over the last 10 years.

Regarding gold, while it acts as a weak safe haven during the whole sample period and the pre–COVID19 crisis, results show that gold lost its safe haven property during the recent health crisis as indicated by a significant but negative $\theta$ estimate. This finding supports the recent findings of Disli et al. (2021), who show that gold, Bitcoin, and oil lost their safe-haven characteristics for traditional, sustainable, and Islamic investors during the pandemic outbreak. However, our results do not align with Baur and Dimpfl (2020), who find that gold is classified as a strong, safe haven asset against the US stock market. and contradict recent findings of Salisu et al. (2021b), who find evidence of hedging effectiveness between gold and sectoral stocks, albeit with low performance, during the COVID-19 pandemic.

5. Conclusion

The ongoing COVID-19 pandemic and associated financial turbulence have increased uncertainty worldwide. This risky environment has recently increased interest in the hedging and safe haven properties of the well-known safe haven assets, such as gold and Bitcoin, during the COVID-19 bear market. A growing body of researches has suggested that Bitcoin acts as a safe haven and a good diversifier in times of extreme political and economic uncertainty. In this study, we focus on the broader cryptocurrency market to first assess the hedging and safe haven properties of the top-5 cryptocurrencies in terms of market capitalization (Bitcoin, Bitcoin Cash, Tether, Ethereum, and XRP) comparing to gold against the global uncertainty. Our methodology consists of two approaches. First, we use the methodology of Baur and McDermott (2010) to assess whether cryptocurrencies and gold may act as a hedge or safe haven against economic policy uncertainty (EPU) before and during the outbreak of the COVID-19 pandemic. Second, for robustness purposes, we apply a new approach proposed by Baur and Dimpfl (2020) based on the so-called “Safe Haven Index” (SHI). According to Baur and Dimpfl (2020), the SHI is a good benchmark to enhance our understanding of safe haven assets and distinguish them from safe and risky assets.

Using the first model of Baur and McDermott (2010), our findings show that all considered cryptocurrencies, as well as gold, cannot act as a hedge against EPU during the whole sample period and during the recent COVID-19 health crisis. Moreover, the Tether, Ethereum, and gold exhibit weak safe haven properties during the whole sample period under study, but all assets lose this property during the onset of the COVID-19 pandemic. These findings imply that investors should not rely on the cryptocurrency or gold markets as alternative assets that shelter from turbulence in traditional markets during increased economic and political uncertainty periods.

Looking at a specific crisis period, we re-estimate the model and focus on the recent health crisis generated by the COVID-19 pandemic. Results show that neither cryptocurrencies nor gold can serve as a hedge or safe haven during this recent crisis.

Further analysis of the SHI Benchmark, we find that the safe haven index returns are very volatile. In addition, the SHI returns decreased considerably with the onset of the COVID-19 pandemic, while the index volatility reached its highest value on this date. Moreover, during the COVID-19 crisis, we find that the SHI returns and volatility go down when the EPU returns and volatility go up. Also, our benchmark reveals that gold may be considered as a safe haven asset during the whole sample period and before the onset of the COVID-19 crisis but not during the recent health crisis. Gold exhibits a weak value of safe haven theta (close to zero) in the pre–COVID-19 health crisis, which classes this asset in the group of safe assets. Moreover, all considered cryptocurrencies, except Tether, are classified as weak safe haven assets given their significant safe haven theta coefficients (exposure to the safe haven index), and this result holds for the whole sample period, before and during the COVID-19 pandemic.

Our findings on the insignificant safe haven property of gold and cryptocurrencies during extreme market uncertainty provide new insights for investors who search for refuge when constructing assets portfolios, i.e., neither cryptocurrencies nor gold can act as strong hedges or strong safe haven under extreme EPU shocks. Moreover, our findings on the hedging and safe haven properties of the cryptocurrency market and gold may provide valuable information for countries and regulatory agencies when they define the positioning of the cryptocurrency market in their financial system and set relevant regulatory policies on cryptocurrencies (Wang et al., 2018).

CRediT authorship contribution statement

Khaled Mokni: Conceptualization, Methodology, Software, Supervision. Manel Youssef: Visualization, Writing - review & editing, Validation. Ahdi Noomen Ajmi: Data curation, Investigation, Writing - original draft.
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.

Appendix A

Table A1
ARCH test with 10 lags on the returns series before and during the COVID-19 pandemic.

|                    | Bitcoin | Ethereum | Tether | XRP    | Bitcoin Cash | Gold   |
|--------------------|---------|----------|--------|--------|--------------|--------|
| **Panel A: pre-COVID-19 period: 01/01/2018 – 03/10/2020** |         |          |        |        |              |        |
| F-Statistics       | 0.0903  | 1.7033   | 4.9663 | 2.2224*| 0.7600       | 0.8511 |
| p-value            | (0.7641)| (0.1523) | (0.4200)| (0.0712)| (0.3852)     | (0.3596) |

|                    |         |          |        |        |              |        |
| **Panel B: COVID-19 period: 03/11/2020 – 07/06/2020** |         |          |        |        |              |        |
| F-statistics       | 0.0903  | 1.7033   | 4.9663 | 2.2224*| 0.7600       | 0.8511 |
| p-value            | (0.7641)| (0.1523) | (0.4200)| (0.0712)| (0.3852)     | (0.3596) |

Notes: This table provides the Fisher statistics and its p-values of ARCH test, for lag k = 10, on the returns series. Numbers between parentheses are the p-values of the tests’ statistics. (*), (**), and (***) indicate the statistical significance of the statistics at 10 %, 5%, and 1% respectively.

Table A2
Residual diagnostic of the model (1) – (3).

|                    | Bitcoin | Ethereum | Tether | XRP    | Bitcoin Cash | Gold   |
|--------------------|---------|----------|--------|--------|--------------|--------|
| **Panel A: pre-COVID-19 period: 01/01/2018 – 03/10/2020** |         |          |        |        |              |        |
| Q(5)               | 8.3612  | 14.1630  | 3.9087 | 10.5230| 1.2547       | 1.3656 |
| p-value            | (0.1370)| (0.0150) | (0.563) | (0.0620)| (0.7451)     | (0.9280) |
| Qs(5)              | 0.9529  | 1.1974   | 9.0740 | 3.0493 | 1.0626       | 0.8952 |
| p-value            | (0.9343)| (0.5432) | (0.7867)| (0.2337)| (0.9751)     | (0.4650) |

|                    |         |          |        |        |              |        |
| **Panel B: COVID-19 period: 03/11/2020 – 07/06/2020** |         |          |        |        |              |        |
| Q(5)               | 45.9740 | 37.1340  | 27.3560| 25.7480| 35.7350      | 12.1210|
| p-value            | (0.0000)| (0.0000) | (0.0000)| (0.0000)| (0.0000)     | (0.0000) |
| Qs(5)              | 4.5830  | 4.5731   | 0.5707 | 5.4202 | 8.7607       | 4.6214 |
| p-value            | (0.4690)| (0.4700) | (0.9890)| (0.3670)| (0.0670)     | (0.4640) |
| ARCH-F             | 0.8595  | 0.8966   | 0.8595 | 1.3975 | 3.2472       |
| p-value            | (0.5899)| (0.9774) | (0.5391)| (0.3558)| (0.2396)     | (0.0505) |

Notes: This table provides the diagnostic tests of the residual series from the model in Eqs. (1) – (3). Q(5) and Qs(5) denote the Ljung-Box statistic for 5th order serial correlation for residual and squared residuals, respectively. ARCH-F denotes the Fisher statistics of ARCH test with lag length k = 10. Numbers between parentheses are the p-values of different tests’ statistics. (*), (**), and (***) indicate the statistical significance of the statistics at 10 %, 5%, and 1% respectively.

Table A3
Residual diagnostic from the safe haven index model (7) – (8).

|                    | Bitcoin | Ethereum | Tether | XRP    | Bitcoin Cash | Gold   |
|--------------------|---------|----------|--------|--------|--------------|--------|
| **Panel A: pre-COVID-19 period: 01/01/2018 – 03/10/2020** |         |          |        |        |              |        |
| Q(5)               | 58.9930 | 80.0120  | 71.9780| 33.6390| 47.9530      | 34.0420|
| p-value            | (0.0000)| (0.0000) | (0.0000)| (0.0000)| (0.0000)     | (0.0050) |
| Qs(5)              | 5.8335  | 1.3948   | 2.5283 | 7.7572 | 5.2519       | 4.4336 |
| p-value            | (0.3230)| (0.2380) | (0.7720)| (0.1700)| (0.3860)     | (0.4890) |
| ARCH-F             | 0.8597  | 1.8880   | 0.4250 | 0.9419 | 0.7513       | 1.4816 |
| p-value            | (0.5307)| (0.0436) | (0.9348)| (0.4937)| (0.6761)     | (0.1414) |

|                    |         |          |        |        |              |        |
| **Panel B: COVID-19 period: 03/11/2020 – 07/06/2020** |         |          |        |        |              |        |
| Q(5)               | 45.9740 | 37.1340  | 27.3560| 25.7480| 35.7350      | 12.1210|
| p-value            | (0.0000)| (0.0000) | (0.0000)| (0.0000)| (0.0000)     | (0.0000) |
| Qs(5)              | 4.5830  | 4.5731   | 0.5707 | 5.4202 | 8.7607       | 4.6214 |
| p-value            | (0.4690)| (0.4700) | (0.9890)| (0.3670)| (0.0670)     | (0.4640) |
| ARCH-F             | 0.6565  | 0.8711   | 1.6578 | 0.7744 | 1.6585       | 0.1784 |
| p-value            | (0.7616)| (0.5626) | (0.0603)| (0.6530)| (0.1017)     | (0.9974) |

Notes: This table provides the diagnostic tests of the residual series from the model in Eqs. (1) – (3). Q(5) and Qs(5) denote the Ljung-Box statistic for 5th order serial correlation for residual and squared residuals, respectively. ARCH-F denotes the Fisher statistics of ARCH test with lag length k = 10. Numbers between parentheses are the p-values of different tests’ statistics. (*), (**), and (***) indicate the statistical significance of the statistics at 10 %, 5%, and 1% respectively.
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