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## Article

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Article

# Analyzing Safe Haven, Hedging and Diversifier Characteristics of Heterogeneous Cryptocurrencies against G7 and BRICS Market Indexes

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**Abstract:** Cryptocurrency markets have experienced large growth in recent years, with an increase in the number and diversity of traded assets. Previous work has addressed the economic properties of Bitcoin with regards to its hedging or diversification properties. However, the surge of many alternatives, applications, and decentralized finance services on a variety of blockchain networks requires a re-examination of those properties, including indexes from outside the big economies and the inclusion of a variety of cryptocurrencies. In this paper, we report the results of studying the most representative cryptocurrency of each consensus mechanism by trading volume, forming a list of twenty-four cryptocurrencies from the 1st of January 2018 to the 30th of September 2022. Using the Baur and McDermott model, we examine hedge, safe haven, and diversifier properties of all assets for all G7 country's major indexes as well as all BRICS major indexes breaking it down by two attributes: kind of blockchain technology and pre/during COVID health crisis. Results show that both attributes play an important role in the hedge, safe haven, and diversifier properties associated with the asset. Concretely: stablecoins appear to be the only ones to maintain hedge property in most analyzed markets pre- and during-COVID; Bitcoin investment properties shifted after the COVID crisis started; China and Russia stopped being correlated with the cryptocurrency after the COVID crisis hit.

**Keywords:** diversifier; safe haven; hedging; G7; BRICS; blockchain technology; blockchain privacy; cryptocurrency



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## 1. Introduction

Bitcoin is the largest and first widely adopted cryptocurrency (Demir et al. 2018). It is a decentralized system existing only in digital form—as a ledger any user can access—and is not governed or issued by any single government or banking entity (Nakamoto and Bitcoin 2008). Given its history of volatility, it is regarded as a high-risk investment. Despite this, due to its innovative and transparent qualities, Bitcoin has continued to grow in popularity since its inception in 2009. Most literature focuses on the safety and legality of Bitcoin, but in recent years an increasing number of articles address the hedge, safe haven, and diversifier properties of cryptocurrencies (Shahzad et al. 2020; Bouri et al. 2017; Dyhrberg 2016; Kang et al. 2020; Beneki et al. 2019; Wang et al. 2019; Jin et al. 2019; Chan et al. 2019; Garcia-Jorcano and Benito 2020; Mensi et al. 2019). Further, the market landscape has changed in recent years, with a variety of new programmable blockchain networks offering alternatives to Bitcoin. Some of them are built with special features (e.g., privacy in the case of ZCash) or platforms targeted to smart contracts that extend their base functionality (e.g., Ethereum). Thus, they might influence how their market behaves beyond pure financial concerns.

The most important added value of this work in comparison to the existing literature is the inclusion indexes of developing countries, as developing countries are leaders in

trading cryptocurrency asset and the interesting results achieved for those indexes makes this research an interesting tool for other researchers and investors.

Additionally, we compare and contrast other cryptocurrencies using the same methodologies to explore how they correlate or deviate from Bitcoin and market indices like the G7 and BRICS markets and how properties changed during pre-COVID and During-COVID.

The remainder of the paper is as follows. Section 2 describes previous relevant work. Section 3 describes our data, model, and methodology. Section 4 reports the results and discusses the findings. Then, Section 5 provides conclusions and an outlook.

## 2. Background

Previous work has reported research on the investment properties of Bitcoin, concretely the properties of Diversifier, Hedge, and Safe Haven. In what follows, we survey the main results to date.

[Fang et al. \(2019\)](#) provide evidence supporting that global economic policy uncertainty affects the long-run volatilities of Bitcoin and some other global equities/commodities but does not affect bonds.

[Bouri et al. \(2017\)](#) used a dynamic conditional correlation model (DCC) to examine whether Bitcoin could act as a cover and refuge for the main world stock indexes, oil bonuses, gold, raw materials, and the US dollar index. The results show that Bitcoin could not be considered a weak haven for the studied assets. The results of the DCC model show that Bitcoin can serve as an effective diversifier in most cases, and in a few cases, Bitcoin has been shown to have safe haven properties. [Dyhrberg \(2016\)](#) uses asymmetric GARCH methodology to show that bitcoin can clearly be used as a hedge against stocks in the Financial Times Stock Exchange Index. [Kang et al. \(2020\)](#) used a variation of the DECO-FIGARCH model and found a high negative correlation during 2011–2013 (European sovereign debt crisis), which demonstrated that Bitcoin could be a hedge asset during market turmoil and that Bitcoin reduces downside risk and reinforces the diversification advantages of equity portfolios during down trending market (bear market). It concludes that Bitcoin is a safe haven ONLY for the S&P 500. In the same direction, [Shahzad et al. \(2020\)](#) compares gold and Bitcoin to decide which of the two is a better safe haven, hedge, or diversifier asset for financial markets of the G7 countries (Canada, France, Germany, Italy, Japan, the UK, and the US), it concludes that gold is a safe haven and hedge for the G7. Bitcoin only shows safe haven and hedge properties for Canada. It concludes that the hedging effectiveness of gold is much higher than that of Bitcoin (Except in Canada).

[Beneki et al. \(2019\)](#) investigated how the emergence of Ethereum affects hedging in Bitcoin. This article is especially interesting because it is one of the first to measure volatility spillovers using the BEKK-GARCH model between a mature cryptocurrency (Bitcoin) with a less mature one (Ethereum). [Wang et al. \(2019\)](#) extended the work of [Beneki et al. \(2019\)](#) using a VAR-GARCH-BEKK model centering its attention on China, a country outside developed markets with much interest in Digital Currency [Kharpal \(2021\)](#).

[Jin et al. \(2019\)](#) included crude oil in the list of hedging assets with gold and Bitcoin. It concludes that the dynamic correlations between gold and crude oil markets are almost positive, indicating that crude oil is a diversifier for gold. However, dynamic correlations between Bitcoin and oil markets are nearly negative, indicating hedge properties.

[Chan et al. \(2019\)](#) expanded the list of market indexes to be Euro STOXX, Nikkei, Shanghai A-Share, S&P 500, and the TSX Index and used Pairwise GARCH models and constant conditional correlation with daily, weekly, and monthly returns from October 2010 to October 2017, concluding that Bitcoin is an effective strong hedge for all these indices under monthly data frequency. [Garcia-Jorcano and Benito \(2020\)](#) looked into similar markets (S&P500 (US), STOXX50 (EU), NIKKEI (Japan), CSI300 (Shanghai), and HSI (Hong Kong)) and confirmed that Bitcoin act as a hedge asset against the stock price movements of all international markets using several copula models, with Gaussian and Student-t copulas being the most relevant.

Mensi et al. (2019) created three types of mixed portfolios (risk-minimizing portfolio, equally weighted portfolio, and hedging portfolio) formed of Bitcoin, Dash, Ethereum, Litecoin, Monero, and Ripple, and showed evidence that a mixed portfolio provides better diversification benefits for investors and portfolio managers.

After reviewing the available literature, we identified the need for further research in two main directions. First, including more reference market indexes outside the big economies, is especially important because owners of cryptocurrencies globally come from outside big economies Sta (2021). Secondly, including additional cryptocurrencies in order to explore investment patterns through Blockchain Technology and maturity (market adoption). On top of that, Table 1 shows a series of articles applying Baur and McDermott's (2010) model for identifying Haven and Hedge properties to one or more asset(s). Therefore, the methodology chosen is Baur and McDermott (2010), which according to Table 1, continues to appear often over the years.

**Table 1.** Articles over the years that applied the Baur and McDermott (2010) model.

Year of Publication	Reference	Asset Analyzed	Method Used
2010	Baur and McDermott (2010)	Gold	Baur and McDermott (2010)
2016	Baur and McDermott (2016)	Gold	Baur and McDermott (2010)
2017	Bouri et al. (2017)	Major world stock indices, bonds, oil, gold	Baur and McDermott (2010) and Baur and Lucey (2010)
2019	Sett (2019)	G7 Stock Indexes and Bonds	Baur and McDermott (2010) and Baur and Lucey (2010)
2020	Baur and Kuck (2020)	S&P 500	Baur and McDermott (2010) and Baur and Lucey (2010) and GARCH model
2021	CITATION	Islamic index, Bitcoin and Gold	Baur and McDermott (2010) and Baur and Lucey (2010)

### 3. Methodology

#### 3.1. Safe Haven Asset, Hedge, and Diversifier Assets

To differentiate between safe haven, hedge, and diversifier assets, we will define all three types using existing frameworks from the literature. Baur and Lucey (2010) were the first to define testable definitions of a diversifier, hedge, and safe haven, making it possible to explore and identify the capabilities of an asset. The definitions are as follows: "A diversifier is defined as an asset that is positively (but not perfectly correlated) with another asset or portfolio on average. A hedge is an asset that is uncorrelated or negatively correlated with another asset or portfolio on average. A strict hedge is (strictly) negatively correlated with another asset or a portfolio 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."

We applied the Baur and McDermott (2010) method, which expanded on these definitions by differentiating between weak and strong forms. "A strong (weak) hedge is defined as an asset that is negatively correlated (uncorrelated) with another asset or portfolio on average. A strong (weak) safe haven is defined as an asset that is negatively correlated (uncorrelated) with another asset or portfolio in certain periods only, e.g., in times of falling stock markets.". This ability is key in the studied period, which includes the COVID pandemic.

Although the application of the method Baur and McDermott (2010) may sound plain vanilla, we have tested Multivariate GARCH and considered the DCC model and asymmetric DCC models; however, due to the extreme volatility in the cryptocurrency market, especially during the COVID pandemic, we encountered that the lack of parsimony of those methods was driving us to wrong decisions about Safe Haven Asset, Hedge and Diversifier properties, the same can be observed Hniopek and Kiselev (2015) where the reported p-values indicate poor goodness of its VAR-GARCH model. Table 1 shows that the

Baur and McDermott (2010) model continues to be used often over the years. We decided to remain with a more plain vanilla method, more appropriate to the volatile cryptocurrency market, as it gave us better control/visibility over adjusting the parameters.

### 3.2. Data Acquisition

We extracted daily historical prices, trading volumes of gold, a series of the most important cryptocurrencies (by volume for each consensus mechanism), and the most important world market indices and their correspondent money currency exchange rate from the 1st of January 2018 up to the 30th of September 2022. This data was extracted from Yahoo Finance. If more data (further into the past) was included, fewer of the newer cryptocurrencies could be included (decreasing the effectiveness of our study). Including market indexes from outside the big economies is extremely important as owners of cryptocurrencies globally come from outside big economies, according to the Statista website data Sta (2021). We also deliberately decided to include pre-COVID and during-COVID data. We analyzed the full period, pre-COVID and after-COVID started named here during-COVID.

A modeling procedure was then used to assess the hedge and safe haven properties of Bitcoin.

Table 2 shows descriptive statistics of the return data over the full sample period for 24 cryptocurrencies and 12 market indices, and gold.

**Table 2.** Descriptive statistics of data over the full sample period. Non US-dollar asset was converted into US-dollar using the closing exchange rate. \* calculated using Close price.

Symbol	Description	Count	Mean *	Std *	Min *	25% *	50% *	75% *	Max *
GC=F	Gold Spot Price	654	1809.155	89.39434	1477.3	1751.3	1805.55	1870.075	2051.5
BTC-USD	Bitcoin USD	945	31,209.08	17,254.67	4970.788	12,965.89	32,569.85	45,555.99	67,566.83
ETH-USD	Ethereum USD	945	1822.112	1304.36	110.6059	412.4576	1772.102	2897.977	4812.087
LTC-USD	Litecoin USD	945	114.4122	68.22829	30.93088	53.81748	106.2749	163.8183	386.4508
BCH-USD	BitcoinCash USD	945	382.2992	220.6646	97.54175	233.1558	307.8653	522.2714	1542.425
BSV-USD	BitcoinSV USD	945	150.6732	64.37677	46.39974	94.76942	162.5261	184.2871	441.3943
DOT-USD	Polkadot USD	773	19.34745	12.64941	2.875028	7.365457	17.89226	28.58062	53.88173
EOS-USD	EOS USD	945	3.205723	1.619418	0.889911	2.358139	2.76872	3.971474	14.36554
LINK-USD	Chainlink USD	945	16.30325	10.13844	1.779877	7.39609	14.12053	24.63165	52.1987
BNB-USD	BinanceCoin USD	945	251.4052	195.5085	9.38605	28.30512	280.0186	402.45	675.6841
VET-USD	VeChain USD	945	0.055395	0.050509	0.002274	0.016395	0.031538	0.08584	0.254632
ATOM-USD	Cosmos USD	945	15.02725	11.0119	1.649203	5.281725	11.76493	23.59488	44.54279
TRX-USD	TRON USD	945	0.057196	0.031805	0.008792	0.026945	0.061292	0.075397	0.16465
NEO-USD	NEO USD	945	26.72435	20.50329	5.377224	11.06976	20.15465	38.14567	122.6834
XTZ-USD	Tezos USD	945	3.287027	1.492052	1.288307	2.153276	2.920266	4.062389	8.703033
XEM-USD	NEM USD	945	0.144905	0.120631	0.032336	0.049496	0.115008	0.185292	0.79527
USDT-USD	Tether USD	945	1.000624	0.002785	0.974248	1.000034	1.000337	1.000848	1.053585
USDC-USD	USDCoin USD	945	1.000184	0.002469	0.970124	0.999861	1.000072	1.000345	1.040553
XMR-USD	Monero USD	945	174.0921	82.5966	33.01032	115.8375	162.3905	230.6996	483.5836
DASH-USD	Dash USD	945	122.7475	72.2015	39.93123	70.98058	97.64275	164.9605	440.8867
ZEC-USD	Zcash USD	945	106.3527	55.31588	24.5043	61.16663	94.35249	143.9968	318.9179
XRP-USD	Ripple USD	945	0.577729	0.357397	0.139635	0.264122	0.471991	0.818588	1.839236
ADA-USD	Cardano USD	945	0.825132	0.723037	0.023961	0.129908	0.559813	1.292388	2.968239
XLM-USD	Stellar USD	945	0.215049	0.14156	0.033441	0.099877	0.185127	0.317452	0.729996
CCXX-USD	CounosX USD	895	56.08887	33.93735	14.45128	20.41959	53.66284	90.71275	179.0048

### 3.3. Data Preparation

Our final dataset was comprised of daily returns data from the 1st January 2018 to the 30th September 2020, standardized to US-dollar. Market indexes are missing when the market is closed (weekends and bank holidays), while Cryptocurrency trading has none missing as it never closes. To merge and compare the two data sets we considered (1) dropping the corresponding weekend and bank holiday from the cryptocurrency when analyzing each country index and cryptocurrency pair; (2) applying a forward filling on the missing market index data due to bank holidays and weekends (market closed). We realized that option 1, dropping Cryptocurrency data, was exaggerating our correlations.

Therefore we opted for option 2, applying a forward filling technique as it seemed a more conservative approach, and we considered that conclusions made in this scenario are valid in both scenarios.

### 3.4. Returns Calculation

Returns were calculated using daily returns:

$$R_t = \frac{P_t}{P_{t-1}}$$

where  $P_t$  is the return of price  $P$  at time (current day)  $t$  divided by the previous day's price  $P_{t-1}$ .

### 3.5. Hedge or Safe Haven Assets Model

As presented in [Baur and McDermott \(2010\)](#), we check the safe haven, hedge, or diversifier property of all cryptocurrencies and gold against extreme conditions of different markets based on a linear regression analysis, using an ordinary least squares model. Further, we analyze the extreme conditions in the lower 10th, 5th, or 1st percentile of the return distribution as follows:

$$r_{Crypto} = c + \gamma_0 * r_{M,t} + \gamma_1 * D(r_{M,q10}) * r_{M,t} + \gamma_2 * D(r_{M,q5}) * r_{M,t} + \gamma_3 * D(r_{M,q1}) * r_{M,t} + \epsilon_t$$

where  $r_{Crypto}$  is the return of the cryptocurrency estimated by the return of the market  $M$ . The constant is represented for the letter  $c$  and the error term for  $\epsilon_t$ . The dummy variables denoted as  $D(.)$  capture extreme stock market movements and are equal to one if the stock market exceeds a certain threshold given by the 10%, 5% and 1% quantile of the return distribution.

### 3.6. Diversifier, Safe Haven or Hedge Criteria

We define the following rules, adapted from both [Baur and McDermott \(2010\)](#) and [Shahzad et al. \(2020\)](#).

neither: if one of the parameters  $\gamma_1$ ,  $\gamma_2$ , and  $\gamma_3$  is significantly different from zero, there is evidence of a non-linear relationship between the cryptocurrency and the stock market (regression  $p$ -value  $\leq 10\%$ ).

diversi: otherwise, the cryptocurrency is considered a diversifier against movements in the market, if  $\gamma_0$  is statistically significantly positive (both  $\gamma_0 > 0.0$  and regression  $p$ -value  $> 10\%$ )

haven+: otherwise, the cryptocurrency is a strong safe haven if the quantile coefficients  $\gamma_1$ ,  $\gamma_2$ , and  $\gamma_3$  are all statistically negative ( $\gamma_{1,2,3} < 0.0$  and regression  $p$ -values  $\leq 10\%$ )

haven-: otherwise, it is a weak safe haven if the quantile coefficients  $\gamma_1$ ,  $\gamma_2$ , and  $\gamma_3$  are negative or statistically insignificantly different from zero ( $\gamma_{1,2,3} < 0.0$  or regression  $p$ -values  $> 10\%$ )

hedge+: otherwise, it is a strong hedge if  $\gamma_0$  is statistically significantly negative (both  $\gamma_0 < 0.0$  and regression  $p$ -value  $\leq 10\%$ )

hedge-: otherwise, it is a weak hedge if  $\gamma_0$  is zero (regression  $p$ -value  $> 10\%$ );

## 4. Results and Discussion

Table 3 presents some qualitative information about each asset (gold and cryptocurrency) used in the analysis; we can observe the year the cryptocurrency was first released to the market; some special cases have the month also indicated as our data selection starts in 1st of January 2018 because we only have partial data for this cryptocurrency, however, for some interesting conclusion can be withdrawn even with partial data. The definition of all Blockchain Technologies ([Wik 2021a, 2021b, 2021c](#)) (PoW, PoS, PoA, SCP, dBFT, PoI, Stablecoin, and a mix of PoW & PoS) can be found in Appendix A. Tables 3–6 are sorted in

descending order by volume of transactions at the 30th of September 2022. This acts as an interesting proxy for market adoption.

**Table 3.** Qualitative information for each asset (gold and cryptocurrency) used in the analysis.

Symbol	Description	Type	Technology	Release	Volume Tril. \$
GC=F	Gold Spot Price	gold	-	-	548
USDT-USD	Tether USD	crypto-public	Stablecoin	2015	27.31292
BTC-USD	Bitcoin USD	crypto-public	PoW	2009	18.71954
ETH-USD	Ethereum USD	crypto-public	PoW	2015	6.227961
USDC-USD	USDCoin USD	crypto-public	Stablecoin	September/2018	3.108134
XRP-USD	Ripple USD	crypto-public	Consensus	2013	1.544058
BNB-USD	BinanceCoin USD	crypto-public	PoS	2017	0.593376
ADA-USD	Cardano USD	crypto-public	PoS	2017	0.317806
LINK-USD	Chainlink USD	crypto-public	PoS	May/2019	0.313342
TRX-USD	TRON USD	crypto-public	PoS	2017	0.292353
XLM-USD	Stellar USD	crypto-public	SCP	2014	0.267535
LTC-USD	Litecoin USD	crypto-public	PoW	2011	0.256914
BCH-USD	BitcoinCash USD	crypto-public	PoW	2017	0.202425
ATOM-USD	Cosmos USD	crypto-public	PoS	March/2019	0.17939
DOT-USD	Polkadot USD	crypto-public	PoS	May/2020	0.177865
EOS-USD	EOS USD	crypto-public	PoS	2017	0.163115
XMR-USD	Monero USD	crypto-private	PoW	2014	0.060837
BSV-USD	BitcoinSV USD	crypto-public	PoW	May/2018	0.052668
DASH-USD	Dash USD	crypto-private	PoW	2014	0.050602
ZEC-USD	Zcash USD	crypto-private	PoW	2016	0.047063
VET-USD	VeChain USD	crypto-public	PoA	2016	0.045363
NEO-USD	NEO USD	crypto-public	dBFT	2014	0.023583
XTZ-USD	Tezos USD	crypto-public	PoS	2017	0.013301
XEM-USD	NEM USD	crypto-public	Pol	2015	0.007806
CCXX-USD	CounosX USD	crypto-public	mix PoW & PoS	June/2019	0.000578

Tables 4–6 present the results obtained for gold and all analyzed cryptocurrency for the BRICS and G7 market indexes during the whole period analyzed, ranging from the 1st of January 2018 to the 30th of September 2022, the pre-COVID period ranging from the 1st of January 2018 to the 29th of February 2020 and during-COVID, the period after COVID health crisis started ranging from the 1st of March 2020 to the 30th of September 2022, respectively.

From the whole period in Table 3, we observed the following:

- Stablecoins Tether (USDT) and USDCoin (USDC) are the most effective hedge/havens compared to other cryptocurrencies.
- Gold acts as a diversifier asset for the majority of indices. Gold can be used for hedging in India and Italy. However, it had no interesting property for Russia and the UK.
- China, Russia, Italy, and the UK appear to be outliers, with a majority of “neither” for most cryptocurrencies.
- In South Africa, Canada, France, and Germany, most cryptocurrencies.
- From the Pre-COVID period Table 4, we observed the following:
- In some markets, Gold is used to hedge against the other assets’ risk.
- Investors in China use multiple Cryptocurrencies as hedge/haven against risk in potentially bad scenarios for their economy.
- Most cryptocurrency acts as a hedge/haven for France, Italy, and Germany, indicating the use of cryptocurrency in European nations to mitigate risk.
- From the during-COVID period Table 5, we observed the following:
- Gold lost hedge properties in most markets and is used to diversify from other assets, but not with offsetting positions (to hedge against the other assets’ risk).
- The Chinese market stopped being correlated with any cryptocurrency. This is likely related to China’s strong regulations on cryptocurrencies, especially in early 2021.
- Most countries continued using Tether (USTD) and USDCoin (USDC) as hedging methods.
- In France, we can observe a shift from hedging to diversifying, meaning a loss of hedging property in those markets.

**Table 4.** Whole Period—Baur and McDermott Model for the BRICS and G7 countries (daily returns in US-dollar for the whole period from 1st of January 2018 to 30th of September 2022), “-” means neither hedge, nor haven, nor diversifier. diversifier: moves in a the same direction of the market index, hedging: moves in the opposite direction of the market index, haven: or safe haven, moves in the opposite direction of the market index in extreme cases. -/+ means often/most cases.

^BVSP	000001.SS	^BSESN	IMOEX.ME	^JN0U.JO	^GSPTSE	^FCHI	^GDAXI	^ITLMS.MI	^N225	^FTSE	^GSPC
IBOVESPA	SSE	SENSEX	MOEX	TRI	TSX	CAC 40	DAX	FTSE Italia	Nikkei 225	FTSE 100	S&P 500
Brazil	China	India	Russia	South Africa	Canada	France	Germany	Italy	Japan	UK	USA
BRICS	BRICS	BRICS	BRICS	BRICS	G7	G7	G7	G7	G7	G7	G7
diversi	diversi	hedge-	-	diversi	diversi	diversi	diversi	hedge+	diversi	-	diversi
hedge+	hedge-	hedge+	hedge-	hedge+	hedge+	hedge+	hedge+	hedge-	diversi	-	hedge+
diversi	-	diversi	hedge-	diversi	diversi	diversi	diversi	diversi	-	-	diversi
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hedge+	haven-	hedge+	hedge-	hedge+	hedge+	hedge+	hedge+	hedge-	diversi	-	hedge+
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haven-	-	-	-	-	diversi	-	diversi	diversi	-	-	-
diversi	-	-	-	hedge-	-	diversi	-	-	diversi	-	-
diversi	-	-	-	diversi	diversi	diversi	diversi	-	-	-	diversi
haven-	-	diversi	-	diversi	diversi	diversi	diversi	-	diversi	-	diversi
diversi	-	diversi	haven-	diversi	diversi	diversi	diversi	-	-	-	diversi
diversi	-	-	-	diversi	diversi	diversi	diversi	-	-	-	-
haven-	-	-	-	diversi	diversi	diversi	diversi	-	-	-	-
hedge-	-	-	-	-	-	-	-	-	diversi	-	-
-	-	-	-	-	-	-	-	-	hedge-	-	-
diversi	-	diversi	hedge-	diversi	diversi	diversi	diversi	-	-	-	diversi
-	-	-	-	-	-	-	-	-	hedge-	-	-
-	-	-	-	-	-	-	-	-	diversi	-	-

**Table 5.** Pre-COVID—Baur and McDermott Model for the BRICS and G7 countries (daily returns in US-dollar for the PRE-COVID from 1st of January 2018 to 29th of February 2020), “-” means neither hedge, nor haven, nor diversifier. diversifier: moves in a the same direction of the market index, hedging: moves in the opposite direction of the market index, haven: or safe haven, moves in the opposite direction of the market index in extreme cases. -/+ means often/most cases.

Description	^BVSP	000001.SS	^BSESN	IMOEX.ME	^JN0U.JO	^GSPTSE	^FCHI	^GDAXI	^ITLMS.MI	^N225	^FTSE	^GSPC
	IBOVESPA	SSE	SENSEX	MOEX	TRI	TSX	CAC 40	DAX	FTSE Italia	Nikkei 225	FTSE 100	S&P 500
	Brazil	China	India	Russia	South Africa	Canada	France	Germany	Italy	Japan	UK	USA
	BRICS	BRICS	BRICS	BRICS	BRICS	G7	G7	G7	G7	G7	G7	G7
Gold Spot Price	-	hedge-	diversi	diversi	diversi	diversi	hedge+	-	hedge-	hedge-	hedge-	-
Tether USD	-	-	-	-	-	-	hedge-	haven-	-	haven-	-	-
Bitcoin USD	-	hedge+	haven-	-	-	diversi	hedge+	haven-	hedge-	haven-	-	-
Ethereum USD	diversi	haven-	hedge-	-	-	diversi	hedge-	hedge-	hedge-	hedge-	-	diversi
USDCoin USD	diversi	haven-	-	-	-	-	hedge-	hedge-	hedge-	-	-	-
Ripple USD	haven- -	-	-	-	hedge-	diversi	hedge-	haven-	-	hedge-	-	-
BinanceCoin USD	-	haven-	-	-	-	diversi	-	-	hedge-	hedge-	-	-
Cardano USD	diversi	-	-	haven-	-	-	-	-	-	-	-	-
Chainlink USD	-	-	-	-	-	diversi	-	-	hedge-	haven-	-	-
TRON USD	-	-	-	-	-	-	-	-	hedge-	-	-	-
Stellar USD	haven-	haven-	-	diversi	hedge-	-	-	-	-	haven-	hedge+	-
Litecoin USD	diversi	haven-	-	-	-	diversi	hedge-	hedge+	hedge-	hedge-	-	-
BitcoinCash USD	haven-	-	-	-	-	diversi	hedge-	hedge-	-	hedge+	-	diversi
Cosmos USD	diversi	haven-	-	-	-	-	-	hedge-	-	-	-	haven-
Polkadot USD	diversi	-	hedge-	-	haven-	haven-	-	-	-	-	-	-
EOS USD	-	-	-	-	-	-	-	-	hedge-	haven-	-	-
Monero USD	diversi	haven-	-	-	-	diversi	hedge-	hedge+	hedge-	hedge+	-	-
BitcoinSV USD	-	hedge-	-	-	diversi	-	hedge-	diversi	hedge-	diversi	-	-
Dash USD	diversi	haven-	-	-	-	-	-	-	-	-	-	-
Zcash USD	diversi	haven-	-	-	hedge-	-	-	-	hedge-	-	-	-
VeChain USD	haven-	haven-	-	-	hedge-	diversi	hedge-	haven-	haven-	hedge-	-	-
NEO USD	-	-	-	-	-	-	-	-	-	hedge-	-	-
Tezos USD	-	-	-	hedge-	-	-	hedge-	hedge-	-	hedge+	-	-
NEM USD	neither	neither	neither	neither	neither	neither	neither	neither	neithe	hedge-	neither	neither
CounosX USD	neither	neither	neither	neither	neither	neither	neither	neither	neithe	diversi	neither	neither

**Table 6.** During-COVID—Baur and McDermott Model for the BRICS and G7 countries (daily returns in US-dollar for the DURING-COVID period from 1st of March 2020 to 30th of September 2020), “-” means neither hedge, nor haven, nor diversifier. diversifier: moves in a the same direction of the market index, hedging: moves in the opposite direction of the market index, haven: or safe haven, moves in the opposite direction of the market index in extreme cases. -/+ means often/most cases.

Description	^BVSP	000001.SS	^BSESN	IMOEX.ME	^JN0U.JO	^GSPTSE	^FCHI	^GDAXI	^ITLMS.MI	^N225	^FTSE	^GSPC
	IBOVESPA	SSE	SENSEX	MOEX	TRI	TSX	CAC 40	DAX	FTSE Italia	Nikkei 225	FTSE 100	S&P 500
	Brazil	China	India	Russia	South Africa	Canada	France	Germany	Italy	Japan	UK	USA
	BRICS	BRICS	BRICS	BRICS	BRICS	G7	G7	G7	G7	G7	G7	G7
Gold Spot Price	diversi	diversi	hedge-	-	diversi	diversi	diversi	diversi	hedge+	diversi	-	diversi
Tether USD	hedge+	-	hedge+	hedge-	hedge+	hedge+	hedge+	hedge+	hedge+	diversi	haven-	hedge+
Bitcoin USD	diversi	-	diversi	-	diversi	diversi	diversi	diversi	diversi	-	-	diversi
Ethereum USD	hedge-	-	diversi	-	diversi	diversi	diversi	diversi	-	-	-	hedge-
USDCoin USD	hedge+	-	hedge+	hedge-	hedge+	hedge+	hedge+	hedge+	hedge-	diversi	haven-	hedge+
Ripple USD	haven-	-	hedge-	-	diversi	-	diversi	diversi	-	-	-	-
BinanceCoin USD	hedge-	-	hedge-	-	diversi	-	diversi	diversi	-	diversi	-	hedge-
Cardano USD	hedge-	-	hedge-	-	hedge-	-	-	-	-	-	-	-
Chainlink USD	haven-	-	-	-	-	-	diversi	diversi	-	-	-	-
TRON USD	-	-	diversi	-	diversi	diversi	diversi	diversi	-	-	-	-
Stellar USD	-	-	hedge-	-	-	-	-	-	-	-	hedge-	-
Litecoin USD	diversi	-	-	-	diversi	diversi	diversi	diversi	-	-	-	diversi
BitcoinCash USD	diversi	-	-	-	diversi	diversi	diversi	diversi	-	hedge-	-	diversi
Cosmos USD	-	-	-	-	-	-	diversi	-	diversi	-	-	-
Polkadot USD	diversi	-	-	-	hedge-	-	diversi	-	-	diversi	-	-
EOS USD	diversi	-	-	-	diversi	diversi	diversi	diversi	-	hedge-	-	diversi
Monero USD	hedge-	-	diversi	-	diversi	diversi	diversi	diversi	-	-	-	hedge-
BitcoinSV USD	diversi	-	diversi	hedge-	diversi	diversi	diversi	diversi	-	hedge-	-	diversi
Dash USD	diversi	-	-	-	diversi	diversi	diversi	diversi	-	hedge-	-	diversi
Zcash USD	-	-	-	-	diversi	diversi	diversi	diversi	-	-	-	-
VeChain USD	-	-	-	-	-	-	-	-	-	-	-	-
NEO USD	-	-	-	-	-	-	-	diversi	-	diversi	-	-
Tezos USD	diversi	-	diversi	-	diversi	diversi	diversi	diversi	-	hedge-	-	diversi
NEM USD	-	-	-	-	-	-	-	-	-	-	-	-
CounosX USD	-	-	-	-	-	-	-	-	-	diversi	-	-

## 5. Conclusions and Outlook

In this paper, we report the results of studying the repeating patterns by Blockchain Technology and maturity (market adoption) of Hedge, Safe Haven, and Diversifier properties of a very extensive list of Cryptocurrencies (Cardano, Cosmos, Cosmos, BitcoinCash, BinanceCoin, BitcoinSV, Bitcoin, COUNOSX, Dash, Polkadot, Polkadot, EOS, Ethereum, Chainlink, Litecoin, NEO, TRON, USDCoin, Tether, VeChain, NEM, Stellar, Monero, XRP, Tezos, Zcash) with daily returns in the period of 1st of January 2018 up to the 30th of September 2022, first by the G7 (Canada, France, Germany, Italy, Japan, UK, and the USA) major market indexes as well as all BRICS (Brazil, China, India, Russia, and South Africa) major market indexes. The period was specially chosen in order to contain data for a great number of the newer cryptocurrencies.

Our results show that gold lost the property of hedging instruments from the pre-COVID to the During-COVID period. We demonstrated that Stablecoins Tether (USDT) and USDCoin (USDC), on the other hand, are effective hedging instruments as the hedging property remained that way for most markets, including S&P 500.

Our results support [Bouri et al.'s \(2017\)](#) conclusions that Bitcoin is an effective diversifier in the During-COVID period and that Bitcoin safe haven property can be found in Japan and China. However, our result expands that demonstrating a shift in properties from hedging to diversifier in Bitcoin since the outbreak of the COVID crisis. Bitcoin, Ethereum, Litecoin, and BitcoinCash behave similarly in all markets, mainly as diversifiers, indicating that investors use Pulic-PoW cryptocurrencies with the same strategy interchangeably. The exception is the immature BitcoinSV.

Our results show that the Chinese market stopped being correlated with any cryptocurrency after the COVID health crisis started; this is likely to be related to China's strong regulations on cryptocurrencies, especially in early 2021. The same happens to the Russian market, but more data is necessary to see if this behavior has to do with COVID or the war in Ukraine.

This paper and its results are not alone as it is related to a recent strand of literature concerning the hedging and safe haven properties of Bitcoin in general and other cryptocurrencies, including stablecoins, in particular, and the effect of uncertainty periods such as the pandemic, as in the following studies: [Usman and Nduka \(2022\)](#); [Bouri et al. \(2018\)](#) and [Shahzad et al. \(2022\)](#).

These papers find evidence that the relationship between cryptocurrencies and uncertainty measures is not the same across various quantiles. In this regard, it supports our main conclusion of the special role of the underlying technology (consensus mechanism) of the cryptocurrency as a possible explanation for its market adoption and its relationship with cryptocurrencies, and the uncertainty measures observed.

## 6. Future Research

China initiated back in 2014 its Digital Yuan project designed to replace the cash and coin in circulation; real-world trials of the Digital Yuan are already underway in 2021 [Kharpal \(2021\)](#). It is important to disclaim that it is not a Cryptocurrency but a Central Bank-backed digital currency, so further investigation is needed to assess how Digital Yuan will affect the Cryptocurrency market and if any volatility spillovers can be observed.

An element to consider for analyzing the formation of the price and economic structure (Safe Have, Hedge, Diversifier) of Cryptocurrencies is changes in the policy and political landscape, specifically those changes captured in the economic policy uncertainty (EPU) index. Although it can be said that this also affects gold and other assets, further investigation is necessary to assess how Cryptocurrencies react to changes in the EPU index [Demir et al. \(2018\)](#).

For future research on this topic, another interesting aspect requiring further investigation is a study of the path to maturity of a cryptocurrency (volume and/or time required for maturity). For example, BitcoinSV USD is a low-volume newly released public PoW

cryptocurrency that is still not behaving as the rest of the public PoW cryptocurrencies analyzed in this study (Bitcoin USD, Ethereum USD, Litecoin USD, BitcoinCash USD).

It would be interesting to delve into Private Cryptocurrencies (Monero, Dash, and Zcash) in order to investigate further the uses of these assets as they seem unrelated to the rest.

Also, a more detailed discussion of country policy implications during the studied period would be very informative for crypto-traders, investors, and policymakers. Further, it would be interesting to repeat the study with a breakdown of the analyzed period by pre-COVID and during-COVID crisis, potentially applying methods like Detrended Fluctuation Analysis (DFA) and the Detrended Cross-Correlation Analysis used in the paper Ferreira (2018) and also wavelet value-at-risk used in the paper Bouri et al. (2020) when studying in the future the relationship across major cryptocurrencies and attractiveness measures since market participants in the cryptocurrency markets have various investment horizons.

Finally, the current work can be improved with a robust statistical comparison of methodologies used for Safe Haven properties, including GARCH, DCC-GARCH, Smooth transition regression (STR) model, Quantile correlation approach, and Detrended partial cross-correlation analysis (DPCCA) and use both diagnostic tests (R-squared and other metrics) and linearity and multicollinearity assumption tests to assess the most appropriate technique for the problem.

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## Appendix A. Blockchain Technology Appendix

Texts extracted from referenced sites.

- PoW: Proof of work (PoW) is a form of cryptographic zero-knowledge proof in which one party (the prover) proves to others (the verifiers) that a certain amount of a specific computational effort has been expended. Verifiers can subsequently confirm this expenditure with minimal effort on their part Wik (2021a).
- PoS: Proof of stake (PoS) protocols are a class of consensus mechanisms for blockchains that work by selecting validators in proportion to their quantity of holdings in the associated cryptocurrency. Unlike a proof of work (PoW) protocol, PoS systems do not incentivize extreme energy consumption. The first functioning use of PoS for cryptocurrency was Peercoin in 2012. Other uses have followed, and the Ethereum Foundation has announced a plan to switch Ethereum from PoW to PoS within 2021 Wik (2021b).
- PoA: Proof of authority (PoA) is an algorithm with blockchains that delivers comparatively fast transactions through a consensus mechanism based on identity as a stake. The most notable platform using PoA is VeChain Wik (2021c).
- SCP: Stellar Consensus Protocol (SCP). The Stellar Consensus Protocol was first described in a whitepaper by David Mazières in 2015. It is a “federated Byzantine

agreement system” that allows decentralized, leaderless computing networks efficiently to reach a consensus outcome on some decisions (Mazieres 2015).

- PoI: Proof of importance (POI) and harvesting. NEM addresses the issue using its POI mechanism, as it gives more “importance” to how much one is “invested” into the NEM system, with realistic “vested” interest. The XEM coins in the wallet and the holding period play a key role in gauging the importance (2021).
- dBFT: Delegated Byzantine Fault Tolerance (dBFT 2021) is a sophisticated algorithm meant to facilitate consensus on a blockchain. Although it is not in common use as of yet, it represents an alternative to simpler proof of stake, proof of importance and proof of work methods.
- Stablecoin: Stablecoins are cryptocurrencies where the price is designed to be pegged to a cryptocurrency, fiat money, or to exchange-traded commodities (Stablecoin Wik (2021a)). USD Coin (USDC) is a type of cryptocurrency that is referred to as a stablecoin; one can always redeem 1 USD Coin for US\$1.00, giving it a stable price (Stablecoin Wik (2021b)).

## References

- Baur, Dirk G., and Brian M. Lucey. 2010. Is Gold a Hedge or a Safe Haven? An Analysis of Stocks, Bonds and Gold. *The Financial Review* 45: 217–29. [CrossRef]
- Baur, Dirk G., and Konstantin Kuck. 2020. The timing of the flight to gold: An intra-day analysis of gold and the sp500. *Finance Research Letters* 33: 101187. [CrossRef]
- Baur, Dirk G., and Thomas K. McDermott. 2010. Is gold a safe haven? International evidence. *Journal of Banking & Finance* 34: 1886–98.
- Baurand, Dirk G., and Thomas K. McDermott. 2016. Why is gold a safe haven? *Journal of Behavioral and Experimental Finance* 10: 63–71.
- Beneki, Christina, Alexandros Koulis, Nikolaos A. Kyriazis, and Stephanos Papadamou. 2019. Investigating volatility transmission and hedging properties between bitcoin and Ethereum. *Research in International Business and Finance* 48: 219–27. [CrossRef]
- Bouri, Elie, Peter Molnár, Georges Azzi, David Roubaud, and Lars Ivar Hagfors. 2017. On the hedge and safe haven properties of Bitcoin: Is it really more than a diversifier? *Finance Research Letters* 20: 192–98. [CrossRef]
- Bouri, Elie, Rangan Gupta, Chi Keung Marco Lau, David Roubaud, and Shixuan Wang. 2018. Bitcoin and global financial stress: A copula-based approach to dependence and causality in the quantiles. *The Quarterly Review of Economics and Finance* 69: 297–307. [CrossRef]
- Bouri, Elie, Syed Jawad Hussain Shahzad, David Roubaud, Ladislav Kristoufek, and Brian Lucey. 2020. Bitcoin, gold, and commodities as safe havens for stocks: New insight through wavelet analysis. *The Quarterly Review of Economics and Finance* 77: 156–64. [CrossRef]
- Chan, Wing Hong, Minh Le, and Yan Wendy Wu. 2019. Holding bitcoin longer: The dynamic hedging abilities of bitcoin. *The Quarterly Review of Economics and Finance* 71: 107–13. [CrossRef]
- Demir, Ender, Giray Gozgor, Chi Keung Marco Lau, and Samuel A. Vigne. 2018. Does economic policy uncertainty predict the bitcoin returns? An empirical investigation. *Finance Research Letters* 26: 145–49. [CrossRef]
- Dyhrberg, Anne Haubo. 2016. Hedging capabilities of bitcoin. Is it the virtual gold? *Finance Research Letters* 16: 139–44. [CrossRef]
- Fang, Libing, Elie Bouri, Rangan Gupta, and David Roubaud. 2019. Does global economic uncertainty matter for the volatility and hedging effectiveness of bitcoin? *International Review of Financial Analysis* 61: 29–36. [CrossRef]
- Ferreira, Paulo. 2018. Long-range dependencies of eastern european stock markets: A dynamic detrended analysis. *Physica A: Statistical Mechanics and its Applications* 505: 454–70. [CrossRef]
- Garcia-Jorcano, Laura, and Sonia Benito. 2020. Studying the properties of the bitcoin as a diversifying and hedging asset through a copula analysis: Constant and time-varying. *Research in International Business and Finance* 54: 101300. [CrossRef]
- Hniopek, Daniel, and Ilya Kiselev. 2015. *Safe Haven Assets—A Long-Term and Short-Term Analysis of Commodities, Currencies and Bonds*. Stockholm: Institutionen för Finansiell ekonomi.
- Jin, Jingyu, Jiang Yu, Yang Hu, and Yue Shang. 2019. Which one is more informative in determining price movements of hedging assets? Evidence from bitcoin, gold and crude oil markets. *Physica A: Statistical Mechanics and its Applications* 527: 121121. [CrossRef]
- Kang, Sang Hoon, Seong-Min Yoon, Stelios Bekiros, and Gazi S. Uddin. 2020. Bitcoin as Hedge or Safe Haven: Evidence from Stock, Currency, Bond and Derivatives Markets. *Computational Economics* 56: 529–45. [CrossRef]
- Kharpal, Arjun. 2021. News: China Has Given Away Millions in Its Digital Yuan Trials. This Is How It Works. News Website: JCNBC. Available online: <https://www.cnbc.com/2021/03/05/chinas-digital-yuan-what-is-it-and-how-does-it-work.html> (accessed on 8 July 2021).
- Mazieres, David. 2015. The Stellar Consensus Protocol: A Federated Model for Internet-Level Consensus. Available online: <https://www.stellar.org/papers/stellar-consensus-protocol> (accessed on 8 July 2021).
- Mensi, Walid, Mobeen Ur Rehman, Khamis Hamed Al-Yahyaee, Idries Mohammad Wanas Al-Jarrah, and Sang Hoon Kang. 2019. Time frequency analysis of the commonalities between bitcoin and major cryptocurrencies: Portfolio risk management implications. *The North American Journal of Economics and Finance* 48: 283–94. [CrossRef]

- Nakamoto, Satoshi, and A. Bitcoin. 2008. A peer-to-peer electronic cash system. *Bitcoin* 4: 2.
- Sett, Kiranjit. 2019. Is gold a better hedge or a safer asset than shares?—Evidence from India. *IUP Journal of Financial Risk Management* 16: 16–27.
- Shahzad, Syed Jawad Hussain, Elie Bouri, David Roubaud, and Ladislav Kristoufek. 2020. Safe haven, hedge and diversification for G7 stock markets: Gold versus bitcoin. *Economic Modelling* 87: 212–24. [CrossRef]
- Shahzad, Syed Jawad Hussain, Elie Bouri, Tanveer Ahmad, and Muhammad Abubakr Naeem. 2022. Extreme tail network analysis of cryptocurrencies and trading strategies. *Finance Research Letters* 44: 102106. [CrossRef]
- Sta. 2021. Global Cryptocurrency Ownership—Statista. Available online: <https://www.statista.com/statistics/1202468/global-cryptocurrency-ownership/> (accessed on 8 July 2021).
- Stablecoin Wik. 2021a. Stablecoin—Wikipedia, the Free Encyclopedia. Available online: <https://en.wikipedia.org/wiki/Stablecoin> (accessed on 8 July 2021).
- Stablecoin Wik. 2021b. Usd Coin—Wikipedia, the Free Encyclopedia. Available online: [https://en.wikipedia.org/wiki/USD\\_Coin](https://en.wikipedia.org/wiki/USD_Coin) (accessed on 8 July 2021).
- Techopedia Explains Delegated Byzantine Fault Tolerance (dBFT). 2021. Available online: <https://www.techopedia.com/definition/33598/delegated-byzantine-fault-tolerance-dbft> (accessed on 8 July 2021).
- Usman, Nuruddeen, and Kodili Nwanneka Nduka. 2022. Announcement effect of COVID-19 on cryptocurrencies. *Asian Economics Letters* 3: 29953. [CrossRef]
- Wang, Gangjin, Yanping Tang, Chi Xie, and Shou Chen. 2019. Is bitcoin a safe haven or a hedging asset? Evidence from China. *Journal of Management Science and Engineering* 4: 173–88. [CrossRef]
- Wik. 2021a. Proof of Work—Wikipedia, the Free Encyclopedia. Available online: [https://en.wikipedia.org/wiki/Proof\\_of\\_work](https://en.wikipedia.org/wiki/Proof_of_work) (accessed on 8 July 2021).
- Wik. 2021b. Proof of Stake—Wikipedia, the Free Encyclopedia. Available online: [https://en.wikipedia.org/wiki/Proof\\_of\\_stake](https://en.wikipedia.org/wiki/Proof_of_stake) (accessed on 8 July 2021).
- Wik. 2021c. Proof of Authority—Wikipedia, the Free Encyclopedia. Available online: [https://en.wikipedia.org/wiki/Proof\\_of\\_authority](https://en.wikipedia.org/wiki/Proof_of_authority) (accessed on 8 July 2021).