

Systematic Review

Portfolio Diversification, Hedge and Safe-Haven Properties in Cryptocurrency Investments and Financial Economics: A Systematic Literature Review

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Abstract: Our study collected and synthesized the existing knowledge on portfolio diversification, hedge, and safe-haven properties in cryptocurrency investments. We sampled 146 studies published in journals ranked in the Association of Business Schools 2021 journals list, considering all fields of knowledge, and elaborated a systematic literature review along with a bibliometric analysis. Our results indicate a fast-growing literature evidencing cryptocurrencies' ability to hedge against stocks, fiat currencies, geopolitical risks, and Economic Policy Uncertainty (EPU) risk; also, that cryptocurrencies present diversification and safe-haven properties; that stablecoins reveal unstable peg with the US dollar; that uncertainty is a determinant for cryptocurrency returns. Additionally, we show that investors should consider Gold, along with the European carbon market, CBOE Bitcoin futures, and crude oil to hedge against unexpected movements in the cryptocurrency market.

Keywords: cryptocurrencies; Bitcoin; hedge; safe-haven; portfolio diversification; SLR

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1. Introduction

The paper published by Nakamoto (2008) was the precursor of the cryptocurrency market. Today it is well known that cryptocurrencies are decentralized digital currencies, which represent a disruption in the traditional financial system (Almeida 2021).

The cryptocurrency market had rapid development and is still evolving (Białkowski 2020; Fang et al. 2021; Li et al. 2021). It fascinates and draws the attention of individual investors, institutional investors, regulators, and the media, and consequently is also an actual and important topic of research in numerous fields of academia (Angerer et al. 2020).

Investors have the necessity to properly manage their portfolios. Empirical research stresses the importance of cryptocurrencies' relationships with other assets (Bouri et al. 2022) and among themselves (Kumar et al. 2022), as well as their volatility traits (Klinkova and Grabinski 2017; Wang et al. 2022) in portfolio management. Therefore, information on assets' diversification, hedge, and safe-haven properties is of extreme importance. Even more so when we consider investment in the cryptocurrency market since it is a very recent market.

With this in mind, coupled with the fast production of new empirical evidence on cryptocurrencies, it is imperative to aggregate and synthesize all quality knowledge produced so far, as well as to identify literature gaps to facilitate future research lines (Angerer et al. 2020; Corbet et al. 2019). To this end, we conduct a systematic literature review process.

Our motives are twofold: (1) provide a better understanding of the existing academic literature on portfolio diversification, hedge, and safe-haven properties in cryptocurrency

investments; (2) present important research findings for investors, policymakers, academics, businesses, and society in general.

We contribute to the literature in several ways. Firstly, we present the most comprehensive and up-to-date systematic literature review along with bibliometric analysis contributing to knowledge consolidation on portfolio diversification, hedge, and safe-haven properties in cryptocurrency investments.

Secondly, with our literature review, we contribute with the identification and explanation of the current academic knowledge apprehended so far in portfolio diversification, hedge and safe-haven properties in cryptocurrency investments, complementing the broader and more general review of the literature findings of Almeida (2021); (Almeida and Gonçalves 2022; Angerer et al. 2020; Bariviera and Merediz-Solà 2021; Corbet et al. 2019; Flori 2019b; Hairudin et al. 2020; Haq et al. 2021; Jalal et al. 2021; Kyriazis et al. 2020).

Thirdly, in our research we use more inclusive keywords on our WoS search, thus considering the possible contributions of more peripheral studies on the topic of portfolio diversification, hedge, and safe-haven properties in cryptocurrency investments. The use of VOSviewer along with this methodology enables the emergence of a cluster related to the research topic.

Finally, we extend previous reviews by aggregating both a bibliometric analysis with a critical review of the findings in extant literature. We also contribute to the identification of research gaps and future venues about the use of crypto assets in investment strategies.

Our findings are important for researchers and academics in general, investors and analysts, and regulators. They provide researchers with structured networking for research outlets and literature strands, with time-trended information relevant to future studies on portfolio diversification, hedge, and safe-haven properties of cryptocurrency investments. Concurrently, we provide investors and analysts with a highly important compilation of practical findings that can help them better devise their investment strategies. In addition, our syntheses provide insights for regulators to effectively regulate the cryptocurrency markets.

We explore a growing literature and identify the most cited author in this research field Elie Bouri with 11 publications and 404 citations, as the most cited institution Trinity College Dublin, whereas the most cited journal is the Finance research letters, and the most cited country is China.

Our findings reveal that cryptocurrencies may hedge against stocks, fiat currencies, geopolitical risks, Economic Policy Uncertainty (EPU), however, these properties are time-varying. Extant research also indicates that cryptocurrencies present diversification and safe-haven properties, nonetheless, they vary across time and market conditions. Concurrently, stablecoins may act as a safe-haven and diversifiers and contribute to market efficiency, however, they reveal an unstable peg with the US dollar. Another significant finding in the literature analyzed is that uncertainty is indeed a determinant of cryptocurrency returns. Additionally, we show that investors should consider Gold, along with the European carbon market, CBOE Bitcoin futures, and crude oil to hedge against unexpected movements in the cryptocurrency market.

The remainder of the paper is structured as follows: Section 2, presents the methodology used. Section 3 presents the bibliometric analysis. In Section 4 we present the literature analysis regarding portfolio diversification, hedge and safe-haven properties in cryptocurrency investments, and highlight future research venues. Finally, in Section 5, we present our conclusions.

2. Methodology

We decided to adopt a systematic review process for our research. Based on the studies of (Almeida and Gonçalves 2022; Jiang et al. 2021a; Liang et al. 2016; Linnenluecke et al. 2020; Milian et al. 2019; Yue et al. 2021) We research search in the Web of Science database (WoS) to ensure integrity in our sample.

Since our aim is to cover the whole period, from the publication of the first article related to cryptocurrencies until nowadays, we considered the article published by Nakamoto (2008), which introduces cryptocurrencies, as our reference date. Therefore, we searched WoS from 1 January 2009, up until 4 November 2021, to cover all the cryptocurrency literature.

In our approach we consider broader keywords regarding portfolio diversification, hedge and safe-haven properties in cryptocurrency investments, which differentiates our research from other reviews such as Flori (2019a); Haq et al. (2021); Jalal et al. (2021); Kyriazis et al. (2020) We have selected the following keywords: “Cryptocurrency”, “Cryptocurrencies”, “Bitcoin”, “Portfolio diversification”, “Investment”, “Investor”, “investors”, “Alternative investment”; which resulted in the following research equation: “cryptocurrenc* OR Bitcoin AND diversification AND portfolio AND invest* AND alternative”.

To confer a higher quality to our research, we have only considered English-written journal articles listed in the Academic Journal Guide ABS (Association of Business Schools) list of 2021. Furthermore, all the articles should address cryptocurrencies through the perspective of investor/investment (not ignoring methodologies).

Moreover, we did not impose any restrictions regarding the areas of knowledge. Therefore, we could also enrich our research in portfolio diversification, hedge, and safe-haven properties in cryptocurrency investments with peripheral studies. Our final sample revealed 146 articles.

Following the studies by Bartolacci et al. (2020); Ding et al. (2014); Galvao et al. (2019); Rialti et al. (2019); Sadeghi Moghadam et al. (2021); Van Eck and Waltman (2017), we conduct our bibliometric analysis using VOSviewer.

We used the bibliographic coupling since it organizes the articles into clusters based on their shared references (Bartolacci et al. 2020; Rialti et al. 2019; Van Eck and Waltman 2017). Additionally, to reduce the bias related to the fact that older published articles might have higher citations than the new ones, we also use normalized citations (Bartolacci et al. 2020; Caputo et al. 2019; Van Eck and Waltman 2017).

The VOSviewer analysis provides relationships, between the articles, which appear as closer as their relationship is stronger (Bartolacci et al. 2020; Rialti et al. 2019). Consequently, through the bibliographic coupling a cluster related to portfolio diversification, hedge and safe-haven properties in cryptocurrency investments arise.

3. Literature Mapping and Bibliometric Analysis

In our first analysis, Figure 1, we show the number of publications and citations related to the literature on portfolio diversification, hedge, and safe-haven properties in cryptocurrency investments. We identify as the year with fewer publications 2018 (2) and, on the other hand, as the year with the higher publications 2021 (81). The highest citation year is 2020, with 942 citations. These results suggest an increasing interest of academics in this field of knowledge, as well as its novelty.

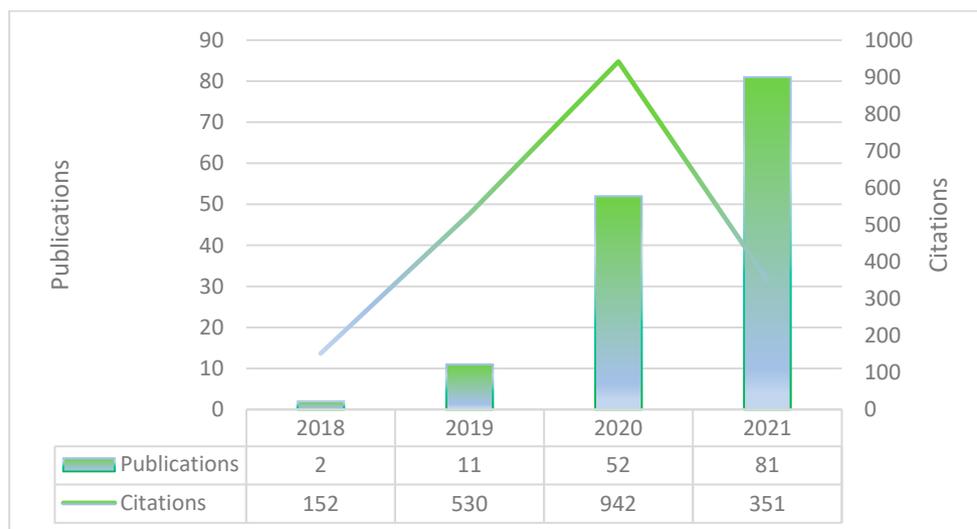


Figure 1. Citations and publications over time.

3.1. Top Articles Analysis

In Table 1, we present the top 10 most cited articles in the portfolio diversification, hedge, and safe-haven properties in cryptocurrency investments literature. Corbet et al. (2020c), Ji et al. (2019a), and Yi et al. (2018) are the top three most cited articles, with more than 100 citations each.

Table 1. Top 10 articles by number of citations (1975 Citation and 146 Publications).

Rank	Article	Citations
1	Corbet et al. (2020c)	171
2	Ji et al. (2019a)	136
3	Yi et al. (2018)	104
4	Conlon et al. (2020)	83
5	Goodell and Goutte (2021a)	74
6	Ji et al. (2019b)	67
7	Katsiampa et al. (2019a)	59
8	Bouri et al. (2019)	57
9	Wang et al. (2019)	56
10	Sun et al. (2020)	54

3.2. Author’s Analysis

Table 2 shows the top 10 most cited authors regarding portfolio diversification, hedge, and safe-haven properties in cryptocurrency investment literature. Bouri, Roubaud, and Corbet are the most cited authors and are also the ones with the most published articles. Nonetheless, Xu and Yi are the authors with the highest citation per publication ratios (104.00).

Table 2. Top 10 authors by number of citations.

Rank	Authors	Publications	Citations	Citations per Publications
1	Bouri, Elie	11	404	36.73
2	Roubaud, David	9	389	43.22
3	Corbet, Shaen	11	379	34.45
4	Lucey, Brian	6	346	57.67
5	Lau, Chi Keung Marco	6	206	34.33
6	Ji, Qiang	2	203	101.50
7	Larkin, Charles	3	198	66.00

8	Wang, Gang-Jin	3	168	56.00
9	Xu, Zishuang	1	104	104.00
10	Yi, Shuyue	1	104	104.00

Figure 2 showed, regarding normalized citations, that Bouri and Larkin were the most cited authors at the beginning of the year 2020, Corbet and Colon at the end of 2020, and in 2021 Goodell and Fared are the most cited authors.

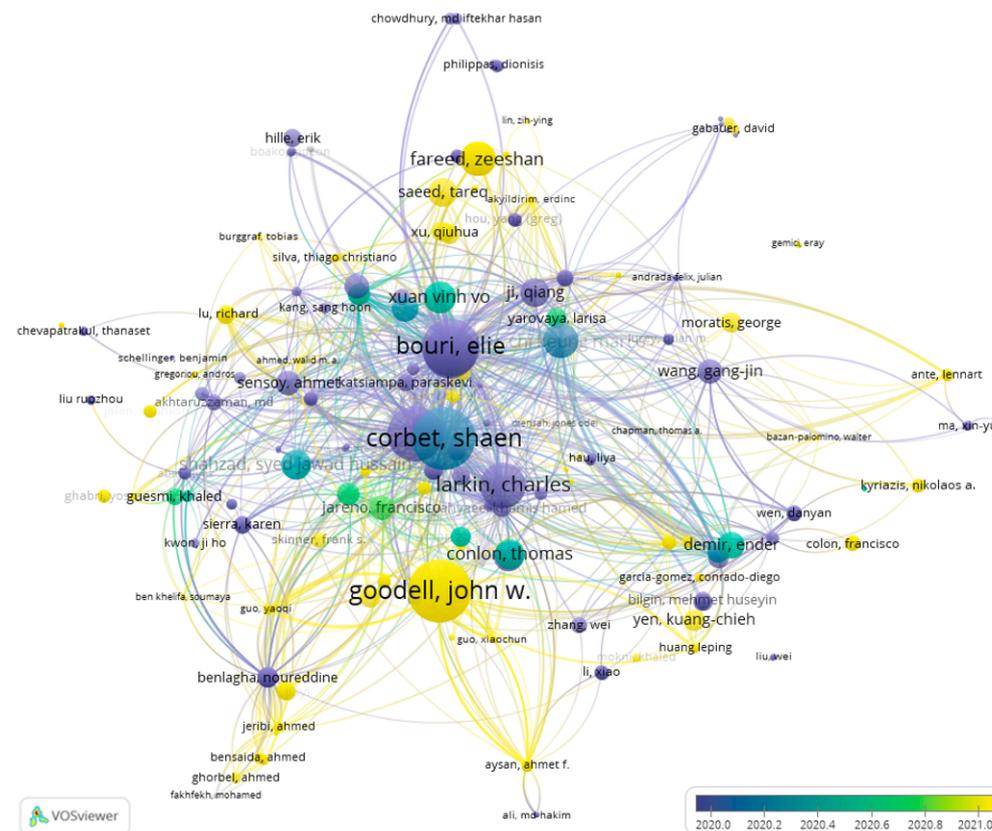


Figure 2. Normalized citations of authors by year.

3.3. Institution’s Analysis

Table 3 shows the most productive institutions for portfolio diversification, hedge, and safe-haven properties in cryptocurrency investments literature. Trinity College Dublin appears as the most cited institution in our dataset with 386 citations, followed by Dublin City University (379) and Montpellier Business School (372). However, the highest citations per publication ratio belongs to the University Bath (58.75).

Table 3. Top 10 institutions by number of citations.

Rank	Institutions	Publications	Citations	Citations per Publications
1	Trinity College Dublin	9	386	42.89
2	Dublin City University	11	379	34.45
3	Montpellier Business School	12	372	31.00
4	Holy Spirit University Kaslik	8	363	45.38
5	University Economics Ho Chi Minh City	15	361	24.07
6	University Waikato	9	293	32.56
7	University Sydney	5	276	55.20
8	Chinese Academy of Science	6	261	43.50
9	University Bath	4	235	58.75

10	University Huddersfield	6	223	37.17
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Figure 3 highlights that regarding normalized citations, Holy Spirit University Kaslik, and the Montpellier Business School were the most cited institutions at the beginning of the year 2020, Paris School of Business at the end of 2020, and 2021 Akron University is the most cited institution.

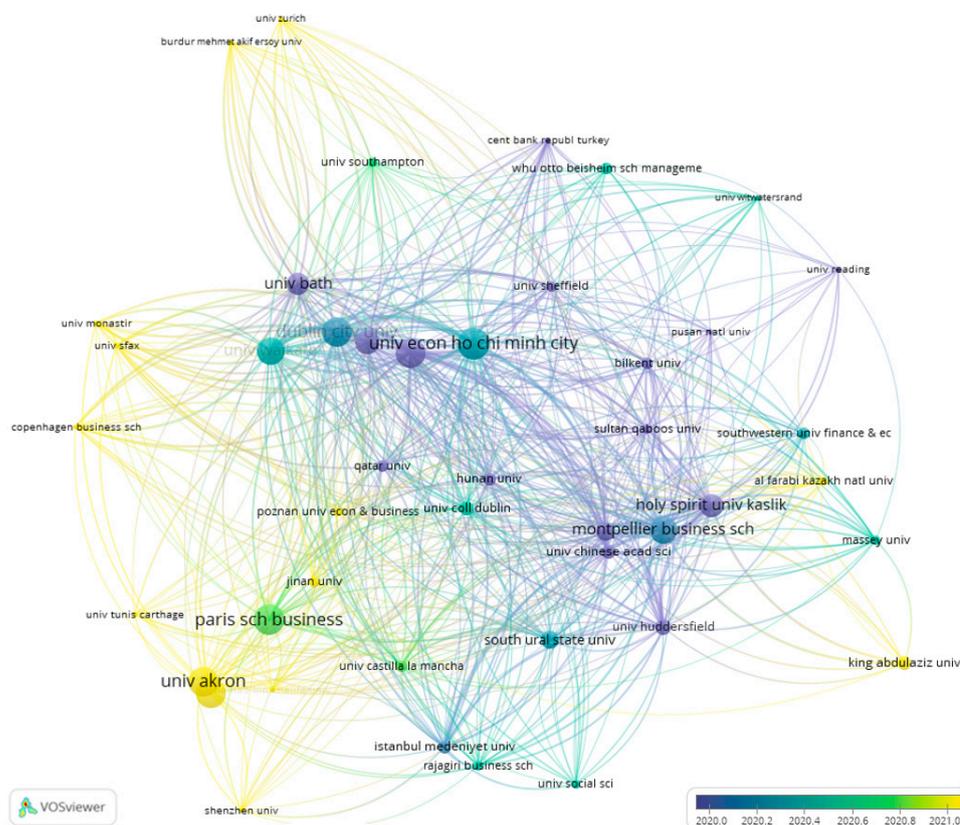


Figure 3. Normalized citations of institutions by year.

3.4. Journal Analysis

Table 4 presents the most productive journals regarding portfolio diversification, hedge, and safe-haven properties in cryptocurrency investments in our dataset. Finance Research Letters is the most cited journal with 716 citations and is also the journal with the most contributions to this field of knowledge (34). The International Review of Financial Analysis with 345 citations and the Research in International Business and Finance with 178 citations are the second and third most cited journals in our dataset. Nevertheless, the journal with the highest ratio of citations per publication is Energy Economics.

Figure 4 presents the analysis of the most productive research areas, and as expected finance and economy are the most contributing with 89 and 48 contributions, respectively. With this analysis, we also reveal how other areas of knowledge contributed to better understanding of portfolio diversification, hedge, and safe-haven properties in cryptocurrency investments.

Table 4. Top 10 journals by number of citations.

<i>Rank</i>	<i>Journals</i>	<i>Publications</i>	<i>Citations</i>	<i>Citations per Publications</i>
1	Finance research letters	34	716	21.06
2	International review of financial analysis	16	345	21.56
3	Research in international business and finance	17	178	10.47
4	Energy economics	2	100	50.00
5	Journal of international financial markets institutions and money	6	93	15.50
6	North American journal of economics and finance	10	92	9.20
7	Economic modeling	4	79	19.75
8	Technological forecasting and social change	5	73	14.60
9	Quarterly review of economics and finance	7	65	9.29
10	Economics letters	6	53	8.83

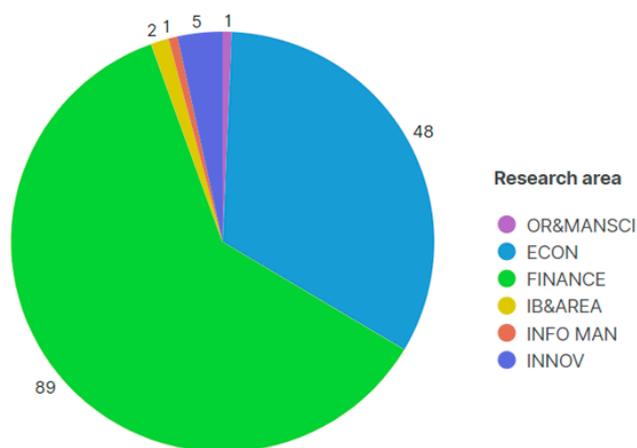


Figure 4. Most productive research areas.

Figure 5 shows evidence that regarding normalized citations Energy Economics is the most cited journal at the beginning of 2020, and Finance Research Letters is the most cited journal at the end of 2020. In 2021, Studies in Economics and Finance is the most cited journal.

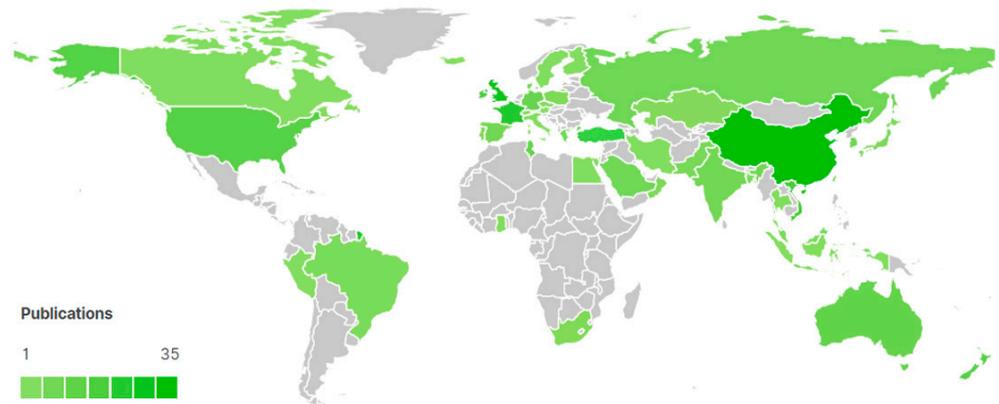


Figure 6. Publications by country world map.

Figure 7 evidence that regarding normalized citations, Lebanon and Australia are the most cited countries at the beginning of 2020, and France, England, and the USA at the end of the same year. In 2021, Indonesia and Greece appear as the most cited countries.

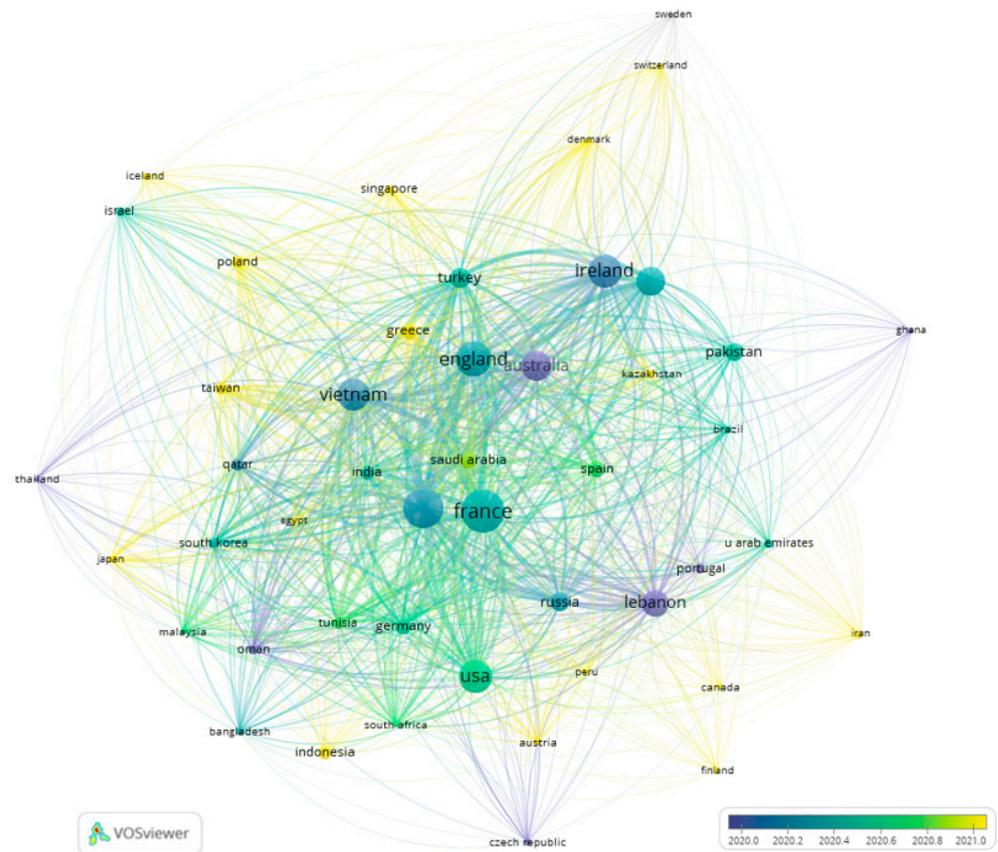


Figure 7. Normalized citations of countries by year.

4. Literature Findings on Portfolio Diversification, Hedge and Safe-Haven Properties of Cryptocurrency Investments

4.1. Do Cryptocurrencies Bear Hedging Properties?

This literature review addresses the hedging properties of cryptocurrencies. In this strand of literature, we found evidence that supports the hedging ability of cryptocurrencies against stocks (Fang et al. 2020; Kumah and Odei-Mensah 2021), fiat currencies (Hsu et al. 2021; Kinkyo 2020), Gold (González et al. 2021; Hsu et al. 2021; Kumah and Mensah

2020), geopolitical risks (Colon et al. 2021), Economic Policy Uncertainty (EPU) risk (Yen and Cheng 2021) as well as against the uncertainty caused by the COVID-19 pandemic (Demir et al. 2020a; Iqbal et al. 2021).

Regarding the specific case of Bitcoin, it is found that it reveals hedging effectiveness (Bhuiyan et al. 2021; Ghabri et al. 2020; Huynh et al. 2020a; Huynh et al. 2020b). Similar to Gold, Bitcoin can be considered a hedge against developed markets (Jeribi and Ghorbel 2021; Zeng et al. 2020), showing the ability to hedge in normal, and also in stressed market conditions (Chemkha et al. 2021). Bitcoin has matured from a speculative trading asset to an investment tool that responds to the underlying macroeconomic factors (Vo et al. 2021). According to the reviewed literature, Bitcoin may be used as a hedge against increased asset volatility due to high uncertainty levels in countries such as the USA, Germany, France, China, Canada, Russia, the UK, and Japan (Mokni 2021). Bitcoin also has the ability to hedge against industry portfolios and bonds (Akhtaruzzaman et al. 2020). It is also able to act as a hedging tool for the crude oil market, and for the Finnish, Dutch, and American stock markets (Ghorbel and Jeribi 2021a; Urom et al. 2020). Moreover, Bitcoin seems to present hedging properties for investors who consider sustainable, Islamic, and traditional investments (Dow Jones Sustainability, Dow Jones Islamic Index, Index Dow Jones Global Index) at different time horizons (Disli et al. 2021), as well as to investors who consider commodities from agricultural and metal groups (Fakhfekh et al. 2021; Naeem et al. 2021a). Furthermore, Bitcoin can be seen as a hedge against Asian fiat currencies in periods of 8 to 32 days, and 32 to 64 days, presenting better results in risk reduction for Asian fiat currencies than Gold or oil, especially over medium- and long-term horizons (Kinkyo 2020). Further evidence indicates that Bitcoin may even act as a hedge against Gold, as well as against other assets highly correlated to Gold since it developed short- and long-term asymmetric responses to Gold returns, especially during the COVID-19 pandemic (González et al. 2021).

Additional evidence reveals that Bitcoin hedging properties during times of instability and market shocks seem to be undermined (Guo et al. 2021). It also reveals that the ability of Bitcoin to be an effective hedge instrument against the Partisan Conflict Index (PCI) and the Economic Policy Uncertainty (EPU) varies across time (Hsu et al. 2021; Jiang et al. 2021c; Wu et al. 2021), meaning that when there is high political and economic uncertainty; those abilities are present; but when the impact of the PCI and EPU is negative, those abilities no longer appear.

This should be a warning sign to investors who consider Bitcoin as an effective hedge against uncertainties (Jiang et al. 2021c; Umar et al. 2021a; Wu et al. 2021). Moreover, the ability of Bitcoin to hedge against fiat currencies (Majdoub et al. 2021), and against the Asian Pacific and Japanese equity markets (Bouri et al. 2020a) vary across time and market conditions (Hsu et al. 2021; Umar and Gubareva 2020; Wang et al. 2021). In addition, cryptocurrency portfolios seem not to be able to hedge against global economic policy uncertainty (GEPU), World Uncertainty Index (WUI) (Nguyen et al. 2020), as well as against increased forward inflation expectations (Conlon et al. 2021).

Nonetheless, there is also evidence that contradicts the previously mentioned literature, indicating that cryptocurrencies do not reveal a good hedging ability for the stock market (Jiang et al. 2021c) since the correlation between stock/cryptocurrency pairs reveals to be positive in most cases (Thampanya et al. 2020). In addition, Bitcoin seems not to be a proper hedging tool for stocks due to its high volatility (Wang et al. 2021). Moreover, most cryptocurrencies have poor hedging capacity, especially Bitcoin and Ethereum, which revealed low levels of hedging effectiveness (Charfeddine et al. 2020).

There is also evidence that indicates that the European carbon market, contrary to the Chinese one, may provide a hedge against the cryptocurrency market (Yang and Hamori 2021). Evidence also points to the fact that the CBOE Bitcoin futures can effectively hedge against Bitcoin itself but also against other cryptocurrencies such as Ethereum, Litecoin, and Ripple (Sebastião and Godinho 2020). Additionally, evidence shows that in the short-term period crude oil assets can hedge against Ethereum. Regarding a long time period,

crude oil can hedge against Solve, Elastos, and Bit Capital Vendor. Thus, crude oil can be used to hedge the risk in the cryptocurrency market (Okorie and Lin 2020). On the other hand, evidence indicates that Gold can also be a good hedge for cryptocurrencies due to its independence (Huynh et al. 2020b). Therefore, investors should consider Gold, along with the European carbon market, CBOE Bitcoin futures, and crude oil to hedge against unexpected movements in the cryptocurrency market (Huynh et al. 2020b).

4.2. Do Cryptocurrencies Bear Diversification Properties?

The diversification ability of cryptocurrencies is also addressed in this strand of cryptocurrency literature. We found evidence that adding cryptocurrencies into traditional portfolios (stocks, currencies, and commodities) increases the benefits of diversification and returns, reducing portfolio volatility (Ma et al. 2020). It can also help to better diversify away the liquidity risk (Ghabri et al. 2020). For instance, adding cryptocurrencies such as Bitcoin, Ethereum, and Litecoin to an equity portfolio present diversification benefit for investors compared to a solo equity portfolio (Bouri et al. 2020a; Kumah and Mensah 2020). The cross-correlation of cryptocurrencies with traditional assets is time-changing and weak. This fact supports the hypothesis of cryptocurrencies' ability to be good financial diversifiers, especially Bitcoin and Ethereum (Charfeddine et al. 2020). Nonetheless, an optimal weight combination of digital and traditional assets must be used (Charfeddine et al. 2020).

Adding cryptocurrencies into small-cap stocks portfolios also result in the improvement of their risk diversification, and returns (Matkovskyy et al. 2021). These diversification benefits seem to be present in the global, developed, emerging, and US markets stock indexes (Jiang et al. 2021b; Kumah and Odei-Mensah 2021).

Considering investments in Gold, cryptocurrencies, such as Cardano, Tether, and Tezos, seem to provide diversification benefits (González et al. 2021; Hsu et al. 2021). Investors in emerging markets may also benefit from holding cryptocurrencies such as Bitcoin or Ripple during times of market turmoil since they can act as diversifiers and also reduce the risk in emerging equities and foreign currency rates during bad market conditions (Omane-Adjepong and Alagidede 2020). Nonetheless, the benefits from the use of these cryptocurrencies vary across regional and country-specific assets, as well as across emerging asset classes such as forex and equities (Omane-Adjepong and Alagidede 2020).

Considering developed stock markets, Monero and Dash can also be considered good diversifiers (Jeribi and Ghorbel 2021). However, the most effective diversifier in the short-term appears to be Ethereum. On the other hand, in the long-term this feature seems to be present in cryptocurrencies such as Bitcoin, Ripple, Litecoin, Stellar, and also in Monero and Dash (Bouri et al. 2020b; Jiang et al. 2021b).

According to the reviewed literature, the specific case of Bitcoin presents diversification benefits for investors (Corbet et al. 2020a; Mensi et al. 2019; Scharnowski 2021). Evidence shows benefits in high-frequency trading on BTC-XRP and BTC-LTC, and benefits in crypto-portfolio diversification with BTC-ETH, BTC-ETC, or BTC-EOR (Wang and Ngene 2020). Furthermore, Bitcoin can offer diversification benefits for conventional equity indices, especially for the Dow Jones Islamic, but also to sustainable indices such as FTSE 4 Good index (Uddin et al. 2020). These diversification benefits hold for short and for long-term periods (Uddin et al. 2020). Bitcoin evidence also reveals that the inclusion of Bitcoin in portfolios denominated in Chinese Yuan, Japanese Yen, and US Dollar improved their risk-adjusted returns, thus highlighting the diversification ability of Bitcoin (Bedi and Nashier 2020). However, for Chinese portfolios, Gold can be seen as a better diversifier than Bitcoin. Nevertheless, Bitcoin can provide higher returns than Gold, but increases the risk. Thus, for risk-seeking Chinese investors, Bitcoin is a better portfolio diversifier (Pho et al. 2021).

The reviewed literature on the diversification properties of Bitcoin also highlights that Bitcoin is relatively isolated from most financial assets, making it able to provide investors with diversification benefits (Bhuiyan et al. 2021). There is limited and time-

varying connectedness between Bitcoin and traditional assets, therefore evidencing its diversification ability (Mensi et al. 2020b; Zeng et al. 2020). Additionally, Bitcoin can also be considered a good diversifier for BRICS economies (Jeribi and Ghorbel 2021), as well as for the FTSE and Nikkei indices, since they present a negative dynamic dependence (Fakhfekh et al. 2021). Additionally, the inexistence risk spillover effect from the EPU to Bitcoin, implies that Bitcoin may be used as a diversifier in extreme EPU shocks (Wang et al. 2019).

During times of instability and market shocks, diversification seemed to be undermined (Guo et al. 2021). Before China banned ICOs in 2017, the inclusion of cryptocurrencies in a portfolio could deliver diversification benefits. However, after the news announcement, evidence reveals that the benefits of portfolio diversification with cryptocurrencies disappear (Zhang and Gregoriou 2021). Additional evidence reveals that the co-movements between cryptocurrencies and stock indices are mostly positive and have increased during the COVID-19 pandemic. Hence, cryptocurrencies in general fail to provide diversification benefits (Goodell and Goutte 2021b). During the COVID-19 period, the diversification benefits in crypto portfolios also deteriorated (Demiralay and Golitsis 2021). Moreover, it is indicated that the possibilities of diversification are undermined due to a close integration across major cryptocurrencies (Naeem et al. 2021b). It is also evidenced that the jumps in one cryptocurrency increase the probability of jumps in other cryptocurrencies, and this also reduces diversification benefits (Bouri et al. 2020c).

Furthermore, evidence reveals that better crypto portfolio management can be achieved with the implementation of a Hierarchical Risk Parity approach since it delivers better portfolio diversification properties, and also compared to traditional risk-based strategies, it better deals with volatility and tail risk (Burggraf 2021).

4.3. Are Cryptocurrencies Safe-Havens?

The safe-haven properties of cryptocurrencies are also addressed in this literature review. Evidence reveals that Bitcoin, Stellar, and Ripple seem to be good safe-havens for US stock indexes, similar to Litecoin and Monero. On the other hand, Ethereum, Dash, and Nem seem to be good safe-havens for the financial sector, telecom services sector, utility sector, and information technology sector (Bouri et al. 2020d). Furthermore, Bitcoin, Ethereum, Ripple, and Litecoin can be seen as safe-havens for commodities of metal and agricultural groups. However, they are less effective as a safe-haven for energy commodities (Naeem et al. 2021a). Even though Ethereum is the least connected cryptocurrency to oil price returns, which allows it to be used as a safe-haven against oil (Jareño et al. 2021), it seems to be a weak safe-haven against the S&P500, STOXX600, DAX, and the FTSE250 (Będowska-Sójka and Kliber 2021). Cardano, Tether, and Tezos may also be used as safe-havens when considering investments in gold (González et al. 2021).

In the specific case of Bitcoin, evidence indicates that it can be considered a strong safe-haven for crude oil. However, it is a weak safe-haven for the S&P500 index (Corbet et al. 2020b), the FTSE250, and the DAX index (Będowska-Sójka and Kliber 2021). Additionally, Bitcoin may be used as a safe-haven in extreme EPU shocks (Jareño et al. 2020; Wang et al. 2019).

On the other hand, there is also evidence that reveals that Bitcoin does not present any safe-haven properties during the COVID-19 pandemic (Disli et al. 2021), especially for investments in energy assets such as crude oil and gas (Ghorbel and Jeribi 2021b). Further evidence reveals that in general cryptocurrencies cannot be considered as safe-havens against stock markets (Conlon et al. 2020; Goodell and Goutte 2021b; Jiang et al. 2021b; Thampanya et al. 2020), and Gold (Corbet et al. 2020b).

Nonetheless, evidence reveals that the safe-haven ability of cryptocurrencies varies across time and market conditions (Będowska-Sójka and Kliber 2021; Conlon et al. 2020; Guo et al. 2021; Hsu et al. 2021; Jareño et al. 2020; Raheem 2021; Umar et al. 2021a; Wang et al. 2020a). However, in periods of high uncertainty cryptocurrencies are highly suitable as safe-haven instruments (Hsu et al. 2021; Jareño et al. 2020). For instance, in times of

high volatility and uncertainty, as was the case of the COVID-19 period, Bitcoin and Ethereum can be used as short-term safe-haven s against the stock market (Corbet et al. 2020a; López-Cabarcos et al. 2021; Mariana et al. 2021).

When uncertainty is present in the cryptocurrency market, investors may consider Gold since it shows stable and reliable safe-haven properties against cryptocurrency uncertainty (Hassan et al. 2021). The European carbon market may also be considered as safe-haven for the cryptocurrency market (Yang and Hamori 2021).

4.4. *The Impact of Uncertainty on Cryptocurrency Investments*

This literature review also contributes to understanding the role of uncertainty in crypto investments. Evidence reveals a strong causal relationship between the uncertainty of social media (Twitter-Based Economic Uncertainty (TEU) and Twitter-Based Market Uncertainty (TMU)), and the cryptocurrency returns (Bitcoin, Ethereum, Bitcoin Cash, and Ripple) (Aharon et al. 2022). When analyzing the reaction of Bitcoin prices to the uncertainty of fiat currencies, evidence reveals that the fiat currency uncertainty creates additional demand for Bitcoin, even though this demand cannot be seen as a determinant of Bitcoin prices (Jin et al. 2021). However, uncertainty effects are found to be determinants of net directional spillovers among cryptocurrency returns (Ji et al. 2019a). Furthermore, uncertainty and trading volume are key determinants for cryptomarket integration (Bouri et al. 2021c). Thus, uncertainty reveals to be indeed a determinant of cryptocurrency returns (Colon et al. 2021).

Additionally, it can be seen, a positive correlation between Bitcoin and trade policy uncertainty in the USA, revealing that Bitcoin returns can significantly be affected by trade policy uncertainty in the USA (Gozgor et al. 2019). Furthermore, during periods of extreme events, Bitcoin returns seem to be negatively related to changes in trade policy uncertainty (Gozgor et al. 2019).

This literature review further highlights that the EPU does not influence higher levels of volatility in the cryptomarket, meaning that high-risk crypto-investors are not influenced by the economic environment (Papadamou et al. 2021). On the other hand, however, it is shown that an increase in the EPU, leads to an increase in cryptocurrencies attractiveness (Balli et al. 2020), and consequently also to higher Bitcoin returns (Wang et al. 2020b). Moreover, evidence reveals that after a spike in United States EPU, the trading volume and volatility of Bitcoin increased. Nonetheless, the same cannot be said for the United Kingdom EPU (Wang et al. 2020b), as well as for the global economic policy uncertainty GEPU (Nguyen Quang et al. 2020). Consequently, the effect of the United Kingdom EPU on the BTC/GBP pair is of a lesser magnitude than the effect of the United States EPU on the BTC/USD pair (Wang et al. 2020b). China's EPU has a significant impact on cryptocurrencies, such as Litecoin and Bitcoin (Yen and Cheng 2021).

4.5. *Sentiment and News Impact on Cryptocurrency Investment*

Sentiment and news' impacts on cryptocurrency investment are also addressed in this literature review. It is revealed that investor attention is influenced by the performances of cryptocurrencies such as Bitcoin, Ethereum, and Litecoin (Lin 2021). Similarly, Bitcoin's return volatility and trading volume are influenced by emotions (Ahn and Kim 2021). The information transmissions flow from the returns of cryptocurrencies toward sentiment (Akyildirim et al. 2021a). Nevertheless, regarding sentiment connectedness, Bitcoin is dominant, probably due to its popularity. Evidence also indicates that the volatility of the sentiment connectedness is higher when compared to the return's connectedness, which indicates that in specific periods, investors have a renewed interest in the cryptocurrency market. (Akyildirim et al. 2021a).

Negative sentiment can be a predictor of Bitcoin returns, realized volatility, jumps, and trading volumes. In fact, evidence reveals that Trump's Twitter sentiment can indeed influence Bitcoin's price (Huynh 2021). Further evidence reveals that tweets related to Bitcoin, as well as Google searches, cause herding amplification in these markets. On the

other hand, EPU patterns, and the connectedness of foreign exchange markets and equity cause herding dampening (Philippas et al. 2020).

Regarding news sentiment in the cryptocurrency market, evidence reports that very good news leads to high returns and trading volume in the cryptocurrency market (Naeem et al. 2020). Furthermore, whereas the returns of traditional currencies tend to increase after positive news and decrease after negative news, Bitcoin reacts positively in both cases, evidencing that the enthusiasm towards Bitcoin is irrespective of the news sentiment. During periods of bubbles, this is even more exacerbated. Nonetheless, in the presence of news related to crypto cyber-attacks and frauds, Bitcoins' returns and volatility fall (Rognone et al. 2020). On the other hand, Bitcoin returns decrease when there is an increase in positive news after unemployment and durable goods announcements (Corbet et al. 2020c). When there is an increase in the number of negative news encompassing these statements Bitcoin returns seem to increase (Corbet et al. 2020c). GBP and Consumer Price Index (CPI) seem not to have any significant relationship with Bitcoin returns (Corbet et al. 2020c).

There is a presence of informed trading in the Bitcoin market, more specifically ahead of crypto-negative market events, and ahead of large positive events. Thus, regarding positive news, informed traders build their positions two days before the event. On the other hand, regarding negative news, they place their orders one day before the event (Feng et al. 2018).

4.6. Stablecoins Role in Cryptocurrency Investment

In the crypto market stablecoins also seem to play an important role (Hoang and Baur 2021). Stablecoins issuances seem to contribute to the market efficiency of cryptocurrencies as well as to price discovery. Stablecoins can also act as safe-havens (Wang et al. 2020a). USD-pegged stablecoins perform better than gold-pegged stablecoins (Wang et al. 2020a). However, this property changes across market conditions. In normal market conditions, stablecoins mostly act as diversifiers (Wang et al. 2020a). For instance, Tether may be used as a diversifier or even as a safe-haven when considering investments in gold (González et al. 2021). Furthermore, since Tether co-moves negatively with stock indices, it is seen as an important safe-haven during times of bad market conditions (Goodell and Goutte 2021b). However, even though Tether might act as a safe-haven, these properties are also not consistent over time, mostly due to the short-term historical losses in Tether related to an unstable peg with the US dollar (Conlon et al. 2020).

Further evidence reveals that stablecoins are not perfect substitutes among themselves (Ante et al. 2021). They also reveal excessive price variation (Hoang and Baur 2021). Additionally, it is highlighted that Bitcoin influences the volatility in stablecoins due to the high correlation of their returns, volumes, and volatility (Hoang and Baur 2021). Consequently, when past Bitcoin volatility declines, the volatility of the stablecoins tends to raise (Grobys et al. 2021).

4.7. Cryptocurrency Market

Evidence highlights that during periods of crisis, investors should consider reducing their exposure to Bitcoin compared to Litecoin, Ethereum, and Ripple, to minimize their risk and maintain their returns (Mensi et al. 2020a). Nonetheless, during the COVID-19 pandemic Bitcoin evolved significantly (Corbet et al. 2020c), since its prices grew with the number of high levels of COVID-19 fatalities (Goodell and Goutte 2021a). Additionally, there is evidence that COVID-19 had no impact on the interaction between cryptocurrency hedge funds and Bitcoin and Ethereum (Khelifa et al. 2021). Bitcoin and Ethereum represented the main cryptocurrencies used by cryptocurrency fund managers (Khelifa et al. 2021). Furthermore, during times of stressed markets, crypto assets can be grouped into speculative assets, which are mainly tail contagion transmitters (where Bitcoin belongs). They can also be grouped into technical assets, which are mainly tail contagion revivers (where Ethereum belongs) (Ahelegbey et al. 2021). Moreover, during bull market periods,

Bitcoin seems to be one of the major risk-driving cryptocurrencies (Nguyen et al. 2020). However, during low volatility periods the correlation of Bitcoin with Bitcoin forks is highly positive, yet, during high volatility periods, it reveals to be negative (Bazán-Palominó 2020).

Considering policy restrictions, it is seen that cryptocurrency returns (Bitcoin, Ethereum, Litecoin, and Ripple) seem to increase during Chinese monetary policy tightening. The same cannot be said for the U.S. monetary policies since they do not significantly affect cryptocurrency returns (Nguyen et al. 2019).

Further evidence reveals that the introduction of Bitcoin futures had no relation to the crash of the Bitcoin spot market in 2017 (Hattori and Ishida 2021). The Bitcoin 2017 bubble's impact on the P2P market depended on the currency and country. However, the US dollar is an exception since it is widely traded all over the world (Holub and Johnson 2019). Even though there is no relation between Bitcoin futures and the 2017 bubble burst, there is a negative relationship between Bitcoin returns and the introduction of Bitcoin futures (Liu et al. 2020a). Furthermore, the introduction of Bitcoin futures reshaped the mean and tail dependence between the stock and cryptocurrency markets (Lahiani et al. 2021). It is also evidenced that the introduction of futures markets may cause convergence shifts between cryptocurrencies (Apergis et al. 2020).

The specific case of Ethereum on the BitMEX swap, reveals that after the introduction of the BitMEX swap, the price volatility of Ether has decreased, the spot trading volume has increased, and market efficiency has improved. Moreover, the day-of-week effect has weakened, and the hour-of-the-day effect has strengthened, which reveals an increased participation of informed institutional traders in the Ether spot markets (Alexander et al. 2020). Additionally, it is identified the existence of extreme positive and negative returns caused by the trading volume of cryptocurrencies. More specifically, a granger causality from the trading volume to the returns of Bitcoin, Ripple, Ethereum, Litecoin, Nem, Dash, and Stellar at both left and right tails (Bouri et al. 2019).

However, other studies highlight that if structural breaks are accounted for there is no causal relationship between COVID-19 growth and cryptocurrency returns. (Sahoo 2021). There is also evidence of asymmetry between the behavior of return spillovers in lower quantiles and upper quantiles. Therefore, during times of market turmoil, investors should consider adopting trading strategies based on the magnitude and flow of the return spillovers within the cryptocurrency market (Bouri et al. 2021a).

When Bitcoin energy consumption is analyzed, evidence shows that there is a relationship between the energy consumption of Bitcoin and its returns and volumes (Huynh et al. 2021). However, contrary to the belief that energy as an important role in cryptocurrencies, evidence reveals a weak connection between energy commodities and cryptocurrencies (Ji et al. 2019b).

Several other studies, make more methodological contributions, and indicate that to better forecast Bitcoin futures prices and volatility, machine learning algorithms (MLAs) should be considered since they outperform benchmark models such as the ARIMA and the random walk in the forecasting of Bitcoin futures prices (Akyildirim et al. 2021b). Additionally, the non-homogeneous hidden Markov (NHHM) model with four states should be considered, highlighting the existence of a predictor with a state-dependent, time-varying predicting power (Koki et al. 2022).

Finally, to forecast the Value-at-Risk (VaR) of Bitcoin, Litecoin, and Ethereum, the Laplace GAS specification which considers the volatility and the asymmetric responses to positive and negative volatility, presents the best performance at most levels (Liu et al. 2020b).

Volatility

Volatility is one of the main characteristics of the cryptocurrency market, thus also being addressed in this literature review. In this regard, we found that the introduction of Bitcoins futures led to upward volatility, liquidity, and kurtosis on the Bitcoin spot

market. On the other hand, it led to a downward impact on Bitcoin returns and skewness (Jalan et al. 2021). Additionally, investors that consider investments in cryptocurrencies with higher idiosyncratic volatility will receive more profits, since the idiosyncratic volatility is positively related to cryptocurrency returns (Zhang and Li 2020).

It is also revealed through this literature review that the volatility connectedness in the cryptocurrency market, as well as between cryptocurrencies and other assets, varies across time and market conditions (Ahmed 2021; Bouri et al. 2021a; Gemici and Polat 2020; Xu et al. 2021). For instance, Bitcoin positively influences developed markets under different market conditions. On the other hand, emerging markets show an asymmetric response to Bitcoin's volatility (Ahmed 2021). Furthermore, the volatility connectedness between cryptocurrencies and traditional currencies is time-varying and arises in periods of economic and financial instability (Andrada-Félix et al. 2020). Consequently, during the COVID-19 period, Bitcoin, Ethereum, and Ripple were net transmitters of returns and volatility, whereas the fiat currencies such as Euro, Yuan, and GBP were net receivers. Nonetheless, the dynamic total return and volatility connectedness vary over time (Umar et al. 2021b).

Additionally, evidence reports that Bitcoin's past realized volatilities (RV) and jumps are important in explaining its future realized volatility (Qiu et al. 2021). Furthermore, Bitcoin volatility can explain most of the volatility in the cryptocurrency market (Dimpfl and Elshiaty 2021). In the cryptocurrency market, volatility seems to have different spillover patterns since the structures of the returns and volatility clusters are different among cryptocurrencies (Sensoy et al. 2021). Nonetheless, large cryptocurrencies such as Bitcoin, Ethereum, and Litecoin receive and transmit volatility spillovers in the cryptocurrency market (Polat and Kabakçı Günay 2021). However, evidence indicates that low-capitalized cryptocurrencies may also be transmitters of volatility connectedness, which is the case for Mailsafe Coin (Yi et al. 2018).

4.8. Cryptocurrency Portfolios

Regarding the construction of portfolios with cryptocurrencies, it is revealed that portfolios that only consider cryptocurrencies in their composition benefit from the use of portfolio selection when compared to naive portfolios; revealing gains of Sharpe ratio and average return (Tavares et al. 2020). Nonetheless, considering the highly speculative nature of the cryptocurrency market, all investors (professional and individual investors) should consider the optimization of their cryptocurrency portfolios enhancing their performance by minimizing their variance (Schellinger 2020). For instance, professional portfolio managers may consider the construction of a global minimum variance portfolio, whereas individual investors (who have less sophisticated resources) may consider investment in coins' market cap portfolios instead of tokens, due to their higher Omega ratio (Schellinger 2020).

Additionally, there is also evidence that indicates that a strategy that regards the construction of a portfolio comprised only of cryptocurrencies may present high risks since Bitcoin and altcoins prices are highly correlated (Demir et al. 2020b; Yang et al. 2020).

Further evidence shows that the use of a two-sided Weibull distribution for portfolio Value-at-Risk (VaR) estimation outperforms other benchmarked methods, when applied to a cryptocurrency portfolio composed of Bitcoin, Ripple, Dash, and Litecoin, since it can capture the stylized facts of cryptocurrencies' time series, such as volatility clustering, heavy tails, skewness, and extreme volatility (Silahli et al. 2021). Additionally, the use of an algorithm based on vine copulas to estimate the Value-at-Risk (VaR) and Expected Shortfall (ES) in a cryptocurrency portfolio proved to display good performance (Trucíos et al. 2020). Furthermore, the Black-Litterman model with variance-based constraints (VBCs) reveals a superior performance compared to the traditional benchmarks in overcoming the difficulties that portfolio theory has when applied to a portfolio of cryptocurrencies given the higher estimation error in the parameters (Platanakis and Urquhart 2019).

4.9. Future Venues of Research

In this strand of cryptocurrency literature that investigates cryptocurrencies as diversifiers, hedgers, and safe-haven s, we find literature gaps that indicate the need to further investigate the potential role of stablecoins as diversifiers, hedges, or safe-haven (Wang et al. 2020a), as well as to further analyze stablecoins volatility (Grobys et al. 2021). Further investigation is also needed to access if the stability of stablecoins is time-varying, and whether new-generation stablecoins are more stable than the older ones (Hoang and Baur 2021).

There are also indications that future research is essential in the investigation of the relationships between cryptocurrencies and other assets classes such as equities, bonds, currencies, and commodities (Bouri et al. 2021a; Cao and Xie 2021; Demiralay and Bayracı 2020; González et al. 2021; Hsu et al. 2021). More specifically to explore these relationships in less studied stock markets such as the African (Kumah and Odei-Mensah 2021) and Islamic stock markets (Aloui et al. 2021), and to consider broader commodity (Kumah and Mensah 2020) and currencies markets (López-Cabarcos et al. 2021). Future research should also consider larger samples of cryptocurrencies in these analyses (Charfeddine et al. 2020; Jiang et al. 2021b). Additionally, it is also imperative to further analyze the environmental sustainability of cryptocurrencies (not just Bitcoin), since they bear different characteristics (different carbon footprints and levels of energy consumption), therefore having different relationships with energy and utility companies (Corbet et al. 2021). This will also help clarify to green investors whether they should allow cryptocurrencies into their portfolios.

Besides the growing contributions in this strand of cryptocurrency literature, further investigation is still required to explore the possibility to hedge Bitcoin as well as other cryptocurrencies with various assets (Majdoub et al. 2021), and also to further analyze cryptocurrency hedging abilities against other markets (Kinkyo 2020), especially during periods of economic turmoil (Jareño et al. 2021). Cryptocurrencies' diversification and safe-haven properties also demand further investigation (González et al. 2021). For instance, to analyze the potential time-variant safe-haven properties of cryptocurrencies (Jareño et al. 2020); what might drive the heterogeneity in the safe-haven and hedge properties of cryptocurrencies for some stock indices such as the US (Bouri et al. 2020d); as well as investigate the diversification benefits in emerging and advanced economies in the context of cryptocurrency regulation (Akhtaruzzaman et al. 2020).

Additionally, since a large number of cryptocurrencies are on the market, it is important to investigate the overall causal relationships among them (Kim et al. 2021), as well as to further investigate cryptocurrency futures and options (Qiao et al. 2020). It is also revealed the need to investigate the relationship between spillover risk and market capitalization (Moratis 2021), as well as the interlinkages between changes in liquidity and price volatility, to better understand the dynamics of cryptocurrency price volatility behavior (Katsiampa et al. 2019).

Future research is also needed to analyze the effects of liquidity and transaction costs on the optimal rebalancing of portfolios and their diversification with cryptocurrencies (Ma et al. 2020). It is also important to investigate the asymmetric effect in bull and bear market periods and their impact on portfolio management (Demir et al. 2020b). Furthermore, the literature also highlights the need to understand the influence of size, frequency, and time off jumps and co-jumps on the correlations in the cryptocurrency market (Mensi et al. 2020a).

Other studies show the need for more research on why and how cryptocurrencies react in a heterogeneous manner to different types of uncertainty (Colon et al. 2021). For instance, future research should consider monetary policy or fiscal policy uncertainty, to examine the effects of uncertainty measures on the returns and volatility of cryptocurrencies (Bedi and Nashier 2020; Bhuiyan et al. 2021; Gozgor et al. 2019); it should also analyze how high and low capitalized cryptocurrencies are affected by changes in Twitter-Based Economic Uncertainty (TEU) and Twitter-Based Market Uncertainty (TMU) (Aharon et al.

2022), as well as to changes in the Economic Policy Uncertainty Index (EPU), and other uncertainty indices (Al-Yahyaee et al. 2019; Jareño et al. 2020; Wang et al. 2021); and it also ought to access if uncertainty is priced in the cross-section of cryptocurrency markets (Aharon et al. 2022).

Studies also indicate the need to further investigate the non-linear reaction of Bitcoin to high-frequency news sentiment (Rognone et al. 2020), as well as the possible existence of a bidirectional relationship between investor sentiment and cryptocurrencies, especially Bitcoin (López-Cabarcos et al. 2021). There are also indications to further investigate investor sentiment considering several proxies such as Google Search, VIX, Tweets, surveys, and the dynamics of cryptocurrency prices (Pho et al. 2021).

The growing use of machine learning methods and techniques in this literature is evident; however, indications of future research point out the need for more promising, powerful deep learning algorithms and machine learning approaches such as the xgtboost (Huynh 2021; Huynh et al. 2020a; Sun et al. 2020)

There are also indications to further employ approaches such as inverse volatility (IV), l2-norm constrained minimum variance (NMV), minimum variance (MV), l2-norm constrained maximum decorrelation (NMC), risk parity (RP), and maximum diversification (MD), to evaluate the construction of portfolios with some weights to cryptocurrency (Huynh et al. 2020b). Additionally, it is also important to evaluate the change of efficient frontier in three-dimensional space (mean–variance–skewness), with Bitcoin as an element of the investment opportunity set (Kwon 2020).

Other methodologies, such as the Value-at-Risk (VaR) analysis in a time rolling-window manner (Chemkha et al. 2021), and the multivariate factor stochastic volatility model (MFSVM) (Shi et al. 2020) are also recommended to investigate portfolio profit and loss dynamics (Chemkha et al. 2021), and to examine the relationship between cryptocurrencies and traditional assets (Shi et al. 2020).

5. Conclusions

To improve our understanding of portfolio diversification, hedge, and safe-haven properties in cryptocurrency investments, we apply for a systematic literature review along with a bibliometric analysis of extant literature. To this end, we used VOSviewer, with data retrieved from the WoS database (2009 to 2021) to conduct our bibliometric analysis.

Our bibliometric analysis highlights that Finance Research Letters is the most cited journal similar to the findings of Aysan et al. (2021), however different from the conclusions made by Almeida and Gonçalves (2022). We indicate Asia as the continent that has contributed the most to portfolio diversification, hedge, and safe-haven properties in cryptocurrency investments literature, with China being its most cited country and major contributor, this contradicts the findings by Almeida and Gonçalves (2022); García-Corral et al. (2022); Jiang et al. (2021c); Yue et al. (2021) where Europe is the continent with more contributions and citations. Trinity College Dublin is the institution with more citations on the research topic.

Our results show that (1) cryptocurrencies may hedge against stocks, fiat currencies, geopolitical risks, Economic Policy Uncertainty (EPU) risk, however, these properties are time-varying; (2) cryptocurrencies present diversification and safe-haven properties, nonetheless, they vary across time and market conditions; (3) investors should consider Gold, along with the European carbon market, CBOE Bitcoin futures and crude oil to hedge against unexpected movements in the cryptocurrency market; (4) uncertainty is indeed a determinant for cryptocurrency returns; (5) stablecoins may act as a safe-haven and diversifiers and contribute to market efficiency, however, they reveal an unstable peg with the US dollar; (6) individual investors may consider investment in coins' market cap portfolios instead of tokens, due to their higher Omega ratio.

A study with these contributions is important for researchers, investors, analysts, regulators, and academics in general. Our findings provide researchers and academics in

general with structured networking for research outlets and literature strands, with time-trended information relevant for future studies on portfolio diversification, hedge, and safe-haven properties of cryptocurrency investments. It also provides investors and analysts with a highly important compilation of practical findings that can help them better devise their investment strategies. In addition, it provides insights for regulators to effectively regulate the cryptocurrency markets.

As a limitation of our research, we point out the use of only one database (WoS). However, due to our quality criterion (ABS journal guide list), there were no significant contributions from other databases (Scopus). Further updates should follow to ensure timeliness in identifying research trends and unsolved research inquiries and debate current and future research streams. Clustering our research literature allowed us to note more clearly the extant findings and future venues, further (sub)clustering could provide new highlights with potential for scientific contribution.

As future research venues, and in reaction to the recent event related to the UST stablecoin meltdown, and the Russia-Ukraine War, we highlight the importance of exploring and accessing if the stability of stablecoins is time-varying and their potential role as diversifiers, hedges, or safe-havens. Furthermore, a critical discussion of underlying events and their roots ought to be carried out in light of the 2022 Bitcoin and other cryptocurrencies' crash. Value (conservation) and returns might be significantly at odds in crypto markets, which influences volatility (Appel and Grabinski 2011). As argued by Klinkova and Grabinski (2017), the resulting market instability may lead to chaotic behavior, which is mathematically challenging and significantly different from randomness in investment modeling (Grabinski and Klinkova 2019, 2020). Finally, research analyzing rising connectedness between several cryptocurrencies, and their implication for investing, has emerged (Kumar et al. 2022; Bouri et al. 2022; Wang et al. 2022) and further investigation should be pursued to shed light on the role of these inter-assets dynamics on portfolio management.

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