Unpacking the financial attributes of blue-chip non-fungible tokens (NFTs) against traditional and digital assets

Shinta Amalina Hazrati Havidz, Maria Divina Santoso, Theodore Alexander and Caroline Caroline

Finance Program, Accounting Department, School of Accounting, Bina Nusantara University, Jakarta, Indonesia

Abstract

Purpose – This study aims to identify the financial attributes of non-fungible tokens (NFTs) as safe havens, hedges or diversifiers against traditional (stock indices, foreign exchange, gold and government bonds) and digital (Bitcoin and Ethereum) assets.

Design/methodology/approach – The quantile via moments was utilized, and the data spanned from 20 September 2021 to 31 January 2022. The authors incorporated feasible generalized least squares (FGLS) and difference-generalized method of moments (diff-GMM) as the robustness check.

Findings – Overall, NFTs offer strongly safe havens, hedging and diversifier attributes against cryptocurrencies, while weak properties for traditional assets. The specific findings are: (1) Bored Ape Yacht Club (BAYC) serves as a strong hedge for Bitcoin during market rise; (2) Mutant Ape Yacht Club (MAYC) serves as a strong safe haven against Bitcoin during market bull; (3) Crypto punk (CP) provides strong safe havens properties for gold during market turmoil while serving as a strong hedge against gold and Bitcoin on average and (4) the three blue-chip NFTs are powered by Ethereum blockchain, thus serving as a diversifier against Ethereum.

Practical implications – Bitcoin investors are suggested to include NFTs in their investment portfolio to mitigate the losses when Bitcoin falls. Meanwhile, the inclusion of crypto punk is advised for risk-averse investors who invest in gold. NFTs are powered by the Ethereum blockchain, indicating co-movement among them and thus, serve as diversifiers. Policymakers and regulators are suggested to watch closely over NFTs' great development and restructure the existing policies and thus, stabilization of asset markets can be achieved.

Originality/value – The originality aspects are: (1) focusing on the three blue-chip NFTs (i.e. BAYC, MAYC and CP) that are categorized as the largest NFTs by floor market capitalization; (2) testing the NFT attributes (safe havens, hedges or diversifiers) against traditional and digital assets, a.k.a., cryptocurrencies and (3) panel setting on 14 countries with the highest NFT users.

Keywords Blockchain, Diversifier, Hedge, NFTs, Quantile via moments, Safe havens

Paper type Research paper

1. Introduction

Although digital assets such as Bitcoin and Ethereum show rapid development (Zhang *et al.*, 2022) due to the blockchain technology first established by Nakamoto (2008), non-fungible

tokens (NFTs) provide blockchain technology novelty (Wilson *et al.*, 2022). Public interest in blockchain technology is growing rapidly. In 2016, over $1bn was invested in blockchain solution deployment held by financial services and technology companies to their businesses, and it is expected to increase dramatically in the next few years [1]. Blockchain technology, which delivers trust-free transactions without intermediaries, has been an interest since 2008 during the financial crisis that happened globally. It occurred due to the financial institutions and banks who failed to mitigate risk. Blockchain is believed to be a solution to the trust deterioration in intermediaries, especially financial intermediaries, since it eliminates the need for third parties (intermediaries) when doing transactions (De Filippi *et al.*, 2020). It can be seen from global spending on blockchain solutions rising from $0.95bn in 2017 to over $4.5bn in 2020. Statistics also forecast that over the year 2021 until 2024, the spending will continue to grow from 6.6bn US dollars to reaching almost $19bn in 2024 [2].

At the beginning of March 2021, the new existence of NFT art entitled *Everyday: The First 5000 Days* sold 69m US dollars and became the largest art sale in history (Rehman *et al.*, 2021). Since then, public attention on NFT exploded and made *OpenSea* one of the largest NFT marketplaces, reaching one million users in early 2022 from only 37,400 users in 2021 [3]. NFTs are cryptographic assets that produce images, videos, songs and virtual lands (Kanellopoulos *et al.*, 2021) and offer potential revenue and store value (Kumar and Padakandla, 2023). Not only obtaining social attention (Zhang *et al.*, 2022) but also young investors are very excited about the revolution of new digital assets, a.k.a., NFTs. Shortly, it could be a prospective digital asset (Ali *et al.*, 2023a).

Every day, thousands of hundreds of NFTs were traded with an average volume of $3bn per day [4] and it was proven that NFTs serve not as currency, a commodity or a technology, but as an asset (Dowling, 2022). Although NFTs are difficult to value, it is observed that NFTs are a new asset class that may mature over time. Shortly, NFTs can be strongly related to cryptocurrency as its native currency and other asset classes (Ante, 2021). These indicate that NFTs can be used as an alternative investment.

Financial researchers have examined the connectedness and spillover studies of NFTs with existing financial assets or among NFTs (Dowling, 2022; Aharon and Demir, 2022; Urom *et al.*, 2022; Umar *et al.*, 2022a, b). Remarkably, we found scarce research that focuses on the safe havens and hedge attributes of NFTs (Zhang *et al.*, 2022; Ko and Lee, 2023; Kumar and Padakandla, 2023). Therefore, we are motivated to identify the function of NFTs, either as safe havens, hedges or diversifiers against financial assets. We examine a comprehensive study by utilizing the blue-chip NFTs against traditional (i.e. stock, foreign exchange, gold and government bond) and digital (i.e. Bitcoin and Ethereum) assets. Such work remains unexplored.

Zhang *et al.* (2022) examined the NFTs' attributes as safe havens and hedges against the US dollar, bonds, stocks, crude oil, gold and Bitcoin. Ko and Lee (2023) utilized the NFT index to discover either as a safe haven or hedge against the financial asset indices (i.e. stock, commodity, bond and US dollar) and cryptocurrencies (i.e. Bitcoin and Ethereum). Kumar and Padakandla (2023) employed log returns from four NFTs average prices (i.e. Cryptokiteis, Decentraland, SuperRare and Cryptopunks) and further examined the safe havens or hedge properties against Bitcoin and Ethereum. None of the earlier studies focused on the NFTs individually, while investors are going to invest in certain NFTs that they have an interest in. Therefore, we fill the research gap by examining the NFT attributes individually on the three blue-chip NFTs (i.e. Bored Ape Yacht Club (BAYC), Mutant Ape Yacht Club (MAYC) and Crypto-Punks (CP)).

Our research contributes by providing new insights to the literature, investors and stakeholders in threefold (1) updating the function and effectiveness (i.e. safe havens, hedges and diversifiers): literature, as the prior works favor gold as safe haven assets (Shahzad *et al.*, 2020; Li and Lucey, 2017; Baur and Lucey, 2010; Lucey and Li, 2015; Baur and Mcdermott, 2010).

Cryptocurrencies (Bitcoin and Ethereum) as digital assets have also been examined (Antonakakis *et al.*, 2019; Disli *et al.*, 2021; Stensås *et al.*, 2019; Mariana *et al.*, 2021; Kang *et al.*, 2020). Through this study, the revolution of NFTs as new digital assets can be determined; (2) we selected the sample based on the largest users of NFT based on Statista (2022) and thus, panel setting is applied (3) focusing on the three blue-chip NFTs (i.e. BAYC, MAYC and CP) that are categorized as the largest NFTs by floor market capitalization.

The rest of the section on this paper is structured as follows. Discusses tokens, financial attributes theory and related prior works in section 2. Section 3 explains the data and core methodology. Section 4 elaborates on the findings. Discusses further analysis of the results in section 5. Lastly, conclusions and recommendations in section 6.

2. Literature review
2.1 Tokens
The application of blockchain-based has gained popularity among Fintech breakthroughs (Cong *et al.*, 2021). Blockchain technology provides smart solutions for traditional platforms that heavily depend on the innovations of payment to stimulate the exchanges of economics among users. The birth of digital platforms offers tokens of crypto to serve as local currency (Cong *et al.*, 2022). Not only as currency but also tokens are considered as investment tools. Asset-backed tokens rely on an asset to back and thus have intrinsic value (Hassan *et al.*, 2021). Gold-backed cryptocurrency (GBC) garnered the attention of investors since the beginning of COVID-19 (Jalan *et al.*, 2021). Hassan *et al.* (2021) explored the precious metal-backed cryptocurrency (PMBC), while gold-backed Islamic cryptocurrencies (GBIC) provide new attractive investment tools to faith-based investors (Lahmiri and Bekiros, 2019; Aloui *et al.*, 2021; Mnif and Jarboui, 2021, 2022; Ali *et al.*, 2022, 2024; Nugroho, 2023; Trichilli and Boujelbéne, 2023; Zaman *et al.*, 2023). The energy sectors have also adopted the digital revolution by transforming to energy tokens, which are considered unconventional instruments of financial. This has garnered the attention of commodity investors (Ali *et al.*, 2023b; Yousaf *et al.*, 2022). Tokenization indeed provides better services in the form of non-fungible tokens (NFTs) and Decentralized Finance (DeFi) (Umar *et al.*, 2022a, b; Yousaf and Yarovaya, 2022; Corbet *et al.*, 2023), asset management (Yousaf *et al.*, 2023) and metaverse (Vidal-Tomás, 2022) tokens.

2.2 The theory of safe havens, hedges and diversifiers
The Modern Portfolio Theory is an investment method for investors to have an efficient portfolio by diversifying the assets with expected return and variance of return consideration; thus, the return will be optimized and the risk will be tolerable (Markowitz, 1952). To make an efficient portfolio, correlation among securities is one of the most important aspects, which needs to be non-correlated and low-correlated with other securities to eliminate and reduce the risk (Markowitz, 1971). Baur and Mcdermott (2010) and Baur and Lucey (2010) define an empirical testable of the three types of asset diversification in an investment portfolio (i.e. safe havens, hedges and diversifiers). A safe haven is a property that is negatively correlated to other financial assets in market turmoil. A hedge asset is a property that is negatively correlated to other financial assets on average. Meanwhile, a diversifier is positively correlated to other financial assets on average.

2.3 Previous research on safe havens, hedges and diversifiers
The literature on NFTs as safe havens and hedges has been growing but is still limited. Kumar and Padakandla (2023) confirm that NFTs are exhibited as a hedge against Bitcoin by employing the effectiveness of a dynamic hedge. Further, based on the Wavelet Quantile

Correlation results, NFTs offer a safe haven to Bitcoin for the short run. Meanwhile, NFTs serve as diversifiers for Ethereum in the short-medium term. Ko and Lee (2023) show that NFTs are attributed as safe havens and hedges against certain stocks, oil, US indices and bonds with various degrees. It is further confirmed during the outbreak of COVID-19 that NFTs provide safe haven attributes for USD indices and bonds. Zhang et al. (2022) employ the NARDL model and find a hedge property of NFTs against bonds, gold and USD on normal market for the full period. Before COVID-19, NFTs had hedge benefits for the US dollar and stocks on average, while safe havens against USD during the outbreak.

Before NFTs gained popularity, numerous studies tested how gold, cryptocurrencies (Bitcoin and Ethereum) and other financial assets functioned against financial assets. Baur and Lucey (2010) find gold provides a safe haven attribute to the UK, US and German stock indices. Not only serving as a safe haven for conventional assets but also gold is able to be a safe haven property for Islamic equities (Tirosh and Barkai, 2007; Chkili, 2017). Lucey and Li (2015) applied multivariate GARCH DCC and proved that gold acted as a safe haven against US bonds and stocks. Li and Lucey (2017) further reassess and find gold acts as a safe haven for bonds (France, Canada, Italy and the UK) and stocks (Germany, the US, Italy, Japan and the UK). Shahzad et al. (2019) depict weak gold as safe haven property in emerging and developed stock markets. Indeed, the superiority of gold as a safe haven was confirmed during the COVID-19 crisis and uncertainty (Ji et al., 2020; Liu, 2020; Huang and Chang, 2021). Kumar and Padakandla (2022) indicate that gold remains to act as a safe haven (hedges) in the long and short (medium) term. Widjaja et al. (2023) evidence that gold comes out as the big winner of safe havens against stocks and bonds in Islamic and conventional markets. Meanwhile, the UCRY price only serves as a strong safe haven for conventional equities, while weak safe haven attributes for Islamic stocks.

Before the COVID-19 period, Bitcoin was a poor hedge except for weekly movement in China stocks. US dollars, gold, commodities and Bitcoin can be safe haven assets against stock markets (Wen and Cheng, 2018; Chen and Wang, 2019). Nevertheless, it can give a diversification benefit against almost all the stock indices, US dollar, commodities, oil and gold, while safe-haven benefits against Asian stocks (Bouri et al., 2017). The hedge and diversifier attribute of Bitcoin against several financial assets is confirmed, while a safe haven benefits against the monetary market in China (Wang et al., 2019). Bitcoin acts as a weak hedge property to Estonia, Sweden, Venezuela, China and Japan stocks in US dollars trade. Meanwhile, in local currency trade, it serves as a safe haven property in Venezuela and also a diversifier property in China and Japan (Kliber et al., 2019). Bitcoin provides a safe haven benefit to US stocks and a diversifier in the long run. Bitcoin's utility to be a diversifier is confirmed, despite it not serving as a safe haven for other financial assets (Lavelle et al., 2022).

During the COVID-19 pandemic, it is further examined and proven Bitcoin serves as a safe haven for all sectors of US stocks, while Ethereum serves as a hedge only toward several sectors (Bouri et al., 2020a). Moreover, Bitcoin also has a hedge potential against stock prices but is a diversifier during extreme market conditions (Garcia-Jorcano and Benito, 2020). Several cryptocurrencies, including Bitcoin, are able to give diversification gains within a short-term period (Corbet et al., 2018) and safe haven benefits (Bouri et al., 2020b). Bitcoin also remains a diversifier (Huang et al., 2021). By contrast, Bitcoin and Ethereum cannot serve as a safe haven for stock markets due to increasing the downside risk portfolio (Conlon and McGee, 2020; Conlon et al., 2020).

3. Data and methodology

3.1 Data

We selected three blue-chip NFT projects with the biggest capitalization of market as of February 2022 (i.e. Bored Ape Yacht Club (BAYC), Mutant Ape Yacht Club (MAYC) and

Crypto-Punks (CP)) that are operated by using the Ethereum chain [5]. BAYC is an ape-type NFT project that is being developed by Yuga Labs. The lucky holders will receive a reward for having a mutation version of their Bored Ape, known as Mutant Ape. MAYC is created by serums that had been airdropped randomly to the Bored Ape token holders. It is a form of the final tier of BAYC membership [6]. Meanwhile, Crypto-Punks is a character type of NFT project that was created by Larva Labs and has been acquired by Yuga Labs [7].

To provide reliable results, we focused on the countries with the largest users of NFT based on Statista (2022) with the criteria as listed in Table 1. As 14 countries were selected as our samples, we covered the daily period from 20 September 2021 to 31 January 2022. The data with five days of daily data basis (i.e. stock indices, foreign exchange and government bonds – see Table A1 in the appendix) were linearly interpolated to seven-day daily data. Linear interpolation is the simplest way of interpolation method that allows the estimation of missing values when there is a gap between the measurements (Gray et al., 2018). Hence, the entire variables are using seven days of daily data. We used nine indicators, which consist of three dependent variables (bored ape, mutant ape and crypto punk) and six independent variables (stock indices (SR), foreign exchange (FR), gold (GR), government bonds (GBR), Bitcoin (BTC) and Ethereum (ETH)). Three variables (stocks, foreign exchange and government bonds) employed country-level data, while the remaining variables employed global data. As for the independent variables, we extract the return data from the sources, while daily closing price data for the dependent variables and then, transform it into a return form, which is calculated as $(P_1 - P_0)/P_0 \times 100$. Therefore, the entire variables are in the return form. Data sources and summary variables are attached in Table 2.

3.2 Quantile regression via moments

Koenker and Bassett (1978) first introduced regression quantiles further developed by Gutenbrunner and Jureckova (1992), which consider the conditional means. Following Dias et al. (2022), Gozgor and Karakas (2023) and Raifu et al. (2023), we also employ the quantile regression constructed by Machado and Santos Silva (2019), named quantile via moments to identify the safe haven, hedge, and diversifier attributes of NFTs against traditional and digital assets. Some benefits of applying quantile via moments are: (1) a novel approach of quantile regression to accommodate the heterogeneous issue of panel data, in our case the countries (Raifu et al., 2023); (2) it addresses a new way of predictors that impact the whole conditional distribution, especially when the predictors deal with the endogenous issue and entrench with individual effects (Awosusi et al., 2022). The equation of our quantile regression is presented as follows:

$$Q_y\left(\tau | X_{it}\right) = \left(a_i(\tau) + \delta_i q(\tau)\right) + X'_{it}\beta(\tau) + Z'_{it}\gamma(\tau) \tag{1}$$

Where $Q_y(\tau|X_{it})$ describes the quantile for dependent variables, $(a_i(\tau)$ reflects the quantile of the distributional effect, which refers to countries used in this paper, $\delta_i q(\tau)$ denotes the scale effect, $X'_{it}\beta(\tau)$ implies the independent variables and Z' refers to the known differentiable

No	Criteria	Countries
1	Countries with the highest number of adults who either own or plan to buy NFT	19
2	Countries with unavailable forex data	1
3	Countries with unavailable 10 years of government bonds data	4
	Countries selected as the samples	14

Source(s): Created by authors

Variables	Sources	Mean	Std dev	Min	Max	Obs
BAYC	Coingecko.com	0.85	4.58	−10.96	19.82	1,876
CP	Coingecko.com	−0.59	3.92	−8.22	21.06	1,876
MAYC	Coingecko.com	1.67	9.33	−8.52	86.25	1,876
SR	Investing.com	0.23	1.04	−4.15	6.31	1,876
FR	Investing.com	−0.14	0.43	−3.05	2.37	1,876
GR	Investing.com	−0.17	0.63	−2.43	2.02	1,876
GBR	Investing.com	0.20	9.47	−129.79	200	1,876
BTC	Investing.com	−0.09	3.33	−10.41	9.86	1,876
ETH	Investing.com	−0.07	4.19	−14.43	11.45	1,876

Source(s): Created by authors

Table 2.
Descriptive summary
and data sources

vector transformations of X components. Given the equation, as provided above, our model equation can be formed as follows:

$$(\text{BAYC}|\text{MAYC}|\text{CP})\, Q_y\,(\tau|X_{it}) = (a_i(\tau) + \delta_i q(\tau)) + \beta_1 SR_{it} + \beta_2 FR_{it} + \beta_3 GR_{it} + \beta_4 GBR_{it}$$
$$+ \beta_5 BTC_{it} + \beta_6 ETH_{it} + Z'_{it}\gamma(\tau)$$

(2)

Referring to Yıldırım and Çelik (2021) and Singh and Kannadhasan (2020), we applied 10%–90% quantiles. We classify the nine quantiles into three phases based on market conditions that reflect the NFTs market condition: (a) bearish market (10–30%), (b) normal market (40–60%) and (c) bullish market (70–90%). The classification is divided into three: (1) strong (weak) safe haven is classified when revealing a negative coefficient and statistically significant (insignificant) in a bearish market, (2) strong (weak) hedge is classified when revealing a negative coefficient and statistically significant (insignificant) in normal and bullish markets and (3) strong (weak) diversifier is classified when revealing a positive coefficient and statistically significant (insignificant) under all market conditions.

To ensure the quality of the data, we ran several tests before proceeding to the quantile regression test. The cross-section dependency test by Pesaran (2021) was conducted first to check the dependency between the cross-section data used in this research. Second, we run a panel unit root test by Levin et al. (2002) to ensure the stationarity in our time series data. We used the LLC method because all variables are using the same number of time series (Choi, 2001).

3.3 Robustness tests
We conducted two-fold robustness tests as additional regressions to check the consistency results from our main regression. Feasible generalized least square (FGLS) was employed in the first step. Due to the existence of heteroskedasticity, the FGLS model is more efficient than OLS (Bai et al., 2020). Not only solving the heteroskedasticity issues but also FGLS is more attractive for large observations (Wooldridge, 2018). Arellano and Bond (1991) found difference generalized methods of moments (diff-GMM), which we employed on the second stage of robustness. The benefits of applying diff-GMM are overcoming the endogeneity from the regressors, and it can avoid dynamic panel bias (Abdeljawad et al., 2013).

4. Results
4.1 Unit root test and cross-section dependency results
The findings show that all variables utilized are stationary at level, which means there was no unit root problem in our time series data. The cross-section dependency test shows the

existence of cross-section dependency between countries used in this paper. Therefore, the null hypothesis, which refers to no cross-sectional dependence, was rejected at 1% significance for all variables. Refer to Table 3 for both results.

4.2 Quantile via moments results

As for comparison, ordinary least square (OLS) is included, and the results implied correspond directions with quantile regression. Refer to Table 4. Panel A: BAYC, we found positive [negative] BAYC coefficient and statistically insignificant to stock under bearish and bullish (10–30% and 80–90%) [normal] (50–60%) conditions. It reveals that BAYC served as a weak diversifier [weak hedge]. The negative coefficient of BAYC statistically insignificant to foreign exchange, gold and government bonds under all market conditions signifies that BAYC offered a weak safe haven and hedge. Our findings support the prior findings by Zhang *et al.* (2022), Aharon and Demir (2022), Umar *et al.* (2022). Confirming the findings of Kumar and Padakandla (2023), a negative BAYC coefficient and statistically insignificant [significant] against Bitcoin under bearish and normal (10–50%); [bullish] (70–80%) conditions. It implies BAYC serves as a weak safe haven and hedge [strong hedge] against Bitcoin. BAYC offered a strong diversifier for Ethereum in all market conditions (10–40% and 60–80%) as it shows a positive coefficient of BAYC and is statistically significant as argued by Kong and Lin (2021) and Dowling (2022).

Panel B: MAYC of Table 4 reveals a positive coefficient of MAYC and is statistically insignificant to stocks under all market conditions (10–20%; 40–50% and 70–90%). It implies that MAYC serves as a weak diversifier for stocks. As for foreign exchange and gold, it was found that the MAYC coefficient outlines a positive significant [insignificant] in bear [normal] markets (10–30%) [40–60%]. It implied that MAYC acted as a strong [weak] diversifier for foreign exchange and gold under both markets mentioned earlier. Our results support the earlier findings by Kong and Lin (2021), which confirm the function of NFTs as diversifiers. Meanwhile, MAYC proved as a weak diversifier [strong hedge] in the bull market against foreign exchange [gold], as the coefficient of MAYC reveals positive insignificant [negative significant]. MAYC exhibited a negative coefficient and was insignificant against government bonds in all markets (10–90%). This signifies MAYC acted as a weak safe haven and hedge against bonds as argued by Ko and Lee (2023) and Zhang *et al.* (2022). Supporting the findings of Kumar and Padakandla (2023), MAYC revealed a negative coefficient and significance during market crises (20–30%) for Bitcoin, which serves as a strong safe haven. Meanwhile, a positive, insignificant coefficient of MAYC against Bitcoin on average (40–50% and 80–90%)

Variables	LLC-test	CD-test
BAYC	−23.2212***	110.426***
CP	−22.5191***	110.426***
MAYC	−24.1667***	110.426***
SR	−18.4437***	26.693***
FR	−19.2159***	13.277***
GR	−20.5194***	110.426***
GBR	−16.4202***	11.476***
BTC	−30.6115***	110.426***
ETH	−32.5763***	110.426***

Note(s): ***Stands for 1% level of significance
Source(s): Created by authors

Table 3.
Results from LLC-test
and CD-test

	SR	FR	GR	GBR	BTC	ETH
Panel A: BAYC						
OLS	0.127	−0.199	0.276*	−0.011	−0.078	0.153***
0.1	0.002	−0.02	0.508*	−0.003	−0.158	0.241***
0.2	0.005	−0.204	−0.202	−0.011	−0.099	0.267***
0.3	0.063	−0.242	−0.1	−0.011	−0.023	0.155***
0.4	0.013	−0.313**	−0.097	−0.003	−0.042	0.115***
0.5	−0.022	−0.128	−0.066	−0.002	−0.077	0.085
0.6	−0.03	−0.12	−0.256	−0.013	−0.353***	0.279***
0.7	−0.042	−0.269	0.479**	−0.024	−0.255***	0.242***
0.8	0.09	0.033	−0.107	−0.013	−0.422***	0.319***
0.9	0.489	−0.592	−0.232	−0.017	−0.031	−0.066
Panel B: MAYC						
OLS	0.08	1.298***	−0.143	−0.032	−0.132	−0.077
0.1	0.172	1.401***	1.082***	−0.015	−0.162	−0.075
0.2	0.216	0.793**	0.841***	−0.01	*−0.326***	0.151**
0.3	0.441**	0.84*	0.534*	−0.013	*−0.268***	0.102
0.4	0.127	0.262	0.165	−0.01	0.054	−0.034
0.5	0.008	0.042	0.353***	−0.005	0.042	−0.008
0.6	−0.063	0.233	0.319	−0.023	0.249***	−0.054
0.7	0.116	0.584	−0.234	−0.029	0.394***	−0.109
0.8	0.146	0.073	−1.167***	−0.02	0.041	0.178**
0.9	0.243	0.366	−2.875***	−0.026	0.034	0.449**
Panel C: CP						
OLS	0.017	0.547***	−0.355**	0.008	0.048	0.054
0.1	−0.113	0.369	*−0.661***	0.027*	−0.287***	0.346***
0.2	−0.02	−0.131	*−0.504***	0.008	0.044	0.065
0.3	0.039	0.145	*−0.639***	0.003	−0.032	0.071***
0.4	0.074	0.421**	−0.503***	0.007	−0.104**	0.035
0.5	0.01	0.113	−0.484***	0.001	−0.165***	0.094***
0.6	−0.009	0.197	−0.094	0.006	−0.161***	0.093
0.7	0.003	0.512*	0.196	0.005	−0.122**	0.092*
0.8	0.098	0.391	0.49**	0.006	0.067	−0.059
0.9	0.065	0.214	−0.36	0.015	0.502***	−0.237*

Note(s): ***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$; strong safe haven marked in italic
Source(s): Authors' own creation

Table 4.
Ordinary least square and quantile regression results

refers to a weak diversifier. A negative insignificant coefficient of MAYC against Ethereum on average (40–60%) proved a weak hedge, while a strong diversifier of MAYC against Ethereum during the market rise and sound economy (80–90%). We contribute new findings to the earlier findings of Kumar and Padakandla (2023) that NFTs could serve as a safe haven and hedge not only for Bitcoin but also for Ethereum. Additionally, diversifier properties of NFTs not only served for Ethereum but also for Bitcoin. In this case, MAYC is the NFT.

Table 4. Panel C: crypto punk exhibited a negative insignificant [positive insignificant] coefficient of CP against stocks during market crises (10–20%) [normal market and rise economy] (40–50% and 70–90%). Hence crypto punk could act as a weak safe haven and diversifier for stocks (Kong and Lin, 2021; Ko and Lee, 2023). Moreover, crypto punk also serves as a weak diversifier at all market conditions against foreign exchange and government bonds because it shows positive, insignificant coefficients of crypto punk. A

negative significant coefficient of crypto punk against gold at the bear market (10–30%) proves strong safe haven attributes of crypto punk against gold, while crypto punk serves as a strong hedge on average for gold and Bitcoin because of the negative significant coefficient of crypto punk at the normal market. Similar to BAYC, crypto punk offers strong diversification benefits during the market downturn for Ethereum because of the positive coefficient and significance of crypto punk against Ethereum. On the other hand, it reveals a weak diversifier on average by the positive, insignificant coefficient of crypto punk against Ethereum. Therefore, our new findings indicate that crypto punk offered diversification benefits not only for Ethereum (Kong and Lin, 2021; Dowling, 2022) but also for foreign exchange and government bonds.

4.3 FGLS and diff-GMM as robustness check
The robustness test results from FGLS and diff-GMM revealed consistency directions. Therefore, our estimations were robust across two different approaches among the regressors toward the NFTs variables (refer to Table 5).

5. Discussion
This research utilized three blue-chip NFTs (i.e. bored ape, mutant ape and crypto punk) (Bloomberg News, 2023a, b) and further examined the financial properties. NFTs, as a blockchain-based technology, could only serve as a strong hedge and safe haven for digital assets that also applied the blockchain system, Bitcoin. Bored ape and crypto punk revealed a strong hedge attribute for Bitcoin on average, while mutant ape offers strong safe haven benefits to Bitcoin during market turmoil. Our results supported the findings of Kumar and Padakandla (2023). Bitcoin investors could mitigate the risk by including mutant ape during the market downturn, while bored ape and crypto punk during the economic recovery or normal market to the investment portfolio. Similarly, the NFTs market is dominated by risk-seeking investors who have a high desire to build a high-risk portfolio (Hayes, 2022). The large, sudden numbers of investors entering the NFT markets have led to a bubble coin. Given that situation, it creates higher volatility among cryptocurrencies, thus raising their values (Wilson *et al.*, 2022).

Confirming the results of Zhang *et al.* (2022), NFTs, in our case crypto punk, also serve as a strong hedge against gold. However, we provide new insights into the safe haven benefits of crypto punk against gold. Therefore, crypto punk is the only NFT that could serve as a safe haven and hedge to commodity assets. In addition, crypto punk, as one of the pioneers in NFT [8], has the holders' behavior tending to hold rather than pump and dump, which could

	BAYC		MAYC		CP	
	FGLS	GMM	FGLS	GMM	FGLS	GMM
SR	0.127	0.148	0.08	0.048	0.017	−0.007
FR	−0.199	−0.343	1.298***	2.06***	0.547***	0.878***
GR	0.276*	0.399**	−0.143	−0.104	−0.355**	−0.297**
GBR	−0.011	−0.022	−0.032	−0.07**	0.008	0.015
BTC	−0.078	−0.101*	−0.132	−0.131	0.048	0.051
ETH	0.153***	0.147***	−0.077	−0.116	0.054	0.034
No. of obs	1876	1848	1876	1848	1876	1848
Wald χ^2	26.22	43.73	19.26	31.06	30.73	34.31
Prob > χ^2	0.000	0.000	0.004	0.000	0.000	0.000

Note(s): ***$p < 0.01$, **$p < 0.05$ and *$p < 0.1$
Source(s): Authors' own creation

Table 5.
Robustness test
results: FGLS
and GMM

maintain the market stability that will impact its risk. Therefore, it may attract investors who are risk-averse and are inclined to invest in gold to make a less risky portfolio (Wong, 2009).

Although Bored Ape also offers safe haven and hedge benefits against traditional assets (i.e. stocks, foreign exchange, gold and government bonds), it is only in a weak mode. Hence, it is insignificant to include bored ape in the portfolio when having traditional assets. In contrast, mutant ape offers a strong diversification for foreign exchange and gold during market downturns and, on average, is weak for stocks. Confirming the findings of Ko and Lee (2023), NFTs, in our case mutant ape, could absorb the unexpected shocks and thus provide diversification opportunities against traditional assets. Further, mutant ape also provide safe havens and hedge property against government bonds but are weak. Overall, the three blue-chip NFTs are powered by the Ethereum blockchain in conducting the transactions, then it serves as a diversifier against Ethereum under the majority of market conditions. The results are consistent with Kumar and Padakandla (2023), exhibiting a co-movement between Ethereum and NFTs.

6. Conclusion and recommendations

NFTs can be seen as potential alternative investments. Given the situation that there are more upcoming people, begin to see and accept NFTs as a new digital asset. These findings support Ante (2021) that NFTs will mature over time. Our paper by far gives the most relevant results by using data from selected 14 countries with the highest number of NFT users.

We provide economic implications to policymakers, academic researchers, regulators and investors. NFTs are indeed attractive during the new entrance, which is also largely endorsed by celebrities, thus sharply raising the value. Yet, the NFTs environment is highly volatile and infamously unpredictable (Bloomberg News, 2023c). Therefore, the government and regulator play an important role in determining the future of NFTs. The policy of the government and regulator will drive investors' decision-making and behavior in choosing digital assets. We suggest that governments and regulators should thoroughly analyze the potential of NFTs, construct proper regulations and monitor NFT development because NFTs are potentially having great development (Zhang *et al.*, 2022). Notably, NFTs can be a shelter for investors to diversify their portfolios and manage risk. Our research can be further explored that account for unprecedented times.

Notes

1. Finance Firms Seen Investing \$1 Billion in Blockchain This Year, https://www.bloomberg.com/news/articles/2016-06-23/finance-firms-seen-investing-1-billion-in-blockchain-this-year (Accessed 2 June 2022).

2. Worldwide spending on blockchain solutions from 2017 to 2020, with forecasts for 2021 and 2024, https://www.statista.com/statistics/800426/worldwide-blockchain-solutions-spending/ (Accessed 6 June 2022).

3. Opensea statistics data, https://dune.com/rchen8/opensea (Accessed 21 May 2022).

4. NFT daily trading volume statistic, https://nonfungible.com/market-tracker (Accessed 23 May 2022).

5. Top three NFTs projects based on market capitalization, https://www.coingecko.com/en/nft

6. Bored Ape Yacht Club website, https://boredapeyachtclub.com/

7. CryptoPunks website, https://cryptopunks.app/

8. What Are CryptoPunks: A quick overview, https://www.blockchain-council.org/nft/cryptopunks/ (Accessed 30 May 2022).

References

Abdeljawad, I., Nor, F.M., Ibrahim, I. and Abdul, R. (2013), "Dynamic capital structure trade-off theory: evidence from Malaysia", *Proceedings of 3rd Global Accounting, Finance and Economics Conference*, 5-7 May, Vol. 9 No. 6, pp. 1-10.

Aharon, D.Y. and Demir, E. (2022), "NFTs and asset class spillovers: lessons from the period around the COVID-19 pandemic", *Finance Research Letters*, Vol. 47 October, 102515, doi: 10.1016/j.frl.2021.102515.

Ali, F., Bouri, E., Naifar, N., Shahzad, S.J.H. and AlAhmad, M. (2022), "An examination of whether gold-backed Islamic cryptocurrencies are safe havens for international Islamic equity markets", *Research in International Business and Finance*, Vol. 63 July 2021, 101768, doi: 10.1016/j.ribaf.2022.101768.

Ali, O., Momin, M., Shrestha, A., Das, R., Alhajj, F. and Dwivedi, Y.K. (2023a), "A review of the key challenges of non-fungible tokens", *Technological Forecasting and Social Change*, Vol. 187 August 2022, 122248, doi: 10.1016/j.techfore.2022.122248.

Ali, S., Ijaz, M.S., Yousaf, I. and Li, Y. (2023b), "Connectedness and portfolio management between renewable energy tokens and metals: evidence from TVP-VAR approach", *Energy Economics*, Vol. 127 PA, 107103, doi: 10.1016/j.eneco.2023.107103.

Ali, S., Naveed, M., Hanif, H. and Gubareva, M. (2024), "The resilience of Shariah-compliant investments: probing the static and dynamic connectedness between gold-backed cryptocurrencies and GCC equity markets", *International Review of Financial Analysis*, Vol. 91, 103045, doi: 10.1016/j.irfa.2023.103045.

Aloui, C., Hamida, H.B. and Yarovaya, L. (2021), "Are Islamic gold-backed cryptocurrencies different?", *Finance Research Letters*, Vol. 39 May, 101615, doi: 10.1016/j.frl.2020.101615.

Ante, L. (2021), "The non-fungible token (NFT) market and its relationship with Bitcoin and Ethereum", *SSRN Electronic Journal*, No. 20, pp. 1-9, doi: 10.2139/ssrn.3861106.

Antonakakis, N., Chatziantoniou, I. and Gabauer, D. (2019), "Cryptocurrency market contagion: market uncertainty, market complexity, and dynamic portfolios", *Journal of International Financial Markets, Institutions and Money*, Vol. 61, pp. 37-51, doi: 10.1016/j.intfin.2019.02.003.

Arellano, M. and Bond, S. (1991), "Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations", *The Review of Economic Studies*, Vol. 58 No. 2, pp. 277-297, doi: 10.2307/2297968.

Awosusi, A.A., Adebayo, T.S., Altuntaş, M., Agyekum, E.B., Zawbaa, H.M. and Kamel, S. (2022), "The dynamic impact of biomass and natural resources on ecological footprint in BRICS economies : a quantile regression evidence", *Energy Reports*, Vol. 8, pp. 1979-1994, doi: 10.1016/j.egyr.2022.01.022.

Bai, J., Choi, S.H. and Liao, Y. (2020), "Feasible generalized least squares for panel data with cross-sectional and serial correlations", *Empirical Economics*, Vol. 60 No. 1, pp. 309-326, doi: 10.1007/s00181-020-01977-2.

Baur, D.G. and Lucey, B.M. (2010), "Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold", *Financial Review*, Vol. 45 No. 2, pp. 217-229, doi: 10.1111/j.1540-6288.2010.00244.x.

Baur, D.G. and Mcdermott, T.K. (2010), "Is gold a safe haven ? International evidence", *Journal of Banking and Finance*, Vol. 34 No. 8, pp. 1886-1898, doi: 10.1016/j.jbankfin.2009.12.008.

Bloomberg News (2023a), *Blue-chip NFTs Hit Hard as over 1,200 Liquidations Rock Market*, available at: https://cryptoslate.com/blue-chip-nfts-hit-hard-as-over-1200-liquidations-rock-market/ (accessed 4 July 2023).

Bloomberg News (2023b), *Got Your Eye on a CryptoPunk? it Might Be Time to Buy One*, available at: https://blockworks.co/news/time-to-buy-cryptopunk (accessed 4 July 2023).

Bloomberg News (2023c), *Justin Bieber's $1.3M NFT Investment Depreciates by More than 95%*, available at: https://coinjournal.net/news/justin-biebers-1-3m-nft-investment-depreciates-by-more-than-95/ (accessed 4 July 2023).

Bouri, E., Molnár, P., Azzi, G., Roubaud, D. and Hagfors, L.I. (2017), "On the hedge and safe haven properties of Bitcoin: is it really more than a diversifier?", *Finance Research Letters*, Vol. 20, pp. 192-198, doi: 10.1016/j.frl.2016.09.025.

Bouri, E., Shahzad, S.J.H., Roubaud, D., Kristoufek, L. and Lucey, B. (2020a), "Bitcoin, gold, and commodities as safe havens for stocks: new insight through wavelet analysis", *Quarterly Review of Economics and Finance*, Vol. 77, pp. 156-164, doi: 10.1016/j.qref.2020.03.004.

Bouri, E., Hussain Shahzad, S.J. and Roubaud, D. (2020b), "Cryptocurrencies as hedges and safe-havens for US equity sectors", *Quarterly Review of Economics and Finance*, Vol. 75, pp. 294-307, doi: 10.1016/j.qref.2019.05.001.

Chen, K. and Wang, M. (2019), "Is gold a hedge and safe haven for stock market?", *Applied Economics Letters*, Vol. 26 No. 13, pp. 1080-1086, doi: 10.1080/13504851.2018.1537469.

Chkili, W. (2017), "Is gold a hedge or safe haven for Islamic stock market movements? A Markov switching approach", *Journal of Multinational Financial Management*, Vols 42-43, pp. 152-163, doi: 10.1016/j.mulfin.2017.10.001.

Choi, I. (2001), "Unit root tests for panel data", *Journal of International Money and Finance*, Vol. 20 No. 2, pp. 249-272, doi: 10.1016/S0261-5606(00)00048-6.

Cong, L.W., Li, Y. and Wang, N. (2021), "Tokenomics: dynamic adoption and valuation", *Review of Financial Studies*, Vol. 34 No. 3, pp. 1105-1155, doi: 10.1093/rfs/hhaa089.

Cong, L.W., Li, Y. and Wang, N. (2022), "Token-based platform finance", *Journal of Financial Economics*, Vol. 144 No. 3, pp. 972-991, doi: 10.1016/j.jfineco.2021.10.002.

Conlon, T. and McGee, R. (2020), "Safe haven or risky hazard? Bitcoin during the Covid-19 bear market", *Finance Research Letters*, Vol. 35 April, 101607, doi: 10.1016/j.frl.2020.101607.

Conlon, T., Corbet, S. and McGee, R.J. (2020), "Are cryptocurrencies a safe haven for equity markets? An international perspective from the COVID-19 pandemic", *Research in International Business and Finance*, Vol. 54 May, 101248, doi: 10.1016/j.ribaf.2020.101248.

Corbet, S., Meegan, A., Larkin, C., Lucey, B. and Yarovaya, L. (2018), "Exploring the dynamic relationships between cryptocurrencies and other financial assets", *Economics Letters*, Vol. 165, pp. 28-34, doi: 10.1016/j.econlet.2018.01.004.

Corbet, S., Goodell, J.W., Gunay, S. and Kaskaloglu, K. (2023), "Are DeFi tokens a separate asset class from conventional cryptocurrencies?", *Annals of Operations Research*, Vol. 322 No. 2, pp. 609-630, doi: 10.1007/s10479-022-05150-z.

De Filippi, P., Mannan, M. and Reijers, W. (2020), "Blockchain as a confidence machine: the problem of trust and challenges of governance", *Technology in Society*, Vol. 62 April, 101284, doi: 10.1016/j.techsoc.2020.101284.

Dias, I.K., Fernando, J.M.R. and Fernando, P.N.D. (2022), "Does investor sentiment predict bitcoin return and volatility? A quantile regression approach", *International Review of Financial Analysis*, Vol. 84, 102383, doi: 10.1016/j.irfa.2022.102383.

Disli, M., Nagayev, R., Salim, K., Rizkiah, S.K. and Aysan, A.F. (2021), "In search of safe haven assets during COVID-19 pandemic: an empirical analysis of different investor types", *Research in International Business and Finance*, Vol. 58, 101461, doi: 10.1016/j.ribaf.2021.101461.

Dowling, M. (2022), "Is non-fungible token pricing driven by cryptocurrencies?", *Finance Research Letters*, Vol. 44 March 2021, 102097, doi: 10.1016/j.frl.2021.102097.

Garcia-Jorcano, L. and Benito, S. (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*, Vol. 54 August, 101300, doi: 10.1016/j.ribaf.2020.101300.

Gozgor, K. and Karakas, M. (2023), "How do global financial markets affect the green bond markets? Evidence from different estimation techniques", *Economic Research-Ekonomska Istrazivanja*, Vol. 36 No. 2, 2177703, doi: 10.1080/1331677X.2023.2177703.

Gray, D.K., Hampton, S.E., O'Reilly, C.M., Sharma, S. and Cohen, R.S. (2018), "How do data collection and processing methods impact the accuracy of long-term trend estimation in lake surface-water temperatures?", *Limnology and Oceanography: Methods*, Vol. 16 No. 8, pp. 504-515, doi: 10.1002/lom3.10262.

Gutenbrunner, C. and Jureckova, J. (1992), "Regression rank scores and regression quantiles", *The Annals of Statistics*, Vol. 20 No. 1, pp. 305-330, doi: 10.1214/aos/1176348524, available at: http://www.jstor.org/stable/2242162

Hassan, M.K., Muneeza, A., Abubakar, M. and Haruna, M.A. (2021), "Application of precious metal-backed cryptocurrency in Islamic finance", *Journal of Islamic Finance Accountancy*, Vol. 5 No. 1, pp. 17-26.

Hayes, A. (2022), *Risk-Seeking, Investopedia*.

Huang, W. and Chang, M.S. (2021), "Gold and government bonds as safe-haven assets against stock market turbulence in China", *SAGE Open*, Vol. 11 No. 1, doi: 10.1177/2158244021990655.

Huang, Y., Duan, K. and Mishra, T. (2021), "Is Bitcoin really more than a diversifier? A pre- and post-COVID-19 analysis", *Finance Research Letters*, Vol. 43 March, 102016, doi: 10.1016/j.frl.2021.102016.

Jalan, A., Matkovskyy, R. and Yarovaya, L. (2021), "'Shiny' crypto assets: a systemic look at gold-backed cryptocurrencies during the COVID-19 pandemic", *International Review of Financial Analysis*, Vol. 78, 101958, doi: 10.1016/j.irfa.2021.101958.

Ji, Q., Zhang, D. and Zhao, Y. (2020), "Searching for safe-haven assets during the COVID-19 pandemic", *International Review of Financial Analysis*, Vol. 71, 101526, doi: 10.1016/j.irfa.2020.101526.

Kang, S.H., Yoon, S.M., Bekiros, S. and Uddin, G.S. (2020), "Bitcoin as hedge or safe haven: evidence from stock, currency, bond and derivatives markets", *Computational Economics*, Vol. 56 No. 2, pp. 529-545, doi: 10.1007/s10614-019-09935-6.

Kanellopoulos, I.F., Gutt, D. and Li, T. (2021), "NFT disruption in platform competition: evidence from trading card collectibles", doi: 10.2139/ssrn.3918256, available at: https://ssrn.com/abstract=3918256

Kliber, A., Marszałek, P., Musiałkowska, I. and Świerczyńska, K. (2019), "Bitcoin: safe haven, hedge or diversifier? Perception of bitcoin in the context of a country's economic situation — a stochastic volatility approach", *Physica A: Statistical Mechanics and its Applications*, Vol. 524, pp. 246-257, doi: 10.1016/j.physa.2019.04.145.

Ko, H. and Lee, J. (2023), "Non-fungible tokens: a hedge or a safe haven?", *Applied Economics Letters*, Vol. 31 No. 14, pp. 1278-1285, doi: 10.1080/13504851.2023.2182402.

Koenker, R. and Bassett, G. Jr (1978), "Regression quantiles", *Econometrica: Journal of the Econometric Society*, Vol. 46 No. 1, pp. 33-50, doi: 10.2307/1913643.

Kong, D.-R. and Lin, T.-C. (2021), "Alternative investments in the Fintech era: the risk and return of Non-Fungible Token (NFT)", doi: 10.2139/ssrn.3914085, availabe at: https://ssrn.com/abstract=3914085 (accessed 30 August 2021).

Kumar, A.S. and Padakandla, S.R. (2022), "Testing the safe-haven properties of gold and bitcoin in the backdrop of COVID-19: a wavelet quantile correlation approach", *Finance Research Letters*, Vol. 47, 102707, doi: 10.1016/j.frl.2022.102707.

Kumar, A.S. and Padakandla, S.R. (2023), "Do NFTs act as a good hedge and safe haven against Cryptocurrency fluctuations?", *Finance Research Letters*, Vol. 56, 104131, doi: 10.1016/j.frl.2023.104131.

Lahmiri, S. and Bekiros, S. (2019), "Decomposing the persistence structure of Islamic and green crypto-currencies with nonlinear stepwise filtering", *Chaos, Solitons and Fractals*, Vol. 127, pp. 334-341, doi: 10.1016/j.chaos.2019.07.012.

Lavelle, B., Yamamoto, K.N. and Kinnen, M. (2022), "Cryptocurrencies, correlations, and COVID-19: diversifiers, hedge, or safe haven?", *Review of Integrative Business and Economics Research*, Vol. 11 No. 2, pp. 25-35.

Levin, A., Lin, C.F. and Chu, C.S.J. (2002), "Unit root tests in panel data: asymptotic and finite-sample properties", *Journal of Econometrics*, Vol. 108 No. 1, pp. 1-24, doi: 10.1016/S0304-4076(01)00098-7.

Li, S. and Lucey, B.M. (2017), "Reassessing the role of precious metals as safe havens – what colour is your haven and why ? ☆", *Journal of Commodity Markets*, Vol. 7 May, pp. 1-14, doi: 10.1016/j.jcomm.2017.05.003.

Liu, W.H. (2020), "Are gold and government bond safe-haven assets? An extremal quantile regression analysis", *International Review of Finance*, Vol. 20 No. 2, pp. 451-483, doi: 10.1111/irfi.12232.

Lucey, B.M. and Li, S. (2015), "What precious metals act as safe havens, and when? Some US evidence", *Applied Economics Letters*, Vol. 22 No. 1, pp. 35-45, doi: 10.1080/13504851.2014.920471.

Machado, J.A.F. and Santos Silva, J.M.C. (2019), "Quantiles via moments", *Journal of Econometrics*, Vol. 213 No. 1, pp. 145-173, doi: 10.1016/j.jeconom.2019.04.009.

Mariana, C.D., Ekaputra, I.A. and Husodo, Z.A. (2021), "Are Bitcoin and Ethereum safe-havens for stocks during the COVID-19 pandemic?", *Finance Research Letters*, Vol. 38 September 2020, 101798, doi: 10.1016/j.frl.2020.101798.

Markowitz, H.M. (1952), "Portfolio selection", *The Journal ofFinance*, Vol. 7 No. 1, pp. 77-91, doi: 10.1111/j.1540-6261.1952.tb01525.x.

Markowitz, H.M. (1971), *Portfolio Selection. Efficient Diversification of Investments*, Yale University Press.

Mnif, E. and Jarboui, A. (2021), "Islamic, green, and conventional cryptocurrency market efficiency during the Covid-19 pandemic", *Journal of Islamic Monetary Economics and Finance*, Vol. 7 No. 1, pp. 167-184, doi: 10.21098/jimf.v7i0.1315.

Mnif, E. and Jarboui, A. (2022), "Resilience of islamic cryptocurrency markets to Covid-19 shocks and the federal reserve policy", *Asian Journal of Accounting Research*, Vol. 7 No. 1, pp. 59-70, doi: 10.1108/AJAR-01-2021-0004.

Nakamoto, S. (2008), "Bitcoin: a peer-to-peer electronic cash system", *Manubot*. doi: 10.1007/s10838-008-9062-0.

Nugroho, B.A. (2023), "The stability of islamic cryptocurrencies and copula-based dependence with alternative crypto and fiat currencies", *ISRA International Journal of Islamic Finance*, Vol. 15 No. 2, pp. 80-97, doi: 10.55188/ijif.v15i2.543.

Pesaran, M.H. (2021), "General diagnostic tests for cross-sectional dependence in panels", *Empirical Economics*, Vol. 60 No. 1229, pp. 13-50, doi: 10.1007/s00181-020-01875-7.

Raifu, I.A., Kumeka, T.T. and Aminu, A. (2023), "Financial development and unemployment in MENA: evidence from heterogeneous panel causality and quantile via moment regression", *Journal of the Knowledge Economy*. doi: 10.1007/s13132-023-01260-6.

Rehman, W., Zainab, H.e., Imran, J. and Bawany, N.Z. (2021), "NFTS: applications and challenges", *2021 22nd International Arab Conference on Information Technology, ACIT 2021*, January 2022, doi: 10.1109/ACIT53391.2021.9677260.

Shahzad, S.J.H., Bouri, E., Roubaud, D., Kristoufek, L. and Lucey, B. (2019), "Is Bitcoin a better safe-haven investment than gold and commodities?", *International Review of Financial Analysis*, Vol. 63 September 2018, pp. 322-330, doi: 10.1016/j.irfa.2019.01.002.

Shahzad, S.J.H., Bouri, E., Roubaud, D. and Kristoufek, L. (2020), "Safe haven, hedge and diversification for G7 stock markets: gold versus bitcoin", *Economic Modelling*, Vol. 87, pp. 212-224, doi: 10.1016/j.econmod.2019.07.023.

Singh, B.P. and Kannadhasan, M. (2020), "Corruption and capital structure in emerging markets: a panel quantile regression approach", *Journal of Behavioral and Experimental Finance*, Vol. 28, 100417, doi: 10.1016/j.jbef.2020.100417.

Statista (2022), "Percentage of adults who own an NFT in selected countries worldwide as of September 2021", available at: https://www.statista.com/statistics/1278047/global-nft-adoption-by-country/(accessed 30 April 2022).

Stensås, A., Nygaard, M.F., Kyaw, K. and Treepongkaruna, S. (2019), "Can Bitcoin be a diversifier, hedge or safe haven tool?", *Cogent Economics and Finance*, Vol. 7 No. 1, p. 1593072, doi: 10.1080/23322039.2019.1593072.

Tirosh, I. and Barkai, N. (2007), "Comparative analysis indicates regulatory neofunctionalization of yeast duplicates", *Genome Biology*, Vol. 8 No. 4, pp. 1-22, doi: 10.1186/gb-2007-8-4-r50.

Trichilli, Y. and Boujelbéne, M. (2023), "Regime specific spillover between Dow Jones Islamic Market World Index, Islamic gold-backed crypto currencies and the blockchain halal index", *International Journal of Islamic and Middle Eastern Finance and Management*, Vol. 16 No. 3, pp. 464-481, doi: 10.1108/IMEFM-09-2021-0395.

Umar, Z., Gubareva, M., Teplova, T. and Tran, D.K. (2022a), "Covid-19 impact on NFTs and major asset classes interrelations: insights from the wavelet coherence analysis", *Finance Research Letters*, Vol. 47 February, 102725, doi: 10.1016/j.frl.2022.102725.

Umar, Z., Polat, O., Choi, S.Y. and Teplova, T. (2022b), "Dynamic connectedness between non-fungible tokens, decentralized finance, and conventional financial assets in a time-frequency framework", *Pacific Basin Finance Journal*, Vol. 76 May, 101876, doi: 10.1016/j.pacfin.2022.101876.

Urom, C., Ndubuisi, G. and Guesmi, K. (2022), "Quantile return and volatility connectedness among Non-Fungible Tokens (NFTs) and (un)conventional asset", UNU-MERIT. UNU-MERIT Working Papers No. 017, available at: https://www.merit.unu.edu/publications/wppdf/2022/wp2022-017.pdf

Vidal-Tomás, D. (2022), "The new crypto niche: NFTs, play-to-earn, and metaverse tokens", *Finance Research Letters*, Vol. 47 February, 102742, doi: 10.1016/j.frl.2022.102742.

Wang, G., Tang, Y., Xie, C. and Chen, S. (2019), "Is bitcoin a safe haven or a hedging asset? Evidence from China", *Journal of Management Science and Engineering*, Vol. 4 No. 3, pp. 173-188, doi: 10.1016/j.jmse.2019.09.001.

Wen, X. and Cheng, H. (2018), "Which is the safe haven for emerging stock markets, gold or the US dollar?", *Emerging Markets Review*, Vol. 35, pp. 69-90, doi: 10.1016/j.ememar.2017.12.006.

Widjaja, M., Gaby and Havidz, S.A.H. (2023), "Are gold and cryptocurrency a safe haven for stocks and bonds? Conventional vs Islamic markets during the COVID-19 pandemic", *European Journal of Management and Business Economics*, Vol. 33 No. 1, pp. 96-115, doi: 10.1108/EJMBE-05-2022-0135.

Wilson, K.B., Karg, A. and Ghaderi, H. (2022), "Prospecting non-fungible tokens in the digital economy: stakeholders and ecosystem, risk and opportunity", *Business Horizons*, Vol. 65 No. 5, pp. 657-670, doi: 10.1016/j.bushor.2021.10.007.

Wong, G. (2009), "Does the more risk-averse investor hold a less risky portfolio?", *International Review of Finance*, Vol. 9 No. 3, pp. 319-333, doi: 10.1111/j.1468-2443.2009.01093.x.

Wooldridge, J.M. (2018), *Introductory Econometrics - A Modern Approach*, 7th ed., Cengange, Boston.

Yıldırım, D. and Çelik, A.K. (2021), "Testing the pecking order theory of capital structure: evidence from Turkey using panel quantile regression approach", *Borsa Istanbul Review*, Vol. 21 No. 4, pp. 317-331, doi: 10.1016/j.bir.2020.11.002.

Yousaf, I. and Yarovaya, L. (2022), "Static and dynamic connectedness between NFTs, Defi and other assets: portfolio implication", *Global Finance Journal*, Vol. 53 February, 100719, doi: 10.1016/j.gfj.2022.100719.

Yousaf, I., Nekhili, R. and Umar, M. (2022), "Extreme connectedness between renewable energy tokens and fossil fuel markets", *Energy Economics*, Vol. 114 September, 106305, doi: 10.1016/j.eneco.2022.106305.

Yousaf, I., Riaz, Y. and Goodell, J.W. (2023), "Integration between asset management tokens, asset management stock, and other financial markets: evidence from TVP-VAR modeling", *Finance Research Letters*, Vol. 57 May, 104276, doi: 10.1016/j.frl.2023.104276.

Zaman, A., Tlemsani, I., Matthews, R. and Mohamed Hashim, M.A. (2023), "Assessing the potential of blockchain technology for Islamic crypto assets", *Competitiveness Review*, Vol. ahead-of-print No. ahead-of-print, doi: 10.1108/CR-05-2023-0100.

Zhang, Z., Sun, Q. and Ma, Y. (2022), "The hedge and safe haven properties of non-fungible tokens (NFTs): evidence from the nonlinear autoregressive distributed lag (NARDL) model", *Finance Research Letters*, Vol. 50, 103315, doi: 10.1016/j.frl.2022.103315.

Appendix

Countries	SR	FR
The Philippines	PSEi Composite	PHP/USD
Thailand	SET Index	THB/USD
Malaysia	FTSE Malaysia KLCI	MYR/USD
Vietnam	VN Index	VND/USD
Brazil	Bovespa Index	BRL/USD
Hongkong	Hang Seng Index	HKD/USD
Peru	S&P Lima General Index	PEN/USD
Colombia	Colcap Index	COP/USD
South Africa	FTSE/JSE Top 40	ZAR/USD
Canada	S&P/TSX Composite Index	CAD/USD
Germany	DAX Index	EUR/USD
US	NASDAQ Composite Index	
UK	FTSE 100 Index	GBP/USD
Japan	Nikkei 225 Index	JPY/USD

Table A1.
Indicators of SR, FR and GBR

Note(s): 10-year government bonds are applied to all countries
Source(s): Created by authors

Corresponding author
Shinta Amalina Hazrati Havidz can be contacted at: shinta.h@binus.edu