Cryptocurrencies as safe havens for African stock markets during the Russia-Ukraine war: A wavelet quantile correlation approach

Kwame Poku Frimpong[1]
Siaw Frimpong[2]

[1]kpfrimpong@stu.ucc.edu.gh
[2]sfrimpong@ucc.edu.gh

[1]https://orcid.org/0009-0009-8385-5453
[2]https://orcid.org/0000-0003-4161-321X

[1,2] University of Cape Coast, Ghana

Recommended Reference: Frimpong, K. P., & Frimpong, S. (2026). Cryptocurrencies as safe havens for African stock markets during the Russia-Ukraine war: A wavelet quantile correlation approach. *African Quarterly Social Science Review, 3*(4), 1087–1110. https://doi.org/10.51867/AQSSR.3.4.87

ABSTRACT

This study examines whether Binance Coin (BNB), Bitcoin (BTC), Ethereum (ETH), and Tether (USDT) functioned as diversifiers, hedges, or safe havens for Egyptian, South African, Moroccan, and Nigerian equities during the Russia-Ukraine war. Using 814 daily observations from 24 February 2022 to 17 August 2026, the study applies Wavelet Quantile Correlation (WQC) to capture dependence across short- (4 to 8 days), medium- (16 to 32 days), and long-term (128 to 256 days) horizons and market states. Ethereum acted as a safe haven in Egypt and Nigeria at short and medium horizons and in South Africa at medium and long horizons. Bitcoin was a hedge in Egypt and a medium-term safe haven in South Africa and Nigeria. BNB was a weak safe haven in Egypt, a medium-term one in South Africa, and only a diversifier in Morocco and Nigeria. Tether showed weak short-term safe-haven behaviour in all four markets, while BNB, BTC, and ETH offered no protection in Morocco. The study concludes that cryptocurrency protection for African equities is conditional on the asset, market, and horizon rather than general, and that Tether was the most consistent asset, although its coefficients were close to zero. Investors and portfolio managers should therefore choose crypto assets by equity market and holding horizon and should not assume that developed-market evidence transfers to African equities. Regulators should examine the liquidity, foreign participation, and regulatory features that may explain the absence of protection in Morocco. Transaction costs, capital controls, and regulatory limits were not modelled and may constrain implementation.

Keywords: African Stock Markets; Cryptocurrencies; Russia-Ukraine War, Safe-Haven Assets; Wavelet Quantile Correlation

I. INTRODUCTION

Periods of acute geopolitical and financial stress consistently renew investor demand for assets capable of preserving value when conventional portfolios come under pressure. The distinction between assets that merely diversify risk and those that genuinely shelter capital during turmoil has occupied safe-haven research since Baur and Lucey (2010) and Baur and McDermott (2010) formalised the concept for gold. Since then, the distinction has been extended to a widening set of candidate assets as financial markets have grown more interconnected and more exposed to non-economic shocks.

The Russia-Ukraine war, which began on 24 February 2022, offers a particularly instructive setting for this line of enquiry. The conflict triggered a sharp rise in geopolitical risk (Caldara & Iacoviello, 2022), disrupted energy and commodity supply chains, and prompted sweeping financial sanctions that reshaped cross-border capital flows. These conditions created the kind of extreme, discontinuous market stress against which safe-haven behaviour must properly be assessed, since average correlations calculated over tranquil periods can conceal, or even contradict, an asset's behaviour during genuine crisis episodes.

Cryptocurrencies have been proposed as candidate safe havens on the grounds of their decentralisation and limited direct exposure to sovereign monetary policy, yet the evidence is markedly uneven across asset types. Bitcoin and Ethereum have shown weak or non-existent safe-haven properties for developed equity markets during the war (Bampinas & Panagiotidis, 2024), while fiat-backed stablecoins such as Tether have displayed more consistent

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

protective behaviour in several settings (Fakhfekh et al., 2023; Jana & Sahu, 2023). This heterogeneity is precisely why the conventional cryptocurrencies Bitcoin, Ethereum and Binance Coin warrant separate treatment from the stablecoin Tether rather than being pooled as a single asset class.

Evidence on this question is, however, concentrated in developed and G7 markets. African equity markets, whose capital-market structure, liquidity and exposure to global shocks differ from those of developed economies, remain comparatively underexamined, and the African studies that exist have concentrated on Bitcoin and the COVID-19 period and have measured integration or spillovers rather than conditional protection during the Russia-Ukraine war. The study is warranted because investors and portfolio managers holding African equities need to know whether any cryptocurrency offers protection when equity markets fall, and over what horizon, before relying on it, and because the answer is unlikely to be the same across assets and markets. Evidence of this kind also informs regulators who assess how these assets interact with domestic equity markets in periods of stress. In light of this discussion, the overall aim of the study is to determine whether BNB, BTC, ETH and USDT served as diversifiers, hedges or safe havens for the Egyptian, South African, Moroccan and Nigerian stock markets during the Russia-Ukraine war, using a framework that separates normal from stressed market conditions and short-, medium- and long-term horizons.

1.1 Statement of the Problem

Despite this growing body of evidence, African equity markets remain comparatively underexamined within the safe-haven literature, notwithstanding their distinct capital-market structure, lower liquidity, and heterogeneous exposure to global shocks. Egypt, South Africa, Morocco and Nigeria differ meaningfully in market depth, foreign investor participation, and channels of transmission for geopolitical risk, factors that plausibly condition how cryptocurrencies behave against their equities during crisis periods. Existing African-focused studies have, however, concentrated overwhelmingly on Bitcoin and on the COVID-19 period, leaving the Russia-Ukraine episode, multiple cryptocurrency types, and the specific inclusion of BNB and USDT largely unaddressed (Kumah & Odei-Mensah, 2021).

This concentration produces a threefold gap. Asset coverage remains narrow, with Bitcoin and Ethereum dominating the literature while a major exchange token such as BNB and a leading stablecoin such as USDT are seldom examined jointly, despite prior evidence that stablecoins and volatile cryptocurrencies behave in economically distinct ways (Jana & Sahu, 2023). Geographic coverage remains equally narrow, with the bulk of war-period evidence drawn from G7 and developed markets (Fakhfekh et al., 2023; Hampl et al., 2024), leaving open whether these patterns generalise to African equities. Methodologically, much of the existing African evidence relies on integration or average co-movement measures rather than on frameworks capable of isolating conditional, crisis-specific dependence, which is the standard against which genuine safe-haven behaviour must be judged. It is therefore not known whether BNB, BTC, ETH and USDT functioned as diversifiers, hedges, or safe havens for Egyptian, South African, Moroccan and Nigerian equities specifically during the Russia-Ukraine war, nor whether their behaviour diverged from the patterns documented for developed markets.

1.2 Research Objectives

The overall aim of the study is to determine whether BNB, BTC, ETH, and USDT functioned as diversifiers, hedges, or safe havens for the Egyptian, South African, Moroccan, and Nigerian stock markets during the Russia-Ukraine war. Specifically, the study seeks to:

1. To examine whether BNB, BTC, ETH and USDT functioned as diversifiers, hedges or safe havens for the Egyptian, South African, Moroccan and Nigerian stock markets during the Russia-Ukraine war.
2. To assess the dependence between each cryptocurrency and each equity market under normal and stressed market conditions and across short-, medium- and long-term horizons.
3. To compare the behaviour of the conventional cryptocurrencies (BNB, BTC and ETH) with that of the stablecoin USDT in order to identify asset-type differences.
4. To determine whether the patterns reported in the literature for developed markets are also observed in the African equity markets studied.

II. LITERATURE REVIEW

2.1 Theoretical Review

The theoretical foundation of this study draws on five perspectives. First, the safe-haven framework distinguishes diversifiers, hedges and safe havens according to their correlation with equities under normal and extreme market conditions (Baur & McDermott, 2010; Baur & Lucey, 2010). This framework guides the classification of BNB, BTC, ETH and USDT using Wavelet Quantile Correlation (WQC) coefficients across market states. Second, Modern

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

Portfolio Theory explains how imperfectly correlated assets reduce portfolio risk, although average correlations alone cannot establish protection during market downturns (Markowitz, 1952). Third, liquidity-based theory suggests that funding constraints and liquidity spirals can intensify cross-market dependence during crises, potentially weakening cryptocurrency protection and differentiating USDT's behaviour, although these mechanisms are not tested directly (Brunnermeier & Pedersen, 2009). Fourth, market integration theory explains why asset dependence may differ across national markets because their exposure to global financial shocks varies (Bekaert & Harvey, 1995). Finally, the Fractal Market Hypothesis proposes that market participants operate over different investment horizons, supporting the use of wavelet analysis to examine short-, medium- and long-term dependence (Peters, 1994; Kristoufek, 2013; Kumar & Padakandla, 2022). Collectively, these perspectives suggest that safe-haven properties depend on the asset, equity market, market state and investment horizon.

2.2 Empirical Review

2.2.1 Roles of Cryptocurrencies as Diversifiers, Hedges and Safe Havens

Evidence on whether cryptocurrencies act as diversifiers, hedges or safe havens is mixed but patterned. Using a dynamic conditional correlation model on daily and weekly data from July 2011 to December 2015, Bouri et al. (2017b) find Bitcoin to be a poor hedge suited to diversification, with strong safe-haven behaviour only against weekly extreme downward movements in Asian stocks and properties that vary across horizons. Bouri et al. (2017a) address a different question and reach a more favourable conclusion: after wavelet decomposition, quantile regressions indicate that Bitcoin hedges global uncertainty, measured from the VIX indices of 14 equity markets, mainly at shorter investment horizons. Klein et al. (2018) compare volatility, correlation and portfolio performance and find that Bitcoin behaves unlike gold in downturns, and Smales (2019) argues that its volatility and illiquidity undermine any safe-haven claim. Conlon and McGee (2020) go further, showing that Bitcoin amplified, rather than cushioned, S&P 500 losses in the COVID-19 bear market. For a wider set of coins, Jana and Sahu (2023), who combine wavelets with GARCH models, find that unstable cryptocurrencies, including Bitcoin, Ethereum and Binance Coin, hedged in calm periods but lost this property in turmoil, while Gadi and Sicilia (2022), who examine heterogeneous cryptocurrencies against G7 and BRICS indices, report that BNB and similar altcoins behave predominantly as diversifiers.

These studies agree that protection is weak and conditional. They disagree mainly because they test different benchmarks (equity indices, uncertainty measures and gold) and use different methods, from average conditional correlation to horizon-specific quantile models. Their limitations for present purposes are that most rely on Bitcoin alone, that the Bitcoin-focused studies above pre-date the Russia-Ukraine war, and that none examines African equity indices, so none can classify BNB, BTC, ETH and USDT for the four markets studied here.

2.2.2 Dependence Under Normal and Stressed Conditions and Across Horizons

Studies that condition on market state and horizon are closer to the design of this study. Baur and Lucey (2010) allowed the asset-equity relationship to differ in the extreme lower tail and found gold's safe-haven property to be short-lived. Bouri et al. (2017a) combined wavelets with quantile regression, and Kumar and Padakandla (2022) proposed the Wavelet Quantile Correlation to test the safe-haven properties of gold and Bitcoin in the COVID-19 period, documenting horizon-contingent safe-haven behaviour for Bitcoin in developed markets. Kumar et al. (2026) later retained the medium and long scales but used a 2 to 4 day band for the shortest horizon, arguing that investors differ in liquidity preferences, rebalancing needs and risk appetites. Other quantile-based tools have also been applied. Hampl et al. (2024) use the cross-quantilogram on hourly data from 2 January to 17 July 2022, Bampinas and Panagiotidis (2024) use a local Gaussian partial correlation to compare dependence across segments of the distribution during the pandemic and the war, and Kołodziejczyk (2023) uses a quantile coherency approach for stablecoins. Jana and Sahu (2023) separate calm and turbulent conditions within a wavelet framework.

These studies agree that dependence differs between normal and stressed states and across horizons, so that unconditional or single-scale measures can misclassify an asset. They differ in how stress is defined (extreme quantiles, crisis windows or turbulent regimes) and in how horizon is treated, since the cross-quantilogram and local Gaussian approaches do not decompose dependence by investment horizon. None of the studies reviewed applies a joint state-and-horizon framework to cryptocurrencies and African equities during the war.

2.2.3 Stablecoins and Conventional Cryptocurrencies

Evidence on the difference between stablecoins and volatile cryptocurrencies is more consistent. Baur and Hoang (2021) show that stablecoins act as a safe haven against Bitcoin, which is a different claim from protection against equities. Kołodziejczyk (2023) finds that stablecoins act as weak hedges in calm periods and weak safe havens during turmoil regardless of investment horizon, and Jana and Sahu (2023) report that stablecoins such as Tether retained hedging and safe-haven characteristics that Bitcoin, Ethereum and Binance Coin lost in turmoil. Feng et al. (2024), studying global stock markets during the COVID-19 pandemic, argue that stablecoins can outperform conventional

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

cryptocurrencies as defensive instruments, pointing to their low volatility and dollar peg. For the war period, Hampl et al. (2024) find Tether to be a weak safe haven for the stock market, whereas the other crypto assets they study, including Bitcoin, Ethereum and Solana, could not be used effectively to diversify stock portfolios, and Gadi and Sicilia (2022) classify BNB and similar altcoins mainly as diversifiers.

The studies converge on the direction of the difference, but the strength of protection is qualified in each case: weak safe-haven status, protection against Bitcoin rather than against equities, or evidence from the pandemic rather than the war. The peg also carries issuer and reserve risk. Most of the evidence concerns developed equity markets or other cryptocurrencies, and BNB is seldom examined alongside USDT, so whether the stablecoin advantage holds for African equities remains untested.

2.2.4 Developed-Market and African Evidence

War-period evidence on safe-haven roles comes mainly from developed and large markets. Fakhfekh et al. (2023) examine gold, Bitcoin and Tether for G7 investors and conclude that gold retained strong safe-haven status while cryptocurrencies functioned mainly as diversifiers. Bampinas and Panagiotidis (2024) study six international stock markets (Australia, China, Germany, Japan, the United Kingdom and the United States) and find that the limited diversification and safe-haven properties of Bitcoin and Ethereum diminished further during the war. Gadi and Sicilia (2022) cover both G7 and BRICS indices.

African evidence answers a different question. Kumah and Odei-Mensah (2021) document frequency-dependent integration between cryptocurrencies and African stock markets, and Kumah et al. (2022) extend this with multiresolution analysis, but both measure interdependence rather than tail protection. Anyikwa and Phiri (2023) are broader, finding pronounced spillovers among African equities, commodities, foreign exchange and cryptocurrencies across COVID-19 and the war, yet this breadth sacrifices asset-specific inference. Naeem et al. (2022) address protection directly, identifying gold as the strongest safe haven for African equities, but they do not test cryptocurrencies.

The two strands are therefore not directly comparable. Developed-market work classifies safe-haven roles but in markets whose depth and global integration differ from those of African markets, while African work covers the relevant markets but measures integration or spillovers, which cannot establish safe-haven status because strong spillovers may signal that an asset transmits shocks rather than absorbs them. Pooling African markets also masks heterogeneity in market depth, currency regimes and capital controls, which plausibly shape crypto-equity links in South Africa, Egypt, Morocco and Nigeria. The existing evidence therefore cannot show whether the patterns documented for developed markets apply to these four markets.

2.3 Synthesis and Research Gap

Three concentrations define the existing literature. First, attention has centred on Bitcoin and Ethereum rather than on stablecoins and exchange tokens such as BNB, which are rarely examined together. Second, war-period safe-haven classifications are concentrated in developed and G7 markets. Third, the African evidence relies on integration and spillover measures rather than on quantile or extreme-dependence frameworks capable of isolating crisis-period behaviour. What is established is that safe-haven properties are highly asset- and market-specific, that dependence differs by market state and horizon, and that stablecoins behave differently from volatile cryptocurrencies. What remains unresolved is whether this pattern holds for BNB alongside BTC, ETH and USDT specifically within Egyptian, South African, Moroccan and Nigerian equities during the Russia-Ukraine war, which is the question this study is designed to answer.

III. METHODOLOGY

3.1 Research Design

This study adopts a quantitative approach grounded in positivism, using a non-experimental, correlational time-series design to examine the safe-haven, hedging and diversification properties of BNB, BTC, ETH and USDT across the South African, Moroccan, Egyptian and Nigerian equity markets. The analysis employs Wavelet Quantile Correlation (WQC) to assess dependence across short-, medium- and long-term horizons and bearish, normal and bullish market conditions. The results are classified using sign-based criteria, while the Daubechies D4 filter provides a robustness check against the baseline LA(8) filter. The design aligns with the research objectives by identifying asset-specific, market-state and horizon-dependent relationships. However, it establishes statistical associations rather than causal relationships and is limited to the observed war period.

3.2 Data Sources

Daily price data for eight financial instruments were sourced from Investing.com, used in the financial literature (Frimpong & Siaw, 2026). The Russia-Ukraine war period begins on 24 February 2022, following Russia's

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

announcement of the "special military operation" (Zhang et al., 2025). Because the conflict is ongoing, the war period is defined as running from 24 February 2022 to the end of the available data (17 August 2026), consistent with the open-ended war windows used by Ahad et al. (2024). Safe-haven candidates comprise Bitcoin (BTC), Ethereum (ETH), Binance Coin (BNB) and Tether (USDT). The equity markets are the FTSE All Share Index (South Africa), Morocco All Share Index (MASI), EGX 300 (Egypt), and the Nigeria Exchange Group (NGX) All-Share Index. All series are transformed to continuously compounded logarithmic daily returns:

$$r_t = lnP_t - lnP_{t-1} \quad \text{..... (1)}$$

Non-synchronous trading is addressed by retaining only common trading days across all eight instruments.

3.3 Wavelet Quantile Correlation (WQC)

Kumar and Padakandla (2022) proposed the Wavelet Quantile Correlation (WQC), which combines two analytical dimensions: wavelet decomposition, which separates dependence into short-, medium- and long-term horizons, and quantile correlation, which captures dependence across the whole conditional distribution rather than only at the mean, including the lower and upper quantiles that correspond to bearish and bullish states.

This approach combines two concepts: Quantile Correlation (QC) and the Maximal Overlap Discrete Wavelet Transform (MODWT).

Quantile Correlation

Let $Q_{\tau,X}$ be the τth quantile of a random variable $X$and $Q_{\tau,Y}(X)$ be the τth quantile of Yconditional on X. For $0 < \tau < 1$, the quantile covariance is defined as:

$$qcov_\tau(Y, X) = cov\left(I, \left(Y > Q_{\tau,Y}\right)X\right) \quad \text{..... (2)}$$

The quantile correlation is then:

$$qcor_\tau(X,Y) = \frac{qcov_\tau(Y,X)}{\sqrt{var\left(\phi_\tau(Y-Q_{\tau,Y})\right)var(X)}} \quad \text{..... (3)}$$

Maximal Overlap Discrete Wavelet Transform (MODWT)

We use MODWT to break down each time series $X_t$and Y_t. Let $h_1[i]$and $g_1[i]$be the minimal-pass and high-pass wavelet filters. At the first level, the approximation coefficients $a_1[i]$and detail coefficients $d_1[i]$are obtained by convolution:

$$a_1[i] = h_1[i] * s[i] = \sum_k h_1[i-k]s[k] \quad \text{..... (4)}$$

$$d_1[i] = g_1[i] * s[i] = \sum_k g_1[i-k]s[k] \quad \text{..... (5)}$$

For higher levels $j = 1,2, \dots, J_0 - 1$, the coefficients are computed recursively using up-sampled filters:

$$a_{j+1}[i] = h_{j+1}[i] * a_j[i] = \sum_k h_{j+1}[i-k]a_j[k] \quad \text{..... (6)}$$
$$d_{j+1}[i] = g_{j+1}[i] * a_j[i] = \sum_k g_{j+1}[i-k]a_j[k] \quad \text{..... (7)}$$

where $h_{j+1}[i] = U(h_j[i])$and $g_{j+1}[i] = U(g_j[i])$, and U is the up-sampling operator, which places zeros in between neighbouring components.

Wavelet Quantile Correlation (WQC)

After obtaining the detail coefficients $d_j[X]$and $d_j[Y]$for each decomposition level j, we compute the Quantile Correlation between them. The WQC at level j and quantile τ is:

$$WQC_\tau\left(d_j[X], d_j[Y]\right) = \frac{qcov_\tau\left(d_j[Y], d_j[X]\right)}{\sqrt{var\left(\phi_\tau\left(d_j[Y]-Q_{\tau,d_j[Y]}\right)\right)var(d_j[X])}} \quad \text{..... (8)}$$

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

The maximal overlap discrete wavelet transform (MODWT) is used to decompose each series into scale-specific detail coefficients, because it is non-decimated and shift-invariant, accommodates any sample length, and preserves the sample size at every scale (Percival & Walden, 2000; Gençay et al., 2002; Crowley, 2007). The baseline specification applies the least asymmetric Daubechies filter with eight coefficients, LA(8), whose near-linear phase keeps the wavelet coefficients aligned in time with the data and whose frequency localisation is better than that of shorter Daubechies filters (Daubechies, 1992; Percival & Walden, 2000). As a robustness check, the Daubechies D4 filter (length 4, two vanishing moments) was used, which has different support and phase properties (Daubechies, 1988, 1992) and produces far fewer boundary-affected coefficients at coarse scales, at the cost of weaker frequency localisation. Both specifications use the periodic (circular) boundary, so that the series is treated as one period of a cyclic sequence; at level j, the first $L_j - 1$ coefficients, where $L_j = (2^j - 1)(L - 1) + 1$ and L is the filter length, are influenced by both ends of the sample (Percival & Walden, 2000). The number of decomposition levels is bounded above by $\lfloor \log_2 N \rfloor - 1$, where N is the sample size, and by the highest level needed for the analysis; both the baseline specification and the robustness specification uses $J = 7$ (D4). The level-j detail has a nominal pass band of $1/2^{j+1}$ to $1/2^j$ cycles per observation, corresponding to periods of 2^j to 2^{j+1} observation (Percival & Walden, 2000; Gençay et al., 2002). Shorter time horizon (4–8 days), medium time horizon (16–32 days), and longer time horizon (128–256 days) were used to retrieve the data.

The 4–8, 16–32 and 128–256 day horizons follow the wavelet quantile correlation (WQC) framework of Kumar and Padakandla (2022), who extracted these scales to roughly capture behaviour across one trading week, one trading month and one trading year. A later WQC study (Kumar et al., 2026) retained the medium and long scales but used 2 to 4 day details for the shortest band, arguing that investors have different preferences across timescales, reflecting differences in liquidity preferences, rebalancing needs and risk appetites. This is consistent with the Fractal Market Hypothesis, which holds that markets comprise investors operating at different investment horizons (Peters, 1994), a structure that wavelet decomposition can separate (Kristoufek, 2013). The 4–8 day band therefore represents short-term, trading-driven dynamics, the 16–32 day band medium-term, rebalancing-driven dynamics, and the 128–256 day band (about one trading year) long-term dynamics.

IV. FINDINGS & DISCUSSION

4.1 Descriptive Statistics

Figure 1 presents the return series of the candidate safe-haven assets and African stock markets. The series exhibit typical characteristics of financial returns, fluctuating around zero with periods of heightened volatility. The descriptive statistics are shown in Table 1.

Table 1

Summary statistics

Series	Mean	SD	Skewness	Kurtosis
BNB	0.0003	0.0324	-0.4339	8.6216
BTC	0.0011	0.0294	-0.0908	6.5307
ETH	0.0006	0.0396	0.1977	6.8099
USDT	0.0000	0.0004	-1.6238	18.5125
EGX	0.0016	0.0140	-0.1991	6.4664
FTSE	0.0007	0.0105	0.1532	5.0220
MASI	0.0003	0.0090	-0.5669	10.2531
NGX	0.0015	0.0098	1.3665	20.3523

Note: Mean and SD denote the sample mean and standard deviation of daily returns. Skewness indicates distributional asymmetry, while kurtosis measures tail heaviness relative to the normal distribution.

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

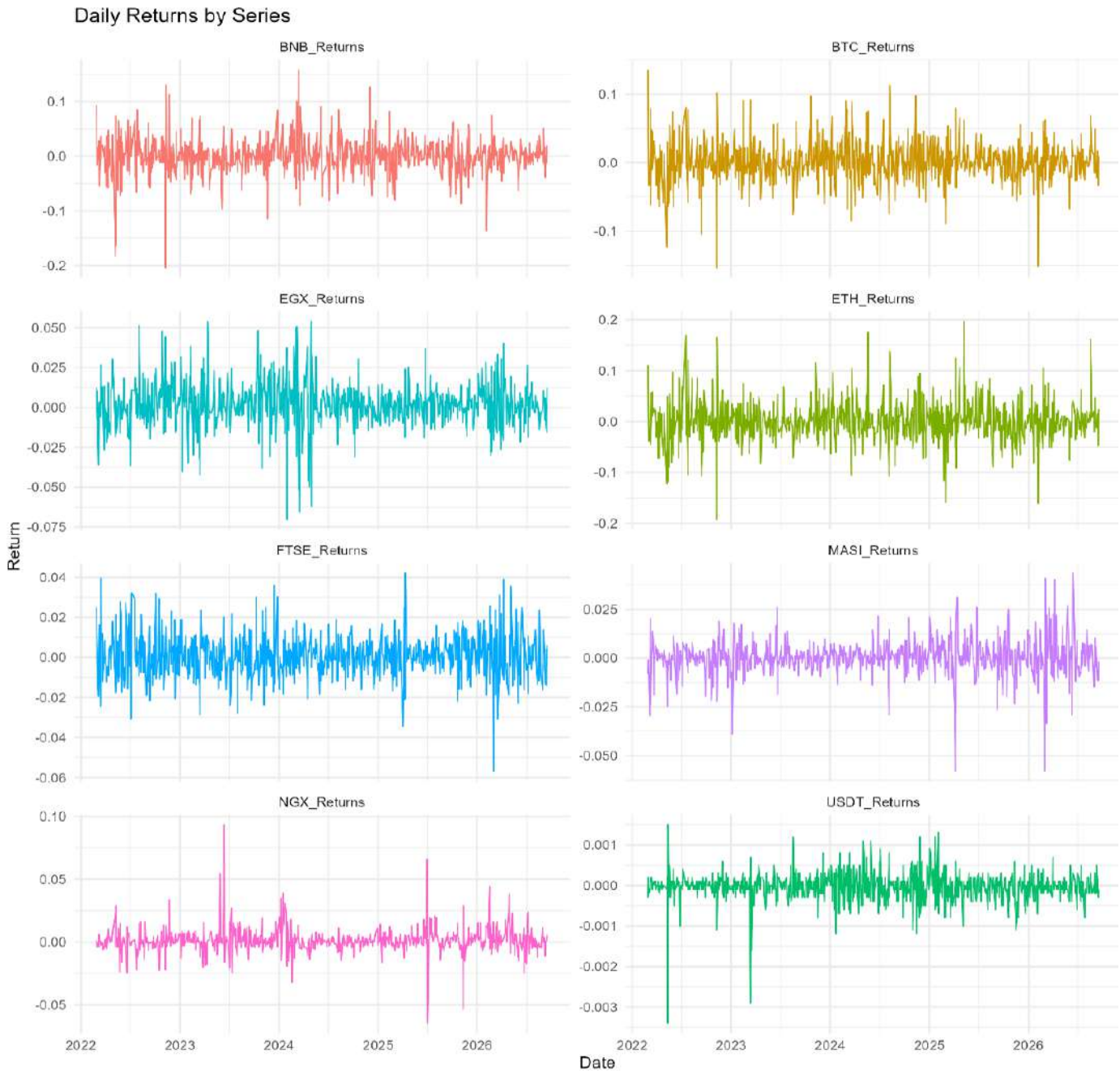


Figure 1
Plots of returns series for all variables.

Table 1 presents the descriptive statistics for the cryptocurrency and African stock market return series. The mean returns are non-negative across all series and generally small. Among the cryptocurrencies, BTC records the highest mean return (0.0011), followed by ETH (0.0006) and BNB (0.0003), while USDT has a mean return close to zero. Among the African stock markets, EGX has the highest mean return (0.0016), followed by NGX (0.0015), FTSE (0.0007), and MASI (0.0003).

The standard deviations indicate substantial differences in volatility. ETH exhibits the highest volatility among the cryptocurrencies (0.0396), followed by BNB (0.0324) and BTC (0.0294). USDT is considerably less volatile, with a standard deviation of only 0.0004, consistent with its stablecoin design. Among the stock markets, EGX has the highest standard deviation (0.0140), whereas MASI records the lowest (0.0090).

The return distributions also display varying degrees of asymmetry. BNB, BTC, USDT, EGX and MASI are negatively skewed, indicating relatively greater exposure to negative extreme returns, while ETH, FTSE and particularly NGX are positively skewed. NGX records the highest positive skewness (1.3665). Kurtosis exceeds the normal-distribution benchmark of 3 for every series, with particularly high values for NGX (20.3523), USDT (18.5125), MASI (10.2531), and BNB (8.6216). This indicates pronounced leptokurtosis and the presence of fat tails and extreme

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

observations across the markets. Overall, the statistics demonstrate considerable heterogeneity in return behaviour and volatility, providing a basis for examining potentially asymmetric safe-haven properties of cryptocurrencies across African equity markets. Table 2 further presents the stationarity test of the variables.

Table 2

Stationarity test

Series	ADF Statistic	ADF p value	PP Statistic	PP p value
BNB	-8.6513	0.01	-871.0775	0.01
BTC	-8.3111	0.01	-881.2078	0.01
ETH	-8.0627	0.01	-855.6180	0.01
USDT	-9.3432	0.01	-969.8801	0.01
EGX	-8.5861	0.01	-836.2974	0.01
FTSE	-10.7634	0.01	-797.5550	0.01
MASI	-10.0976	0.01	-672.9761	0.01
NGX	-6.8745	0.01	-794.4292	0.01

Note: ADF and PP denote the Augmented Dickey-Fuller and Phillips-Perron unit root tests (Dickey & Fuller, 1979, 1981; Phillips & Perron, 1988).

Table 2 reports the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests for all cryptocurrency and African stock market return series. The results show that all series are stationary at the 1% significance level, as the ADF and PP p-values are 0.01 for every variable. The ADF statistics are consistently negative and sufficiently large in absolute value, ranging from -6.8745 for NGX to -10.7634 for FTSE, while the PP statistics similarly provide strong evidence against the null hypothesis of a unit root. These results indicate that the return series do not exhibit unit root behaviour and are suitable for subsequent econometric and wavelet-based analysis. The consistency between the ADF and PP tests further supports the stationarity of the return series.

Figure 2 shows a correlation matrix of cryptocurrency returns (BNB, BTC, ETH, and USDT) alongside four African stock indices (EGX, FTSE, MASI, NGX). The cryptocurrencies cluster tightly together, with BTC, ETH, and BNB showing strong positive correlations (0.72 to 0.85, $p<0.001$), while Tether, as a stablecoin, correlates only weakly with them (0.13 to 0.17). The African indices form a separate, more loosely connected cluster, with modest correlations among FTSE, EGX, and MASI (0.14 to 0.21) and NGX largely uncorrelated with the rest. Cross-market correlations between cryptocurrencies and African equities are small (−.04 to .17) and often not statistically significant, suggesting limited unconditional linkage between the two asset classes.

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

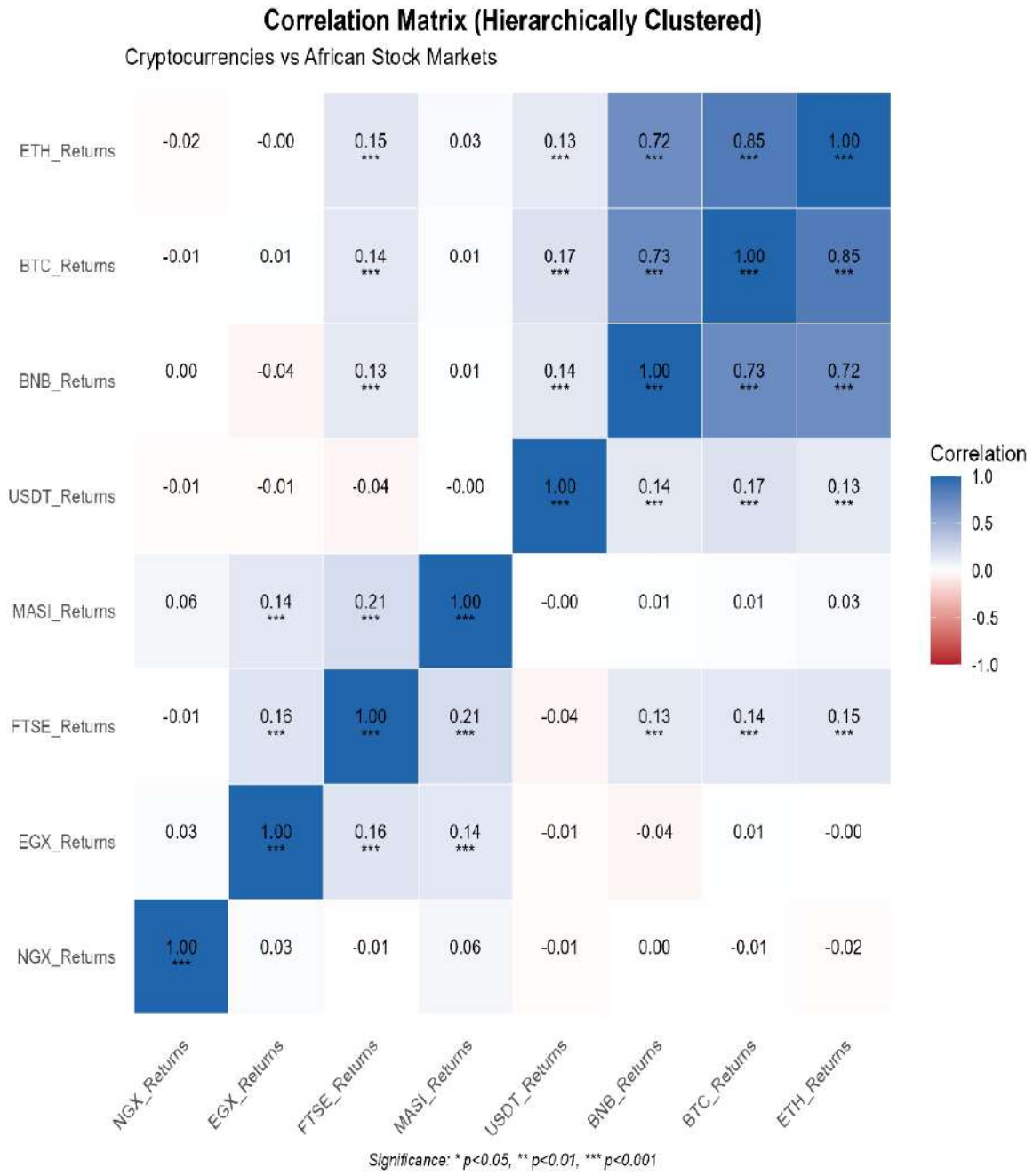


Figure 2
Return correlations between safe-haven assets and African stock markets

The Wavelet Quantile Correlation (WQC) framework is employed to investigate how the selected cryptocurrency assets co-move with African equity markets across different investment horizons and market states. By integrating wavelet decomposition with quantile-based dependence analysis, the approach identifies changes in cross-market relationships across short-, medium-, and long-term frequencies while simultaneously distinguishing between different market conditions. This makes WQC particularly appropriate for examining the behaviour of potential safe-haven assets when equity markets experience substantial uncertainty and stress. In this study, the analysis focuses on Binance Coin, Bitcoin, Ethereum, and Tether in relation to the FTSE All Share Index, MASI, EGX 300, and NGX All-Share Index.

Following the classification proposed by Baur and Lucey (2010), quantiles between 0.10 and 0.30 are interpreted as bearish market conditions, 0.40 to 0.60 as normal conditions, and 0.70 to 0.90 as bullish conditions. The interpretation of asset characteristics is based on the sign and magnitude of the WQC coefficients within these states. A cryptocurrency is regarded as providing safe-haven protection at a particular frequency and market when its WQC is non-positive during bearish conditions. A positive coefficient in this lower-quantile region rules out safe-haven classification, irrespective of the relationship observed under normal or bullish conditions. For normal market

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

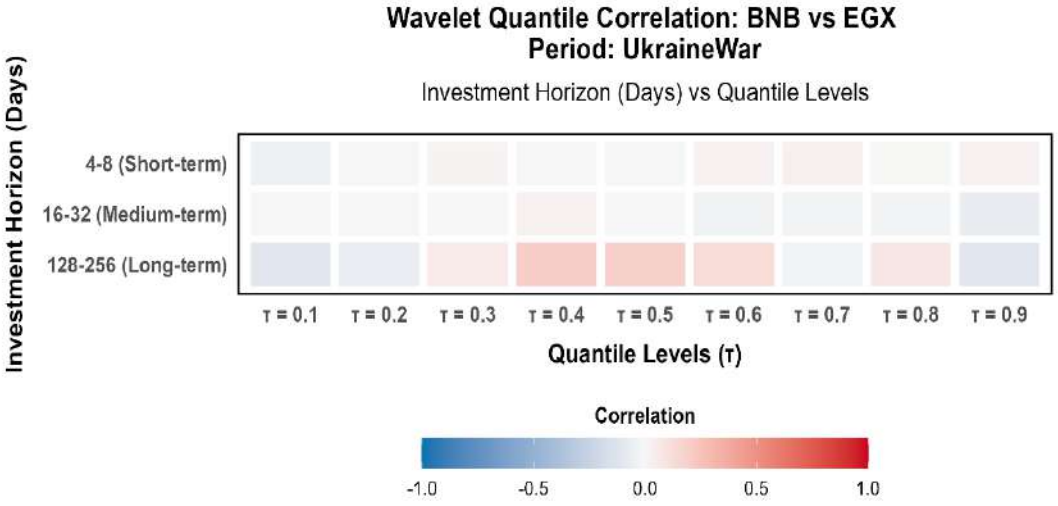
conditions, a non-positive WQC is interpreted as evidence of hedging potential. Under bullish conditions, a positive but less-than-perfect association is considered indicative of diversification benefits.

Binance Coin exhibited a weak safe-haven effect in the lower quantiles across all investment horizons for Egypt, with negative WQC coefficients that, while modest in magnitude, held consistently from the short to the long term. For South Africa, this protective property was confined to the medium term, with the short- and long-term coefficients remaining positive and therefore inconsistent with safe-haven behaviour. In contrast, Binance Coin offered no protection for the Moroccan and Nigerian markets at any horizon; the WQC coefficients in the lower quantiles were positive throughout, indicating that BNB instead functioned predominantly as a diversifier, moving in the same direction as these two markets without amplifying their downside risk disproportionately. These results are presented in Figure 3.

Bitcoin behaved as a hedge rather than a safe haven for Egypt, since its correlations with the Egyptian market in the lower quantiles remained non-negative even as they weakened relative to normal and bullish conditions, satisfying the hedge criterion without meeting the stricter safe-haven threshold. It provided medium-term safe-haven protection for both South Africa and Nigeria, with negative WQC coefficients emerging specifically at the 16 to 32-day frequency band, but showed no comparable property for Morocco at any horizon, where the lower-quantile coefficients were positive at all horizons. These results are presented in Figure 4.

Ethereum served as a safe haven for Egypt and Nigeria in the short and medium terms, with negative lower-quantile coefficients persisting across both frequency bands, and for South Africa in the medium and long terms, indicating a more pronounced low-frequency protective role in that market. It offered no protective properties for Morocco at any horizon, mirroring the pattern observed for Bitcoin and reinforcing Morocco as the market in which lower-tail dependence on cryptocurrencies was positive, particularly at the longest horizon. These results are presented in Figure 5.

Tether, as shown in Figure 6, acted as a safe haven across all four markets in the short term, although the associated correlations were generally weak and close to zero, consistent with its low-volatility, dollar-pegged design. Its protective properties were moderate for Nigeria in the medium term, with a more pronounced negative coefficient than observed for the other three markets at that horizon, while for South Africa it displayed a somewhat stronger negative correlation in the long term, indicating that Tether's defensive role in that market strengthens rather than fades as the investment horizon lengthens.



© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

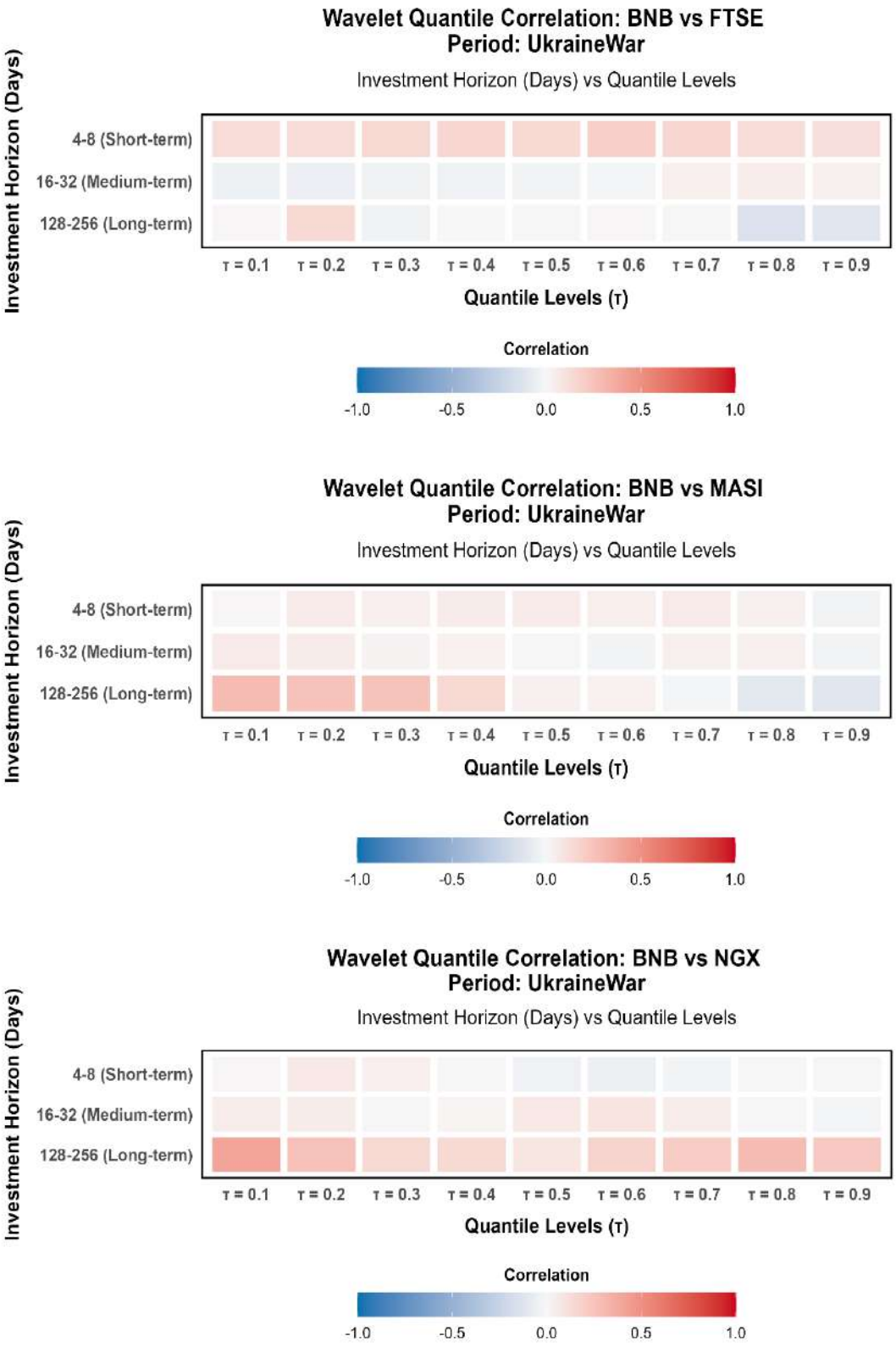
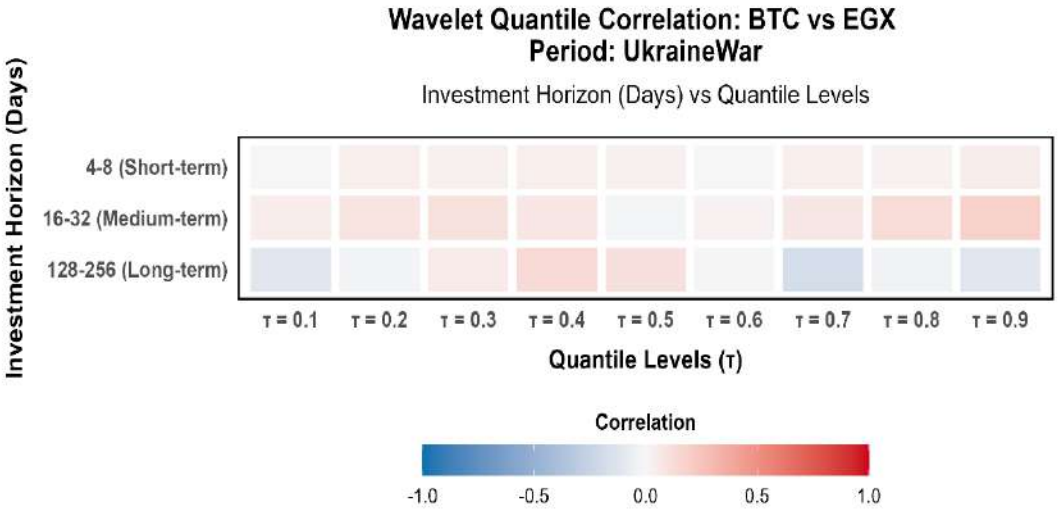
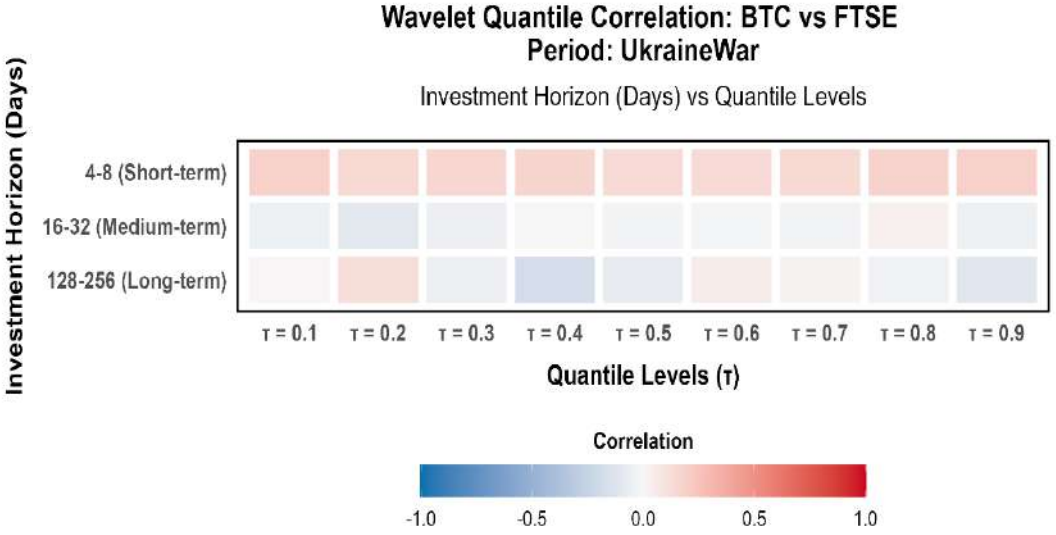
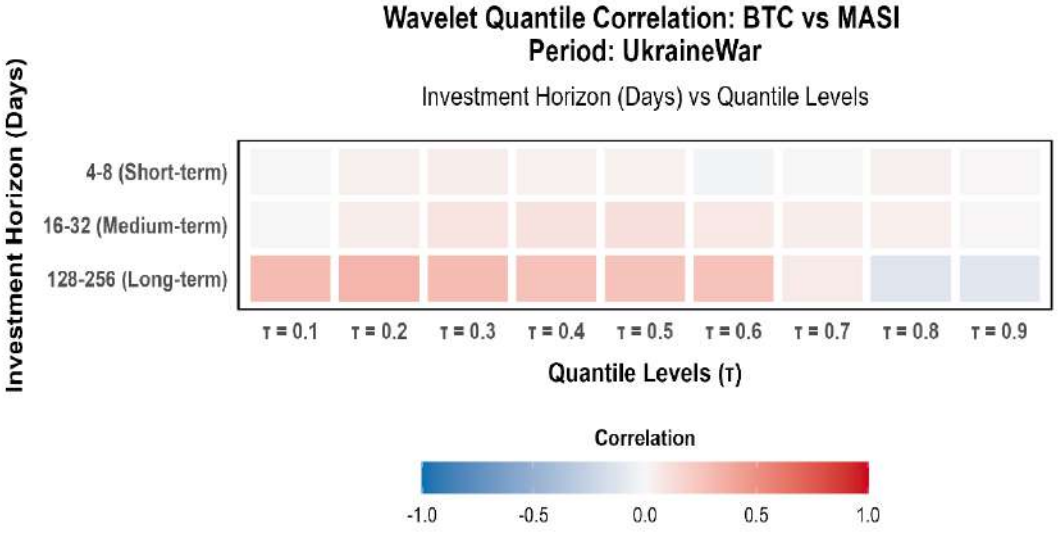


Figure 3
Wavelet Quantile Correlation between Binance Coin and African stock markets during the sample period.

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).







© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

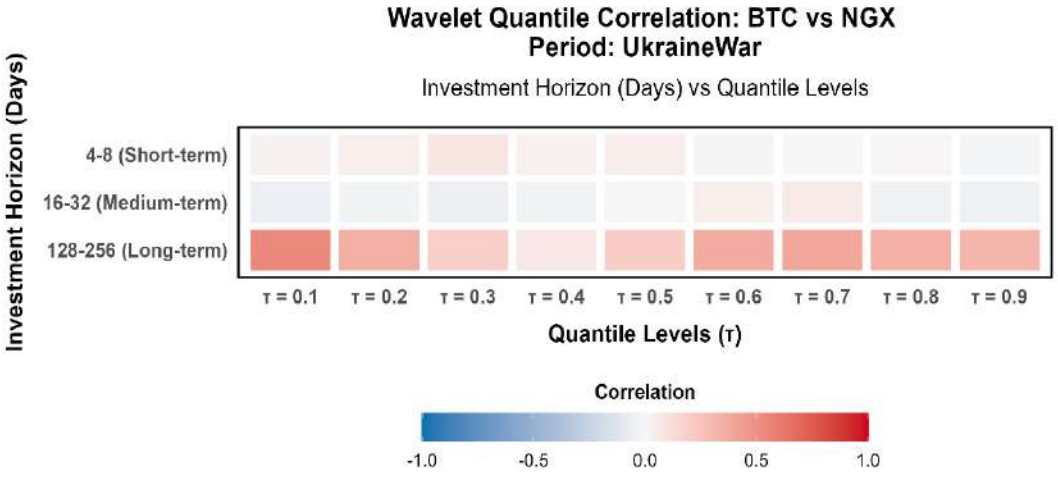
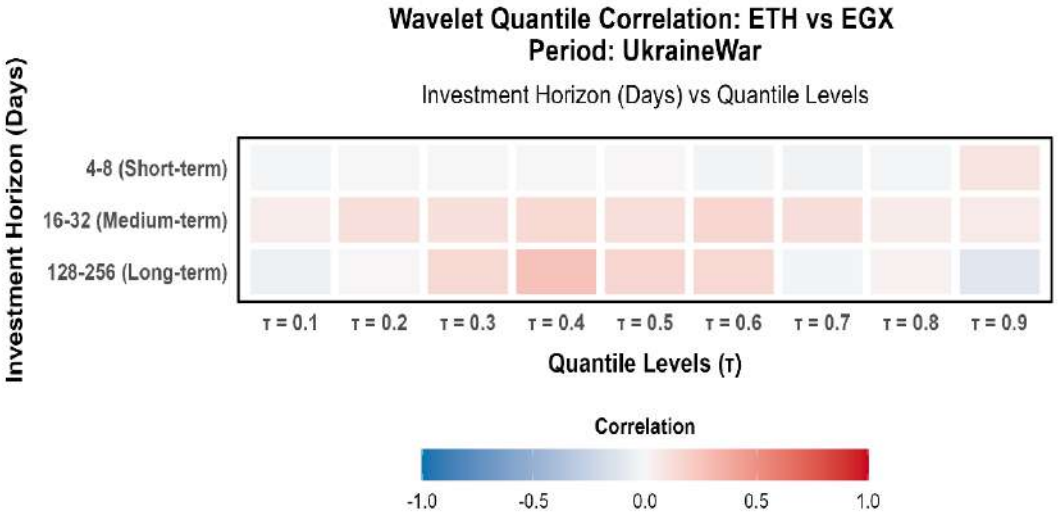
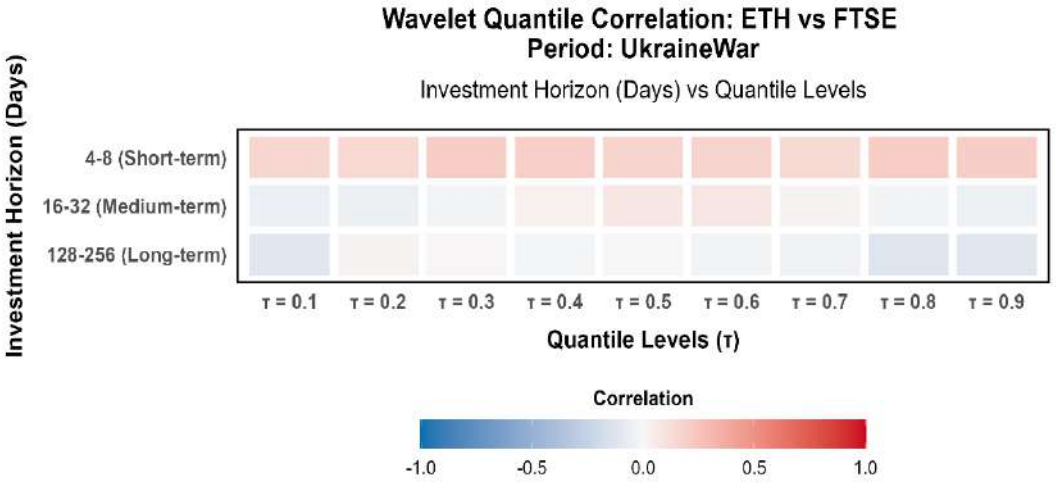


Figure 4
Wavelet Quantile Correlation between Bitcoin and African stock markets during the sample period.





© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

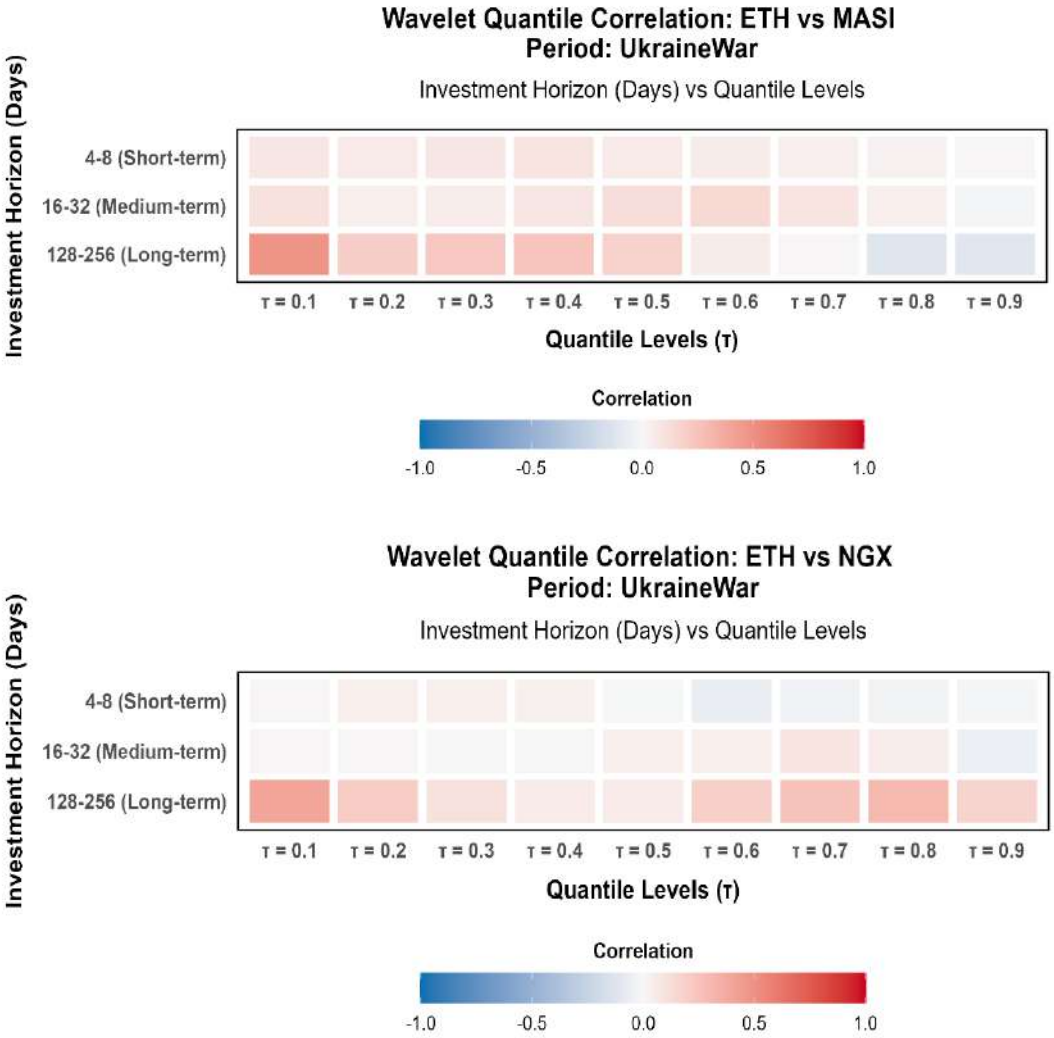
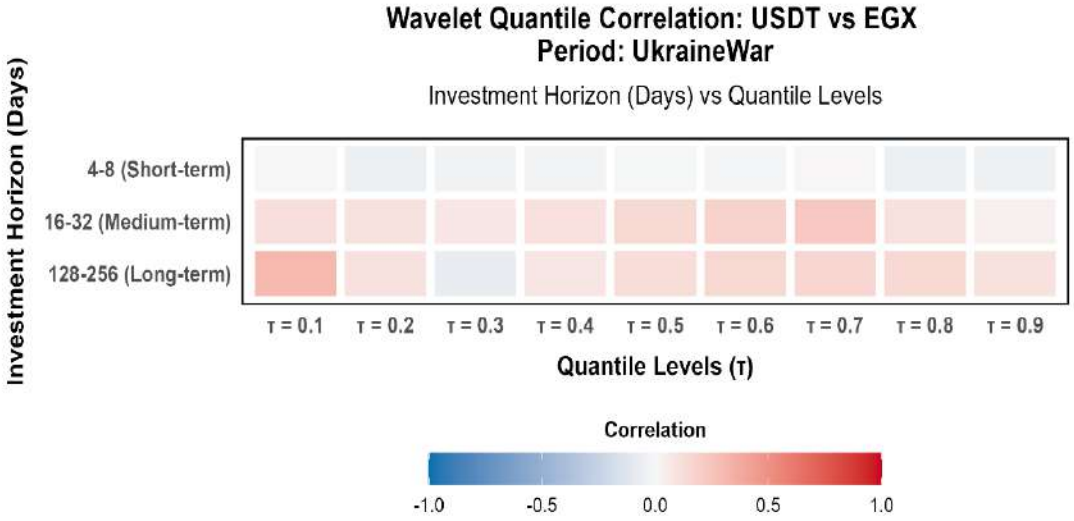


Figure 5. Wavelet Quantile Correlation between Ethereum and African stock markets during the sample period.



© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

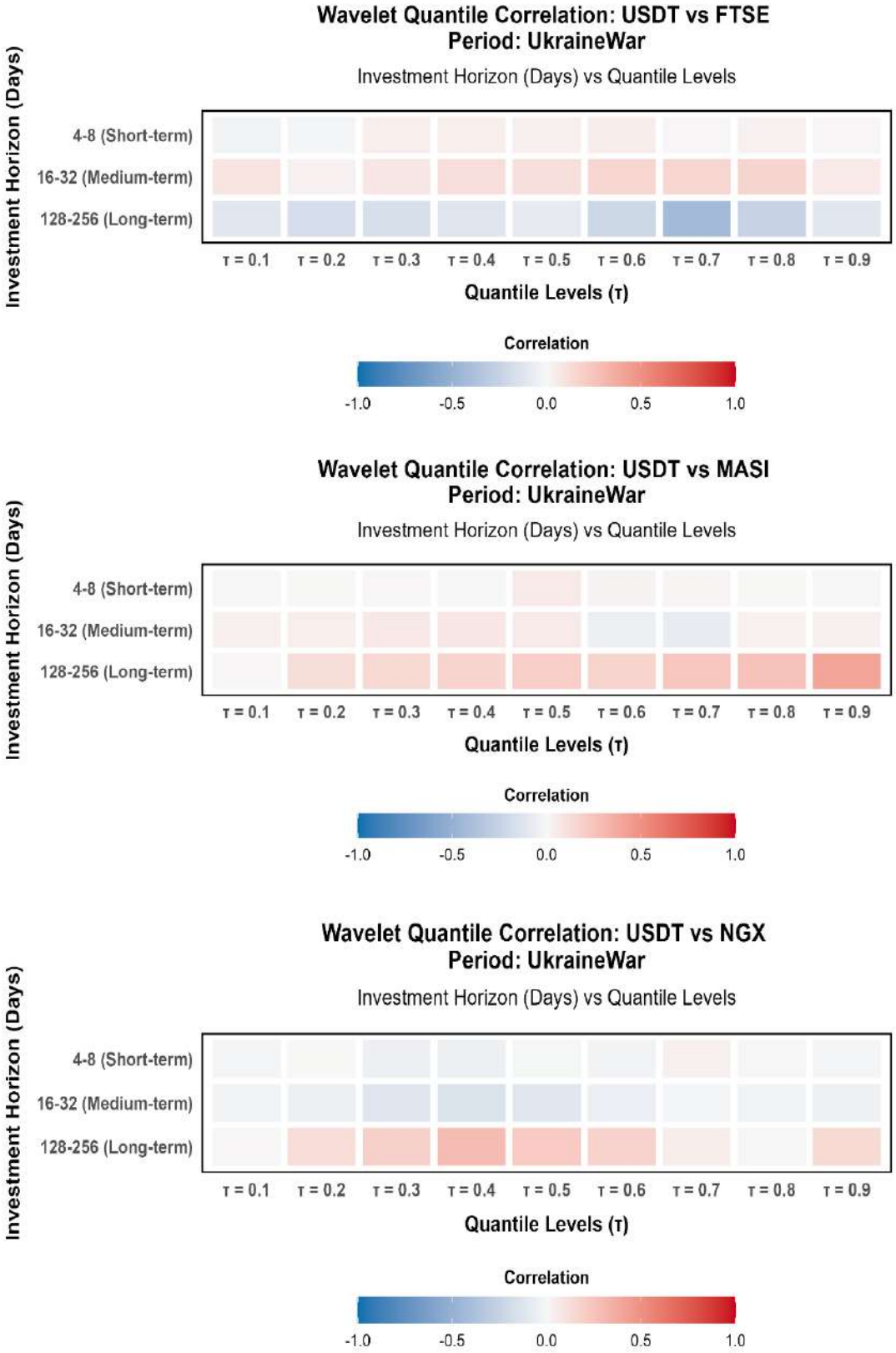


Figure 6
Wavelet Quantile Correlation between Tether and African stock markets during the sample period

4.2 Discussion

The results reveal a heterogeneous and horizon-dependent pattern of cryptocurrency safe-haven behaviour across the four African equity markets, broadly consistent with, while also extending, the existing literature.

Binance Coin (BNB) showed a weak safe-haven effect in the lower quantiles for Egypt across all horizons, a protective role confined to the medium term for South Africa, and pure diversification for Morocco and Nigeria. This

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

pattern is broadly consistent with Gadi and Sicilia (2022), who found that BNB and similar altcoins exhibit predominantly diversifier rather than safe-haven characteristics across G7 and BRICS markets. The horizon-contingent nature of BNB's protection in Egypt also aligns with Jana and Sahu (2023), who show that unstable cryptocurrencies including BNB serve as hedges in stable periods but fail to do so during turmoil. The absence of any protective property for Morocco and Nigeria may reflect structural features of these markets, including low liquidity, limited foreign participation, and, in Nigeria's case, a history of regulatory restriction that has directed cryptocurrency adoption towards transactional rather than risk-management use.

Bitcoin functioned as a hedge rather than a safe haven for Egypt, since its lower-quantile correlations remained non-negative. This corroborates Bouri et al. (2017b), who similarly found Bitcoin to be a poor hedge suited mainly to diversification, albeit capable of safe-haven behaviour under extreme downward movements in some markets. The medium-term safe-haven properties identified for South Africa and Nigeria are more notable and reinforce the view that Bitcoin's protective capacity is weak, conditional and state-contingent, with its benefits concentrated under adverse market conditions. The complete absence of protection for Morocco contrasts with these results and extends Kumar and Padakandla (2022), who documented horizon-contingent safe-haven behaviour for Bitcoin in developed markets. The present study relocates this evidence to African markets and shows that the same methodology can yield materially different outcomes across markets with different market structures.

Ethereum offered short and medium-term protection for Egypt and Nigeria, and medium to long-term protection for South Africa, but none for Morocco. The short-run results align with recent evidence of Ethereum's conditional safe-haven role during periods of market volatility. The persistence of protection into the medium and long term for South Africa is a more novel finding, given that Baur and Lucey (2010) demonstrated, in the gold context, that safe-haven properties are typically short-lived. This durability may reflect South Africa's comparatively developed cryptocurrency infrastructure and closer integration with global risk sentiment. The absence of any protective effect for Morocco parallels the Bitcoin result and reinforces the view, consistent with Jana and Sahu (2023), that limited liquidity and restricted international portfolio flows weaken the transmission channels through which safe-haven behaviour typically emerges.

Tether provided a consistent, if weak, short-term safe-haven effect across all four markets, with moderate medium-term protection for Nigeria and a stronger long-term negative correlation for South Africa. This is broadly consistent with Kołodziejczyk (2023), who found that stablecoins act as weak hedges in calm periods and weak safe havens during turmoil regardless of investment horizon, although the present analysis identifies additional horizon-specific variation not captured by that framework. The cross-market consistency of Tether's short-term role, in contrast to the more uneven performance of BNB, Bitcoin and Ethereum, supports Feng et al. (2024), who argue that stablecoins outperform conventional cryptocurrencies as defensive instruments precisely because of their low volatility and dollar peg. The stronger long-term protection observed in South Africa likely reflects its more developed institutional and regulatory environment, while the moderate medium-term effect in Nigeria may relate to the country's macroeconomic instability, where stablecoins have plausibly functioned as a partial store-of-value hedge against currency depreciation and inflation.

Overall, the findings suggest a hierarchy of defensive utility: Tether's short-term effect was the most consistent across markets, Ethereum's protection appeared in three of four markets, and Bitcoin's and BNB's were confined to fewer market and horizon combinations. Morocco emerges consistently as the market most resistant to cryptocurrency-based protection across all four assets, pointing to structural and institutional factors that merit further investigation. These results confirm that the heterogeneity in cryptocurrency safe-haven properties documented elsewhere is replicated, and further differentiated by investment horizon, within African equity markets.

To assess the reliability of the baseline findings, the wavelet quantile correlation (WQC) analysis was re-estimated using the Daubechies D4 filter in place of the LA(8) filter. D4 differs from LA(8) in filter length, smoothness and frequency localisation, so it provides a meaningful alternative against which to test whether the results depend on the choice of wavelet. All other elements of the design were held constant, including the data, sample period, decomposition levels, investment horizons and quantile grid, so that any divergence could be attributed solely to the filter. The D4-based results are reported in Figures 7 to 10, which present the WQC between the African stock markets and Binance Coin (Figure 7), Bitcoin (Figure 8), Ethereum (Figure 9) and Tether (Figure 10).

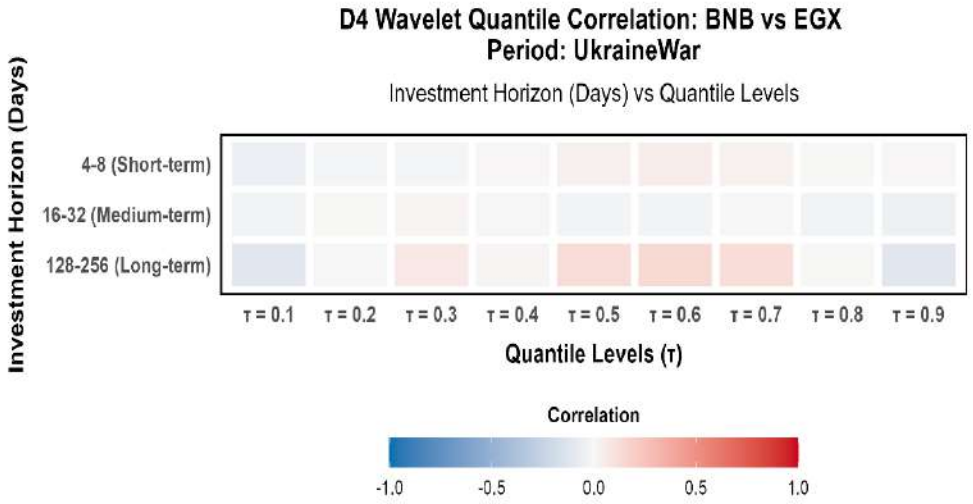
The patterns shown in Figures 7 to 10 are broadly consistent with those obtained under the LA(8) specification. The sign of the quantile correlations, their relative magnitudes, and their variation across investment horizons and quantiles remain largely unchanged for each of the four cryptocurrencies as further shown in Table 3. The conclusions on the safe-haven role of these assets in the African markets are therefore not sensitive to the choice of wavelet filter. Any minor differences in the strength of dependence, particularly at the longest horizon where fewer effective wavelet coefficients are available, do not alter the substantive interpretation. Overall, the evidence indicates that the baseline findings are robust to the alternative filter specification.

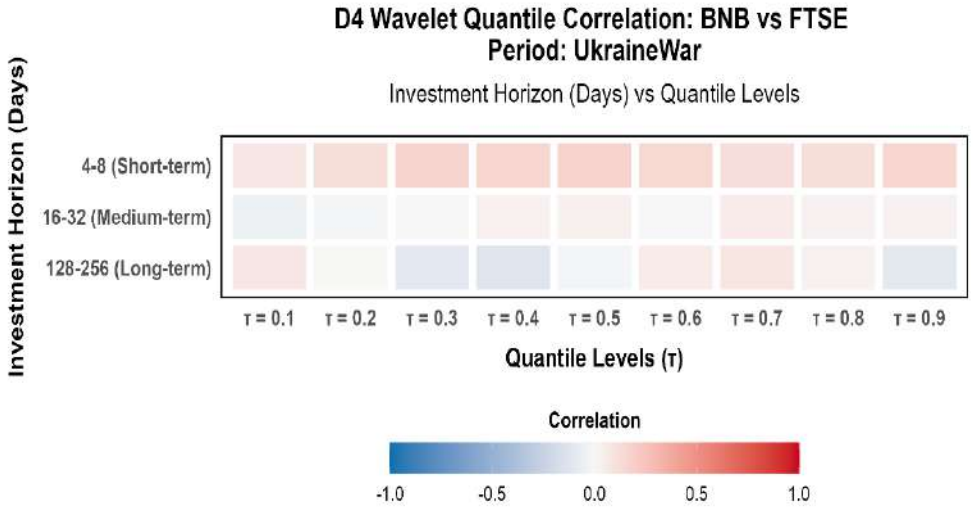
© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

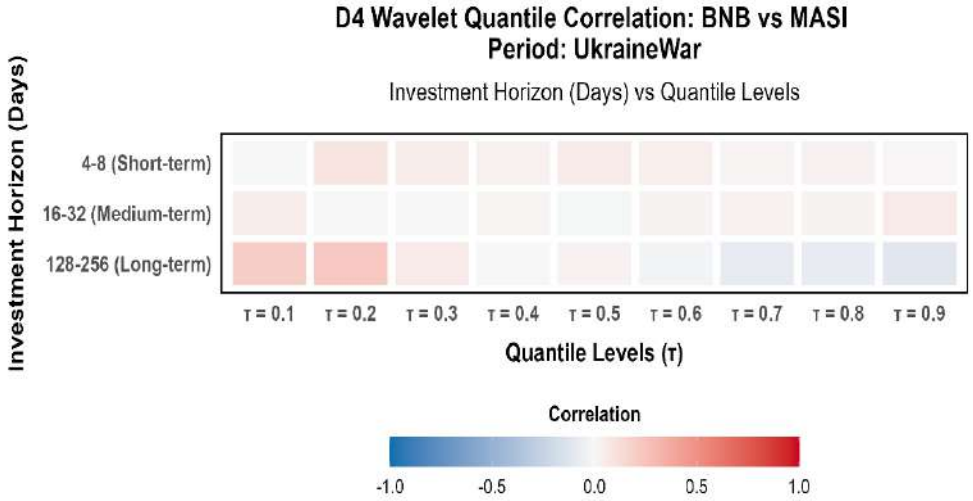
Table 3

Robustness comparison

Cells Compared	Sign Agreement Percent	Correlation between LA(8) and D4	Mean Absolute Difference	Max Absolute Difference
432	81.9	0.794	0.042	0.502







© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

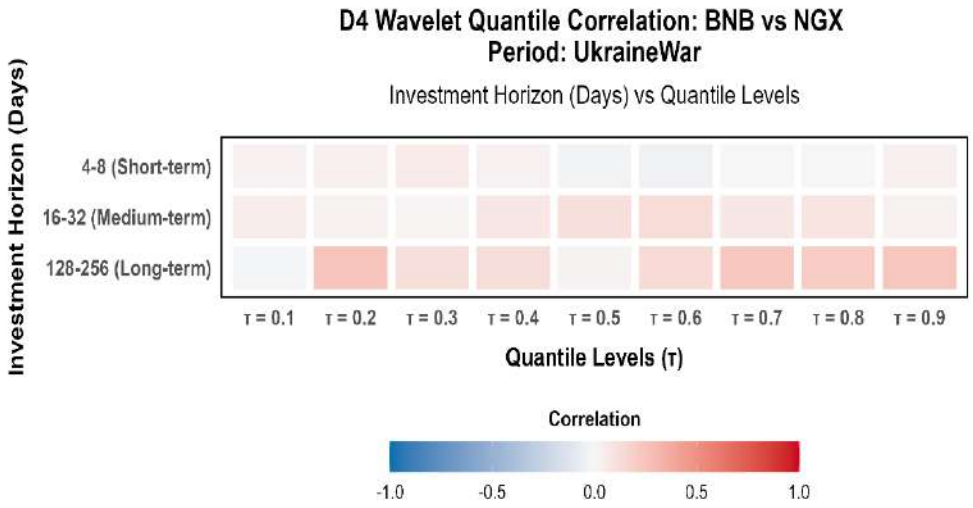
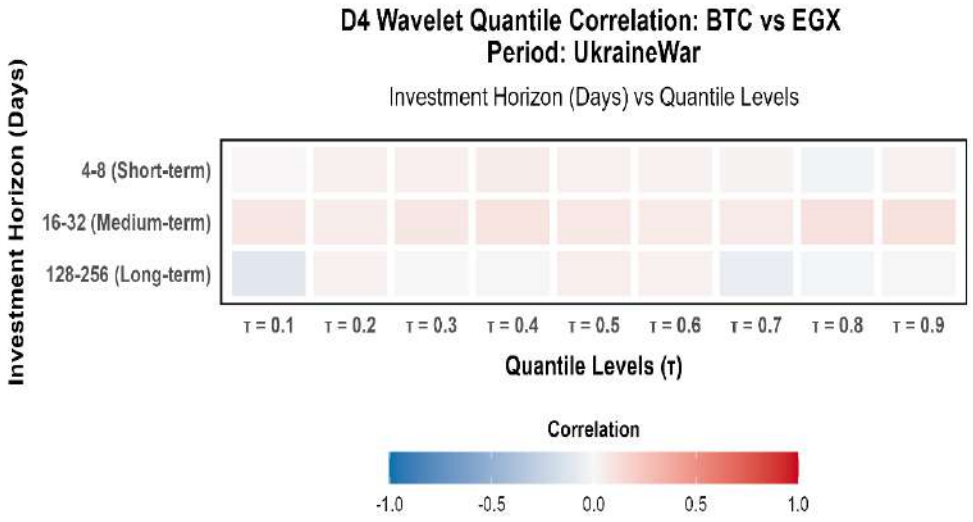
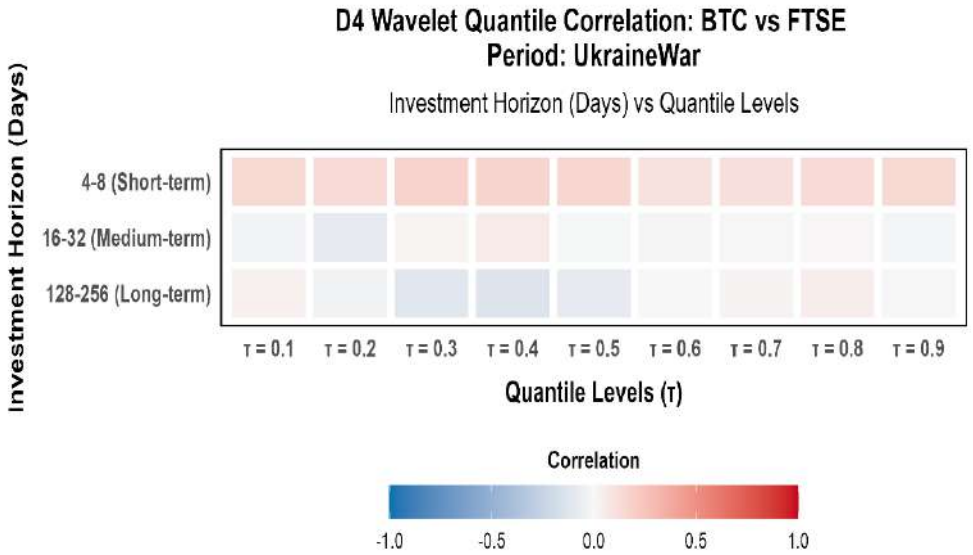


Figure 7

Wavelet Quantile Correlation (D4) between Binance Coin and African stock markets during the sample period.





© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

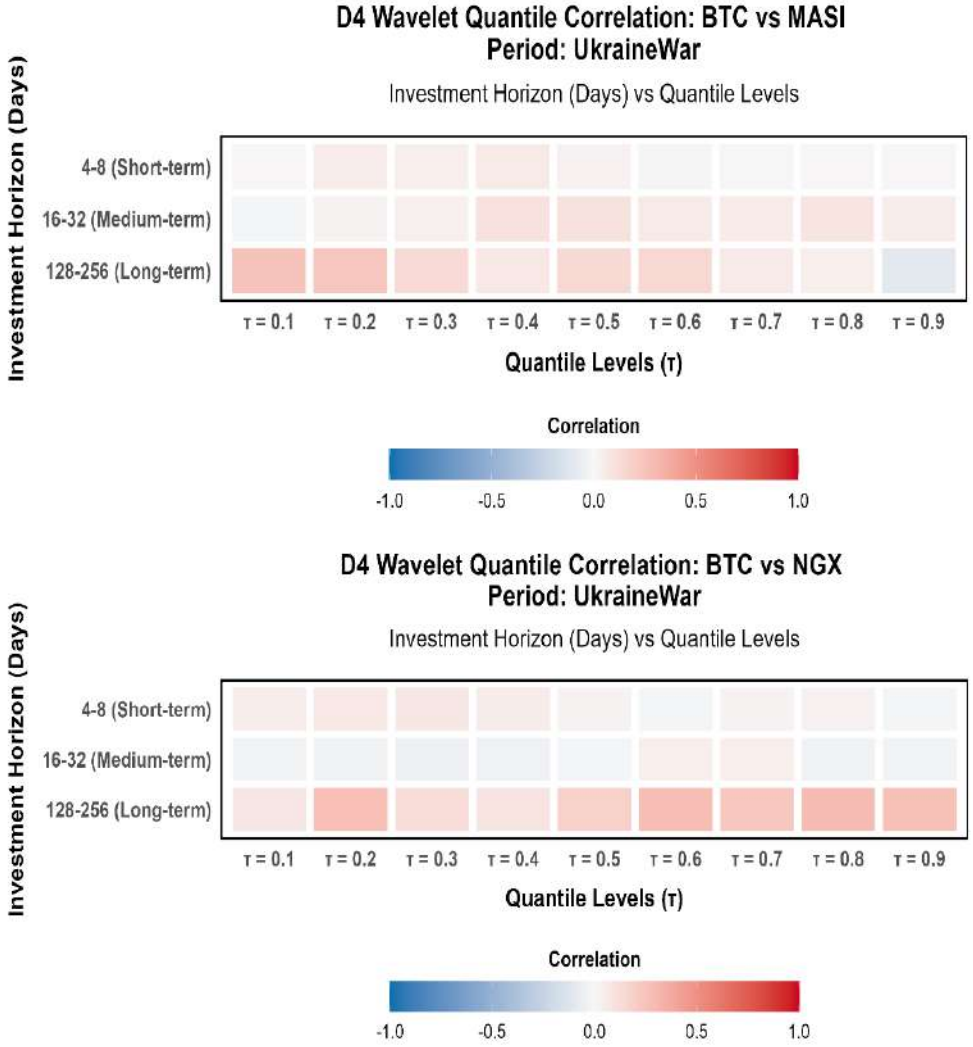
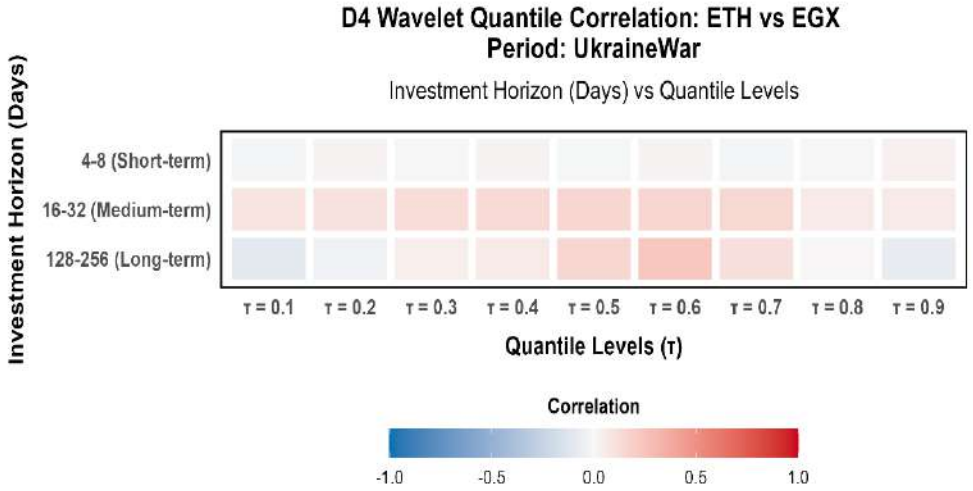


Figure 8

Wavelet Quantile Correlation (D4) between Bitcoin and African stock markets during the sample period.



© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

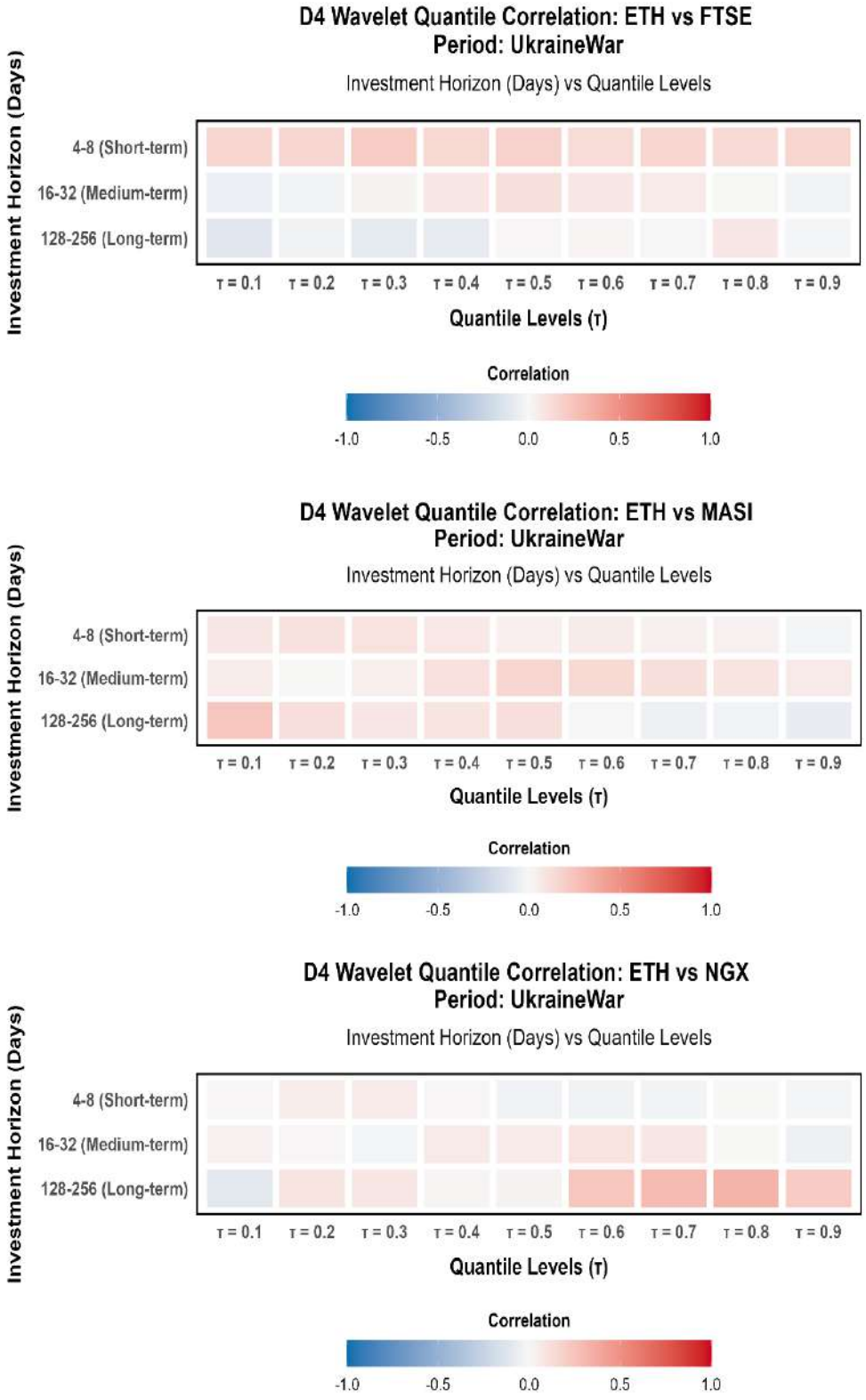
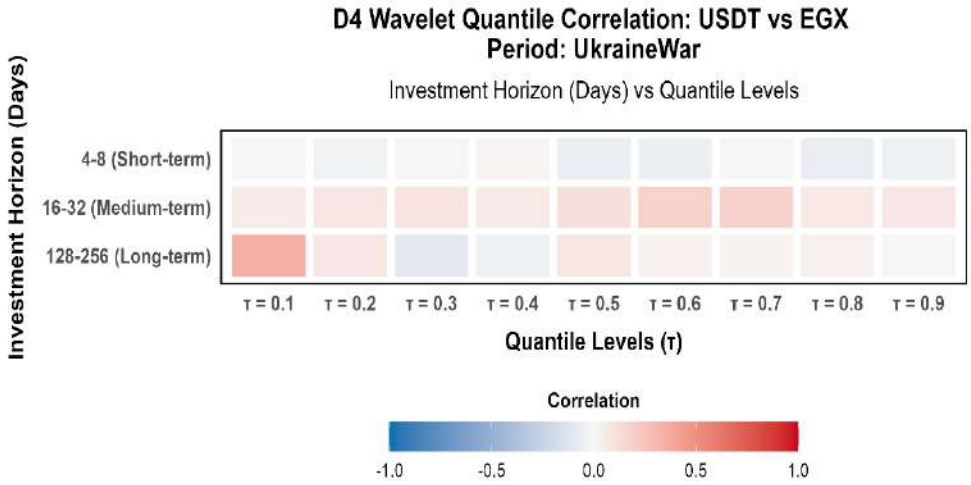
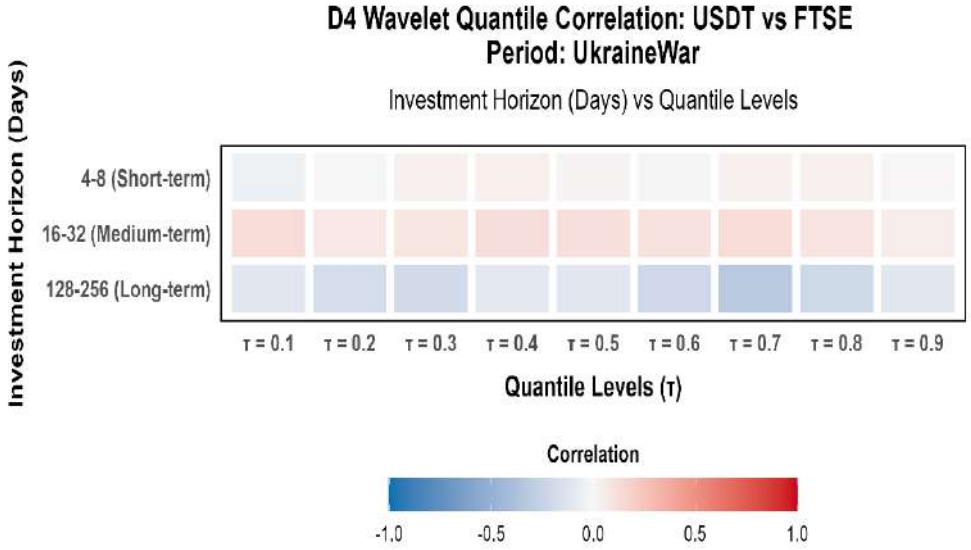


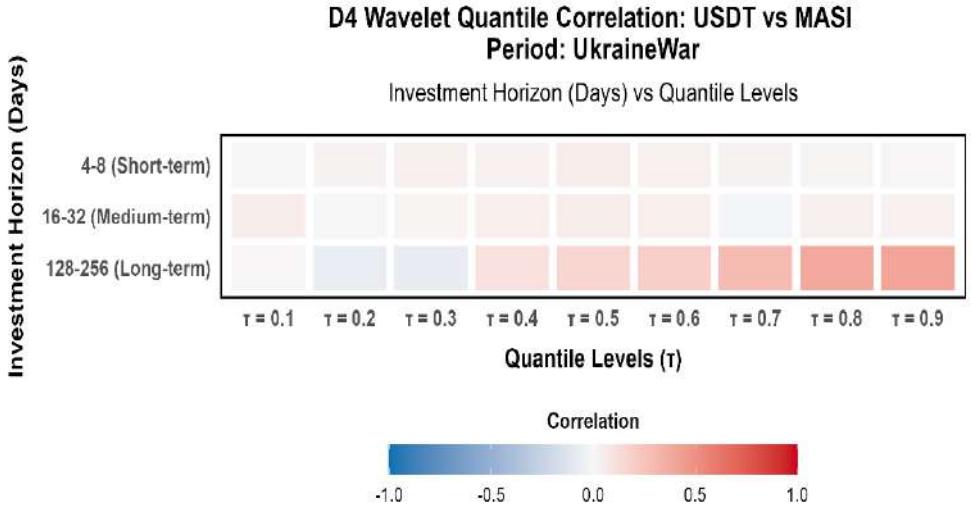
Figure 9

Wavelet Quantile Correlation (D4) between Ethereum and African stock markets during the sample period.

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).







© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

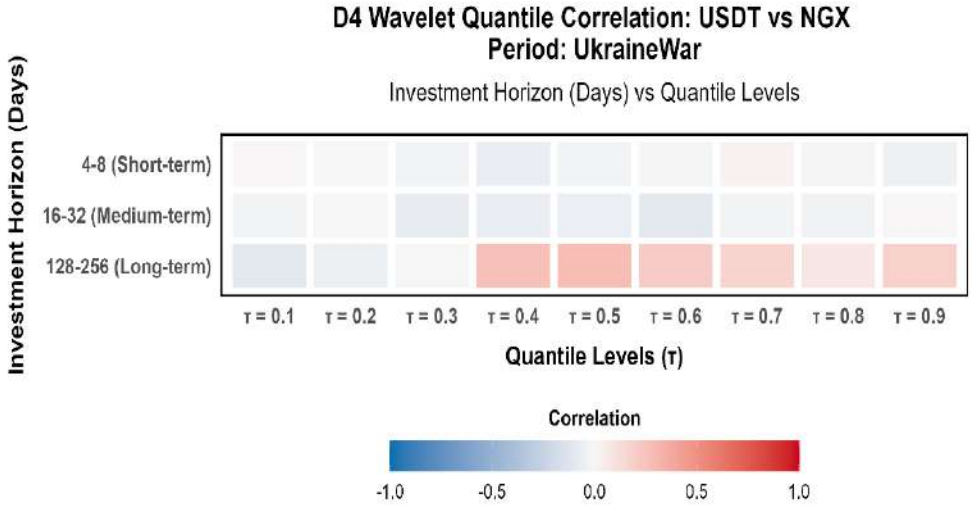


Figure 10
Wavelet Quantile Correlation (D4) between Tether and African stock markets during the sample period.

V. CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusion

This study aimed to determine whether BNB, BTC, ETH and USDT functioned as diversifiers, hedges or safe havens for Egyptian, South African, Moroccan and Nigerian equities during the Russia-Ukraine war. The principal findings are summarised below in relation to each research objective.

In relation to the first objective, all three roles were observed, but none uniformly. Safe-haven behaviour appeared only in specific asset, market and horizon combinations: Ethereum in Egypt and Nigeria at short and medium horizons and in South Africa at medium and long horizons; Bitcoin in South Africa and Nigeria at the medium horizon; BNB weakly in Egypt and at the medium horizon in South Africa; and Tether weakly at the short horizon in all four markets. Hedging was found only for Bitcoin in Egypt, and diversification alone for BNB in Morocco and Nigeria. BNB, BTC and ETH offered no protection in Morocco.

In relation to the second objective, examining normal and stressed conditions separately proved decisive for classification. Bitcoin's lower-quantile coefficients in Egypt weakened relative to normal and bullish states but stayed non-negative, making it a hedge rather than a safe haven, whereas the small unconditional cross-market correlations (−0.04 to 0.17) would have implied diversification potential without distinguishing these roles.

In relation to the third objective, Tether was the most consistent asset, showing short-term safe-haven behaviour in all four markets, although its coefficients were close to zero, while BNB, BTC and ETH were more uneven. The dollar peg may explain this contrast, but it was not tested, so the distinction is an observed pattern, not an established mechanism.

In relation to the fourth objective, the results resemble published developed-market findings that stablecoins behave more consistently than volatile cryptocurrencies, yet differ in showing medium-term safe-haven behaviour for Bitcoin and Ethereum in some African markets.

The study contributes by extending conditional, horizon-specific safe-haven evidence to African equities, covering BNB, BTC, ETH and USDT jointly, and by showing that conclusions about cryptocurrency protection depend on the asset, market and horizon examined. These conclusions apply to the observed war window. Re-estimation with the D4 filter gave broadly consistent results (81.9 per cent sign agreement across 432 comparisons), so classifications close to zero should be treated with caution.

5.2 Recommendations

The recommendations below follow from the findings and apply to the markets and war window studied.

First, investors and portfolio managers should not treat cryptocurrencies as a single protective asset class. For South African equity exposure, the medium-horizon protection found for BNB, Bitcoin and Ethereum, and the longer-horizon protection found for Ethereum, support evaluating these assets as crisis hedges at those horizons. For Egyptian and Nigerian equities, the short- and medium-horizon protection from Ethereum, and the medium-horizon protection from Bitcoin in Nigeria, are the clearest candidates. Allocations should be matched to the holding horizon over which protection was observed and not to an asset's general reputation.

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

Second, because Tether's short-term protection was consistent across all four markets but close to zero in magnitude, it is better regarded as a modest short-horizon defensive position than as a source of substantial offset to equity losses. Investors should also weigh the issuer and reserve risk attached to its peg, which this study did not examine.

Third, investors holding Moroccan equities should not rely on BNB, Bitcoin or Ethereum for protection, since none provided it at any horizon. Other instruments, such as gold, may warrant evaluation, although gold was not tested here.

Fourth, before implementing any allocation, investors should assess net protection after transaction costs, liquidity constraints and capital controls, which were not modelled, and should re-estimate these relationships periodically because the war is ongoing and the results are conditional on the observed window.

Fifth, regulators and policymakers should examine the liquidity depth, foreign participation and domestic cryptocurrency regulation in Morocco, where protective co-movement was persistently absent. These features are candidate explanations that this study did not test, and they may dampen the transmission channels through which safe-haven behaviour emerges elsewhere.

Declaration of Interest

The authors declare that they do not have any known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Funding Declaration

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

REFERENCES

Ahad, M., Imran, Z. A., & Shahzad, K. (2024). Safe haven between European ESG and energy sector under Russian-Ukraine war: Role of sustainable investments for portfolio diversification. *Energy Economics*, *138*, 107853.

Anyikwa, I., & Phiri, A. (2023). Connectedness and spillover between African equity, commodity, foreign exchange and cryptocurrency markets during the COVID-19 and Russia-Ukraine conflict. *Future Business Journal*, *9*(1), 48. https://doi.org/10.1186/s43093-023-00227-y

Bampinas, G., & Panagiotidis, T. (2024). How would the war and the pandemic affect the stock and cryptocurrency cross-market linkages? *Research in International Business and Finance*, *70*, 102272. https://doi.org/10.1016/j.ribaf.2024.102272

Baur, D. G., & Hoang, L. T. (2021). A crypto safe haven against Bitcoin. *Finance Research Letters, 38,* 101431. https://doi.org/10.1016/j.frl.2020.101431

Baur, D. G., & Lucey, B. M. (2010). Is gold a hedge or a safe haven? An analysis of stocks, bonds and gold. *Financial Review*, *45*(2), 217–229. https://doi.org/10.1111/j.1540-6288.2010.00244.x

Baur, D. G., & McDermott, T. K. (2010). Is gold a safe haven? International evidence. *Journal of Banking & Finance*, *34*(8), 1886–1898. https://doi.org/10.1016/j.jbankfin.2009.12.008

Bekaert, G., & Harvey, C. R. (1995). Time-varying world market integration. *The Journal of Finance*, *50*(2), 403–444. https://doi.org/10.1111/j.1540-6261.1995.tb04790.x

Bouri, E., Gupta, R., Tiwari, A. K., & Roubaud, D. (2017a). Does Bitcoin hedge global uncertainty? Evidence from wavelet-based quantile-in-quantile regressions. *Finance Research Letters*, *23*, 87–95. https://doi.org/10.1016/j.frl.2017.02.009

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

Brunnermeier, M. K., & Pedersen, L. H. (2009). Market liquidity and funding liquidity. The Review of Financial Studies, 22(6), 2201–2238. https://doi.org/10.1093/rfs/hhn098

Caldara, D., & Iacoviello, M. (2022). Measuring geopolitical risk. *American Economic Review*, *112*(4), 1194–1225. https://doi.org/10.1257/aer.20191823

Conlon, T., & McGee, R. (2020). Safe haven or risky hazard? Bitcoin during the COVID-19 bear market. *Finance Research Letters, 35,* 101607. https://doi.org/10.1016/j.frl.2020.101607

Crowley, P. M. (2007). A guide to wavelets for economists. *Journal of Economic Surveys, 21*(2), 207-267. https://doi.org/10.1111/j.1467-6419.2006.00502.x

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).

Daubechies, I. (1988). Orthonormal bases of compactly supported wavelets. *Communications on Pure and Applied Mathematics, 41*(7), 909-996. https://doi.org/10.1002/cpa.3160410705

Daubechies, I. (1992). *Ten lectures on wavelets*. SIAM. https://doi.org/10.1137/1.9781611970104

Dickey, D. A., & Fuller, W. A. (1979). Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association, 74*(366), 427–431. https://doi.org/10.1080/01621459.1979.10482531

Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica, 49*(4), 1057–1072. https://doi.org/10.2307/1912517

Fakhfekh, M., Snene Manzli, Y., Béjaoui, A., & Jeribi, A. (2023). Can cryptocurrencies be a safe haven during the 2022 Ukraine crisis? Implications for G7 investors. *Global Business Review*. https://doi.org/10.1177/09721509231164808

Feng, J., Yuan, Y., & Jiang, M. (2024). Are stablecoins better safe havens or hedges against global stock markets than other assets? Comparative analysis during the COVID-19 pandemic. *International Review of Economics & Finance*, *92*, 275–301. https://doi.org/10.1016/j.iref.2024.02.014

Frimpong, K. P., & Siaw, F. (2026). Hedges and safe havens: an examination of gold and African equity markets. *Future Business Journal*, *12*(1), 211. https://doi.org/10.1186/s43093-026-00915-5

Gadi, M. F. A., & Sicilia, M.-A. (2022). Analyzing safe haven, hedging and diversifier characteristics of heterogeneous cryptocurrencies against G7 and BRICS market indexes. *Journal of Risk and Financial Management*, *15*(12), 572. https://doi.org/10.3390/jrfm15120572

Gençay, R., Selçuk, F., & Whitcher, B. (2002). *An introduction to wavelets and other filtering methods in finance and economics*. Academic Press.

Hampl, F., Linnertová, D. V., & Horváth, M. (2024). Crypto havens during war times? Evidence from the Russian invasion of Ukraine. *The North American Journal of Economics and Finance*, *71*, 102093. https://doi.org/10.1016/j.najef.2024.102093

Jana, S., & Sahu, T. N. (2023). Is the cryptocurrency market a hedge against stock market risk? A Wavelet and GARCH approach. *Economic Notes*, *52*(3), e12227. https://doi.org/10.1111/ecno.12227

Klein, T., Pham Thu, H., & Walther, T. (2018). Bitcoin is not the new gold: A comparison of volatility, correlation, and portfolio performance. *International Review of Financial Analysis, 59*, 105–116. https://doi.org/10.1016/j.irfa.2018.07.010

Kołodziejczyk, H. (2023). Stablecoins as diversifiers, hedges and safe havens: A quantile coherency approach. *The North American Journal of Economics and Finance*, *66*, 101912. https://doi.org/10.1016/j.najef.2023.101912

Kristoufek, L. (2013). Fractal markets hypothesis and the global financial crisis: Wavelet power evidence. *Scientific reports*, *3*(1), 2857. https://doi.org/10.1038/srep02857

Kumah, S. P., & Odei-Mensah, J. (2021). Are cryptocurrencies and African stock markets integrated? *The Quarterly Review of Economics and Finance*, *81*, 330–341. https://doi.org/10.1016/j.qref.2021.06.022

Kumah, S. P., Odei-Mensah, J., & Baaba Amanamah, R. (2022). Co-movement of cryptocurrencies and African stock returns: A multiresolution analysis. *Cogent Business & Management*, *9*(1), 2124595. https://doi.org/10.1080/23311975.2022.2124595

Kumar, A. S., & 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*, *47*, 102707. https://doi.org/10.1016/j.frl.2022.102707

Kumar, A. S., Suvvari, A., & Hafsal, K. (2026). How Safe Are the Safe Haven Assets? Insights From a Novel Cross-Frequency Analysis. *Energy Research Letters*, *7*(2). https://doi.org/10.46557/001c.138282

Markowitz, H. (1952). Portfolio selection. *The Journal of Finance, 7*(1), 77–91. https://doi.org/10.1111/j.1540-6261.1952.tb01525.x

Naeem, M. A., Agyemang, A., Chowdhury, M. I. H., Hasan, M., & Shahzad, S. J. H. (2022). Precious metals as hedge and safe haven for African stock markets. *Resources Policy*, *78*, 102781. https://doi.org/10.1016/j.resourpol.2022.102781

Percival, D. B., & Walden, A. T. (2000). *Wavelet methods for time series analysis*. Cambridge University Press. https://doi.org/10.1017/CBO9780511841040

Peters, E. E. (1994). *Fractal market analysis: applying chaos theory to investment and economics*. John Wiley & Sons.

Phillips, P. C. B., & Perron, P. (1988). Testing for a unit root in time series regression. *Biometrika, 75*(2), 335–346. https://doi.org/10.1093/biomet/75.2.335

Smales, L. A. (2019). Bitcoin as a safe haven: Is it even worth considering? *Finance Research Letters, 30*, 385–393. https://doi.org/10.1016/j.frl.2018.11.002

Zhang, C., Liu, S., Qin, M., & Gao, B. (2025). The dependency structure of international commodity and stock markets after the Russia-Ukraine war. *Plos one*, *20*(2), e0316288. https://doi.org/10.1371/journal.pone.0316288

© 2026 Author(s). This article is licensed under the Creative Commons Attribution–NonCommercial 4.0 International License (CC BY-NC 4.0).