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From digital gold to digital mirage? Hedge and safe haven: Evidence from ASEAN+2 and G5 countries

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ABSTRACT

Volatility, economic shocks, geopolitical tensions, and financial crises can cause major investment losses in financial markets and thus emphasize the need for risk-mitigation assets. The growing popularity of cryptocurrencies as risk mitigation assets has attracted increasing scholarly and investor attention. If cryptocurrencies are potential digital gold, do they really offer the same hedging abilities as the universal hedge, gold, or are they merely just a digital mirage? Thus, this study aims to examine the hedge properties of gold and cryptocurrencies against stock markets in ASEAN+2 and G5 countries to uncover evidence in both emerging and developed financial markets. By using daily data spanning from 10 November 2017 to 31 December 2024, the DCC-GJR-GARCH model is employed to estimate optimal portfolio weights, hedge ratios, and hedge effectiveness, while Modified Value at Risk (MVaR) and Modified Conditional Value at Risk (MCVaR) are applied to assess downside risk under varying asset allocations. Results demonstrate that gold remains the most reliable hedging instrument, consistently exhibiting superior hedge effectiveness and significantly reducing tail risks. In contrast, cryptocurrencies provide limited hedging benefits and cannot yet substitute for gold as a universal hedging instrument in both emerging and developed financial markets. Thus, the idea of cryptocurrencies being digital gold is a digital mirage. The findings therefore recommend that national central banks of both emerging and developed countries maintain gold within their reserves to enhance financial resilience against market disruptions. The findings suggest investors should view cryptocurrencies with caution, as they do not function as dependable digital gold.

Contribution/Originality: This study contributes to recent literature by jointly analyzing hedge effectiveness and portfolio downside risk across multiple cryptocurrencies and market conditions, not limited to the European context but also the ASEAN+2 countries through joint analysis of DCC-GJR-GARCH, MVaR, and MCVaR analysis. It enhances understanding of the hedging abilities of both cryptocurrencies and gold in ASEAN+2 and G5 contexts.

1. INTRODUCTION

Over the past decade, gold has consistently been regarded as a hedge and safe-haven asset during periods of financial turmoil. With the growing prominence of digital assets, some scholars argue that cryptocurrencies represent a novel form of "digital gold": a digital store of value comparable to gold (Watters, 2023). However, other studies

contend that the hedging capacity of cryptocurrencies remains limited, raising the question of whether they should be viewed as a reliable hedge or merely a digital mirage; an attractive yet illusory construct driven by speculative enthusiasm (Kruse & Tumbas, 2016). Financial markets are inherently exposed to risks stemming from volatility, economic shocks, geopolitical tensions, and crises, all of which can result in substantial investor losses. Consequently, identifying an effective and dependable hedge instrument remains a central concern for investors.

Cryptocurrency is commonly defined as a digital asset that facilitates transactions through blockchain technology (Härdle, Harvey, & Reule, 2020; Vashisth, Salako, & Pinto, 2024). Cryptocurrencies can be categorized into various types, including transaction-based tokens, distributed computation tokens, utility tokens, security tokens, fungible tokens, non-fungible tokens, and stablecoins. Since the introduction of Bitcoin as the pioneer cryptocurrency, numerous alternative digital currencies have emerged. Despite their widespread popularity, cryptocurrencies are still considered to be in an early stage of development (Matharu, 2019; Shahzad, Xu, Lim, Hasnain, & Nusrat, 2024). Meanwhile, gold is widely recognized as a universal store of value due to its low correlation with equity markets and its relatively stable price behaviour. Given the similarities between cryptocurrencies and gold, particularly their decentralized characteristics and comparatively low correlation with stock markets, some scholars argue that cryptocurrencies may serve as a substitute for gold, functioning as a form of digital gold (Baur, Karlsen, Smales, & Trench, 2024; Watters, 2023).

Moreover, the emergence of major crises, including the Asian Financial Crisis of 1997, the Global Financial Crisis of 2008–2009, the COVID-19 pandemic, and the Russia–Ukraine war has adversely affected global stock markets and reinforced the imperative to identify effective hedge and safe-haven instruments capable of mitigating portfolio risk. Nevertheless, cryptocurrency prices are highly sensitive to a range of factors, including but not limited to supply–demand dynamics. Despite their substantial volatility, investments in cryptocurrencies have continued to grow (Arnone, 2024; Vasudeva, 2023) with investors increasingly incorporating them into diversified portfolios as a potential means of risk reduction. Given this volatility, however, the claim that cryptocurrencies function as digital gold remains inconclusive, necessitating further empirical investigation to determine whether they represent a genuine hedge or simply a digital mirage (Belguith, Alnafisah, Snene Manzli, & Jeribi, 2025; Wang, 2024). In addition, existing literature offers mixed perspectives on the hedging capabilities of cryptocurrencies and gold within stock portfolios (Stensås, Nygaard, Kyaw, & Treepongkaruna, 2019). The degree of cryptocurrency adoption and market integration varies across countries, even among those with comparable economic conditions. Previous studies indicate that the hedge and safe-haven properties of cryptocurrencies are influenced by investment horizons, market regimes, sectors, and regional characteristics (Bouri, Molnár, Azzi, Roubaud, & Hagfors, 2017; Garcia-Jorcano & Benito, 2020; Kakinuma, 2022; Kang, Yoon, Bekiros, & Uddin, 2020; Kliber, Marszałek, Musiałkowska, & Świerczyńska, 2019). However, the global literature still lacks consensus regarding their effectiveness as hedging instruments. Furthermore, much of the existing research relies on conventional regression-based models to examine return relationships without explicitly quantifying underlying risk exposures. Studies focusing on emerging financial markets, particularly within the ASEAN region, also remain comparatively limited.

Accordingly, this study offers several novel contributions to the existing literature. First, it provides evidence on the hedge effectiveness of a broad set of cryptocurrencies, extending beyond the pioneer cryptocurrency, Bitcoin. Second, while prior studies have predominantly focused on Western economies, empirical research examining ASEAN countries alongside China and Russia (ASEAN+2) remains limited. Although this regional grouping is not commonly used in prior literature, it is adopted in this study to explore cross-regional differences in hedge effectiveness. Given the scarcity of studies focusing specifically on ASEAN+2, this research fills an important gap by providing comparative insights into the hedging roles of cryptocurrencies and gold not only within G5 countries but also within these emerging markets. Offering a direct comparison between ASEAN+2 and G5 markets also highlights how differences in financial market development influence the hedge effectiveness of these assets; an aspect that

remains underexplored. This, in turn, supports the need for tailored investment strategies for specific regions rather than relying on broad, global generalizations.

Third, this study evaluates the relative hedge effectiveness of multiple cryptocurrencies versus gold to assess the narrative of cryptocurrencies as "digital gold." Fourth, it departs from much of the existing literature by explicitly quantifying the risks associated with including various cryptocurrencies and gold in investment portfolios. This is achieved through modified risk measures, namely Modified Value-at-Risk (MVaR) and Modified Conditional Value-at-Risk (MCVaR), which offer greater robustness in the presence of non-normal return distributions compared to traditional VaR and CVaR metrics. The integration of GARCH-based volatility modeling with modified risk measures provides a more comprehensive analytical framework that accounts for both hedge effectiveness and extreme tail-risk behavior without overlooking the assets' hedging capabilities.

Overall, the primary objective of this study is to examine the hedge effectiveness of cryptocurrencies and gold in ASEAN+2 and G5 markets, with particular emphasis on overall variance reduction and downside risk mitigation. The findings are intended to provide investors with clearer guidance in selecting reliable instruments for managing portfolio risk. Additionally, the study employs data spanning from 2017 to 2024, allowing the analysis to capture recent market developments and reflect contemporary dynamics. The remainder of this paper is structured as follows: the next section reviews the relevant literature, followed by the research methodology, empirical results and discussion, and finally, the conclusion.

2. LITERATURE REVIEW

Modern portfolio theory (Markowitz, 1952) posits that diversification across assets with low or negative correlations is an effective strategy for reducing idiosyncratic risk. Under this framework, losses in one asset class can be offset by gains in another, particularly during market downturns, thereby emphasizing the importance of identifying reliable hedging instruments. However, this perspective contrasts with the efficient market hypothesis (Fama, 1970), which asserts that asset prices fully incorporate available information, implying that the potential gains from hedging are already reflected in market valuations. In practice, financial markets deviate from the ideal of full efficiency due to behavioural biases, structural frictions, and the occurrence of extreme events. These departures create space for assets to exhibit hedging and safe-haven properties, making the search for effective hedges both relevant and necessary for contemporary portfolio management.

Empirically, the debate remains unsettled. Several studies such as Antar (2025), Jana and Sahu (2025), Abdelmalek (2024), Fakhfekh and Ben Salem (2024), Tan, Ling, Sim, and Ming (2023), Widarto, Muharam, Wahyudi, and Pangestuti (2022), and Mariana, Ekaputra, and Husodo (2021), have reported that cryptocurrencies can provide hedging benefits, thereby reinforcing the narrative of "digital gold" as a functional store of value comparable to physical gold. Conversely, another strand of research, including Nguyen and Pham (2025), Echaust, Just, and Kliber (2024), and Maitra, Rehman, Dash, and Kang (2022), documents the absence of hedging capabilities in cryptocurrencies, challenging the central premise of modern portfolio theory that incorporating low-correlation assets should reduce overall portfolio risk. These competing perspectives underscore a persistent gap in the literature: the lack of consensus on whether cryptocurrencies can truly function as hedges or safe-haven assets across different market environments and regions. This inconsistency provides a strong theoretical and empirical justification for further investigation, particularly in emerging markets where financial structures, adoption levels, and market behaviours may differ markedly from those in advanced economies.

Furthermore, an emerging strand of literature shows that the hedge and safe-haven properties of cryptocurrencies vary considerably across investment horizons (Abdelmalek & Benlagha, 2023; Bouri, Shahzad, Roubaud, Kristoufek, & Lucey, 2020; Jiang, Lie, Wang, & Mu, 2021). Other studies, including Korsah, Mensah, Osei, and Amewu (2026); Tarchella, Khalfaoui, and Hammoudeh (2024); Tan et al. (2023), and Ustaoglu (2023), conclude that the hedging performance of cryptocurrencies is highly market dependent. However, much of this evidence is

situated within European or advanced-economy contexts, with limited attention given to ASEAN markets. For example, Abdelmalek and Benlagha (2023) examine the United States, the United Kingdom, Germany, Japan, and China; Korsah et al. (2026) focus on African equity markets; and Tarchella et al. (2024) investigate G7 economies. Only Tan et al. (2023) assess hedge properties within East Asia-5 markets, yet even their analysis relies solely on regression-based coefficients without explicitly quantifying hedge effectiveness or downside risk exposure. These gaps underscore the need to investigate whether cryptocurrencies exhibit meaningful hedging capabilities within ASEAN countries, particularly in terms of both hedge effectiveness and downside risk mitigation.

In addition, comparative studies examining the hedging performance of multiple cryptocurrencies remain scarce. Findings in the existing literature are mixed: Mariana et al. (2021) and Ma, Ahmad, Liu, and Wang (2020) report that Ethereum offers superior safe-haven or diversification benefits relative to Bitcoin, whereas Ustaoglu (2023) finds that Bitcoin provides stronger protection for emerging markets. Tan et al. (2023) further identify Bitcoin, Litecoin, and Ethereum as strong hedges in East Asia-5 markets. Nevertheless, many studies remain limited to a narrow subset of pioneer cryptocurrencies such as Bitcoin and Ethereum. A broader inclusion of cryptocurrencies is therefore essential to provide a more representative understanding of the overall market's hedging behaviour.

In the domain of portfolio diversification and tail-risk management, several studies have examined the role of cryptocurrencies in mitigating extreme losses. Bányai, Tatay, Thalmeiner, and Pataki (2024) report that cryptocurrencies can enhance diversification benefits in stock portfolios when assessed through Value-at-Risk (VaR) metrics, while Abdelmalek (2024) finds that certain cryptocurrencies improve portfolio performance only in the pre-pandemic period when evaluated using risk-adjusted measures such as the Sharpe and Sortino ratios. However, empirical findings on tail-risk reduction remain mixed and are often limited in scope. A further methodological concern arises from the widespread use of VaR and Sharpe ratios, both of which assume normal return distributions and therefore lack robustness when applied to assets such as cryptocurrencies, which typically exhibit heavy tails, skewness, and excess kurtosis.

With respect to gold, the majority of studies consistently document its strong hedging and safe-haven properties against stock markets (Belhassine & Riahi, 2025; Chkili, 2026; Kakinuma, 2022; Ngene, Mungai, & Hassan, 2026; Vieira, De Carvalho, Curto, & Laureano, 2023). Nevertheless, other studies highlight that gold's hedging effectiveness is sensitive to market regimes and investment horizons (Akhtaruzzaman, Boubaker, Lucey, & Sensoy, 2021; Bahloul, Mroua, & Naifar, 2023; Belhassine & Riahi, 2025; Ben Brayek, Ameur, & Alharbi, 2024; Hossain, Ismail, Akter, & Hossain, 2020; Thuy, Oanh, & Ha, 2024). Prior research also demonstrates that gold can substantially reduce downside risk in stock portfolios (Ali, Jiang, & Sensoy, 2021; Echaust & Just, 2022), reinforcing its longstanding role as a universal store of value. When comparing gold and cryptocurrencies, studies such as Kumar, Mohan, and Niveditha (2025); Klose (2022), and Dutta, Das, Jana, and Vo (2020) conclude that gold remains a superior hedge and safe haven relative to cryptocurrencies. These findings cast doubt on the notion of cryptocurrencies as "digital gold" and underscore the need for further empirical evaluation, particularly in markets where evidence remains scarce or inconclusive.

Overall, many empirical studies such as Korsah et al. (2026); Kumar et al. (2025); Abdelmalek and Benlagha (2023), and Tan et al. (2023), derive their conclusions primarily from coefficient estimates produced by traditional regression models, without explicitly quantifying the underlying risk exposures. While an asset may exhibit a negative correlation or regression coefficient with equities, this theoretical relationship does not necessarily imply meaningful reductions in tail risk during periods of market stress. Consequently, empirical evidence focusing on downside-risk estimation remains limited.

Despite the extensive body of literature examining the hedging and safe-haven attributes of cryptocurrencies and gold, debates remain unresolved, and findings are often mixed. A particularly notable gap exists in the context of ASEAN financial markets, where empirical studies are comparatively sparse. This raises an important question regarding whether cryptocurrencies can provide effective hedging benefits in emerging markets that differ

structurally from advanced economies. To address these gaps, the present study offers a more comprehensive assessment of hedge effectiveness by jointly examining portfolio variance reduction and downside risk mitigation across multiple cryptocurrencies and market conditions. This is achieved through the integration of DCC-GJR-GARCH modeling with Modified Value-at-Risk (MVaR) and Modified Conditional Value-at-Risk (MCVaR) metrics. By extending the analysis beyond the European context and incorporating both ASEAN+2 and G5 markets, this study provides a more robust understanding of the hedging role of cryptocurrencies and gold across diverse financial environments.

Table 1. Summary of variables.

Variables	Descriptions	Sources
BTC	Bitcoin	Investing.com
BCH	Bitcoin Cash	Investing.com
ADA	Cardano	Investing.com
LINK	Chainlink	Investing.com
DOGE	Dogecoin	Investing.com
ETH	Ethereum	Investing.com
XRP	Ripple	Investing.com
TRX	Tron	Investing.com
G	Gold	World Gold Council
JKSE	Jakarta Stock Exchange Composite Index	Investing.com
KLCI	FTSE Bursa Malaysia KLCI Index	Investing.com
STI	Straits Times Index	Investing.com
SETI	Stock Exchange of Thailand Index	Investing.com
VN	Vietnam Index	Investing.com
SSEC	Shanghai Stock Exchange Composite Index	Investing.com
IMOEX	MOEX Russia Index	Investing.com
FCHI	CAC 40 Index	Investing.com
GDAXI	Deutscher Aktienindex Index	Investing.com
N225	Nikkei 225 Index	Investing.com
FTSE	Financial Times Stock Exchange Index	Investing.com
SPX	Standard & Poor 500 Index	Investing.com

3. METHODOLOGY

Table 1 showed the summary of variables used in this study. Overall, this study covered a period of observations from 10 November 2017 until 31 December 2024, focusing on ASEAN+2; Indonesia, Malaysia, Singapore, Thailand, Vietnam, China, and Russia, and G5 countries; France, Germany, Japan, United Kingdom, and United States. Inclusion of both ASEAN+2 and G5 provides robust insight into the hedging capability of cryptocurrencies and gold across different market structures, both advanced and emerging financial markets. Likewise, G5 countries always serve as benchmarks of advanced financial markets, which allow meaningful comparisons with ASEAN+2. The eight cryptocurrencies; Bitcoin, Bitcoin Cash, Cardano, Chainlink, Dogecoin, Ethereum, Ripple, and Tron are selected based on top market capitalization with data availability before 2018 to provide a comprehensive understanding of the well-established cryptocurrency. The stablecoins such as USDC and Tether are not included in this study as their price fluctuations are minimal and do not exhibit significant volatility patterns, which makes them unsuitable for GARCH modeling. Moreover, since the stock market closes during the weekend, the price of cryptocurrencies is removed for the weekend to align the dataset. Similarly, this study acknowledges that the observation on 31 December 2024 reflects atypical year-end behavior. Nevertheless, given that the analysis employs DCC-GJR-GARCH modeling together with Modified VaR and Modified CVaR, both methods are designed to accommodate extreme returns and volatility spikes; hence, the observation is retained in the dataset. All the variables used in this study are sourced from reliable databases such as Investing.com and the World Gold Council, which offer real-time and historical market data with explicit sourcing, readily available, replicable information, and contextual market indicators that support robust and reliable analysis.

Before the estimation, all daily closing prices of cryptocurrencies, gold, and stock indexes are converted to USD to ensure consistency and comparability across countries and cryptocurrencies. Only then are the log returns of each asset calculated and used for the analysis of this study, as shown in the equation below.

$$R_t = ln(P_t) - ln(P_t - 1) \quad (1)$$

Where R_t is the log return, P_t is the price. Next, the diagnostics test, such as the Augmented Dickey Fuller test (ADF), the Ljung-Box test (LB) and the Lagrange Multiplier test (LM) are done to ensure that the data used are stationary, autocorrelated and with the ARCH effect respectively following the assumption of the GARCH model.

Generally, the computation of DCC-GJR-GARCH involves two steps. First, the conditional variance for univariate GJR-GARCH is estimated as shown in the equation below.

$$h_{i,t} = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i h_{i,t-1} + \gamma_i \varepsilon_{i,t-1}^2 I_{i,t-1} \quad (2)$$

Where $h_{i,t}$ is the conditional variance, ω_i is the constant term, $\alpha_i \varepsilon_{i,t-1}^2$ and $\beta_i h_{i,t-1}$ represent the ARCH and GARCH terms respectively, $\gamma_i \varepsilon_{i,t-1}^2 I_{i,t-1}$ denoted the asymmetry effect of shock on volatility. The $I_{i,t-1}$ indicator function is equal to 1 if $\varepsilon_{i,t-1} < 0$ and zero otherwise. Only then are the standardized residuals, $z_{i,t}$ calculated before computing the conditional correlation through the DCC model as shown in the equations below.

$$z_{i,t} = \frac{\varepsilon_{i,t}}{\sqrt{h_{i,t}}} \quad (3)$$

$$Q_t = (1 - \alpha - \beta)\bar{Q} + \alpha z_{t-1} z_{t-1}' + \beta Q_{t-1} \quad (4)$$

$$\rho_{ij,t} = \frac{q_{ij}}{\sqrt{q_{ii,t}\, q_{jj,t}}} \quad (5)$$

Where Q_t is the symmetric positive definite matrix, α and β are parameters represent the effect of previous shocks and previous DCCs on the present DCC respectively, $\bar{Q}$ denotes the $n \times n$ unconditional correlation matrix of standard residuals $z_{i,t}$ and the $\rho_{ij,t}$ is the dynamic conditional correlation (DCC) between pairs of assets i and j.

Later, the conditional covariance and variance derived through DCC-GJR-GARCH modeling are used to compute the optimal weight (w), optimal hedge ratio (HR), and hedge effectiveness (HE). The optimal weight of cryptocurrencies or gold in a one-dollar wallet of stock is calculated as shown in the equation below.

$$w_t = \frac{Var(r_{i,t}) - Cov(r_{i,t}, r_{j,t})}{Var(r_{i,t}) - 2Cov(r_{i,t}, r_{j,t}) + Var(r_{j,t})} \quad (6)$$

$$w_t = f(x) = \begin{cases} 0, & if\ w_t < 0 \\ w_t, & if\ 0 < w_t < 1 \\ 1, & if\ w_t > 0 \end{cases} \quad (7)$$

Next, the Optimal Hedge Ratio (HR) is calculated as shown in the equation below.

$$HR_{ij,t} = \frac{Cov(r_{i,t}, r_{j,t})}{Var(r_{j,t})} \quad (8)$$

Also, the Hedge Effectiveness (HE) is computed as shown below.

$$HE_{ij,t} = \frac{Var_{unhedged} - Var_{hedged}}{Var_{unhedged}} \quad (9)$$

$$Var_{hedged} = (w_t)^2 h_i + (1 - w_t)^2 h_j + 2w_i(1 - w_t)H_t \quad (10)$$

Since our objective here is to study the minimum variance portfolio, the optimal weight is used to compute the hedge effectiveness in accordance with studies such as Tronzano (2023) and Majumder (2022). Optimal weight helps select combinations that minimize risk, while the hedge ratio becomes restrictive when managing a portfolio, as the approach is suitable for basic spot-futures hedging with a fixed one-unit spot position. Overall, a higher HE is favorable, as it implies higher hedge effectiveness. The HE from DCC-GJR-GARCH is compared with that from ADCC-GJR-GARCH; similar findings from both models suggest the results are robust.

Besides, a traditional VAR and CVaR may not be appropriate in this study, as cryptocurrencies and stock prices have extreme price movements that do not follow a normality assumption. Therefore, MVaR and MCVaR are

employed to quantify the downside risk of stock portfolios. MVaR and MCVaR are Corner Fisher expansions of VaR and CVaR, which modify the Z-score of a standard normal distribution to adjust for skewness and kurtosis, approximating the distribution's quantile as shown in the equation below.

$$Z_{mod} = z + \frac{1}{6}(z^2 - 1)S + \frac{1}{24}(z^3 - 3z)K - \frac{1}{36}(2z^3 - 5z)S^2 \quad (11)$$

$$MVaR_{\alpha} = -\mu - (\sigma \times Z_{modified}) \quad (12)$$

$$MCVaR_{\alpha} = -\mu - (\sigma \times \frac{\emptyset Z_{modified}}{1-\alpha}) \quad (13)$$

Where z refers to the quantile from the standard normal distribution, S refers to the skewness of returns while K denotes the excess kurtosis of return, α refers to the confidence level, μ is the mean of return, σ denotes the standard deviation and $\emptyset Z_{modified}$ refers to the standard normal probability density function evaluated at Z_{mod}.

In this study, both the MVaR and MCVaR at 99% and 95% confidence levels of stock portfolios, including cryptocurrencies and gold based on optimal weight allocation (OW) and equal weight allocation (EW), are computed and compared with single stocks to determine whether downside risk is truly reduced. Only when both the MVaR and MCVaR metrics decrease simultaneously does the asset effectively mitigate downside risk. Later, the relative MVaR at a 99% confidence level of all portfolios of cryptocurrency-stock and gold-stock, based on different allocation weights by cryptocurrencies and gold, are graphed to determine how changes in the weighting of cryptocurrencies and gold affect the downside risk of the stock portfolio as a robustness test.

Furthermore, this study employed a two-asset framework, which remains of practical and theoretical importance for both investors and policymakers. Firstly, there are numerous studies, such as Ampountolas (2023), Tronzano (2023), Ali et al. (2021), Conlon and McGee (2020), and Bredin, Conlon, and Potì (2017), that have employed the use of a two-asset framework to study the downside risk reduction of portfolios. These studies continue to use a two-asset framework extensively to isolate the extent to which a single hedging asset reduces the risk of the primary asset. Thus, it is evident that the two-asset framework is not a simplification exclusive to our study rather, it represents the prevailing empirical approach in risk reduction analysis. Likewise, a two-asset framework is analytically clear and easily interpretable both in the theoretical framework and in empirical risk management practices, providing direct quantification of how much risk is reduced. It provides insights into the extent of risk reduction in each hedging asset rather than dispersing effects across multiple assets. Moreover, the two-asset framework is relevant because investors and policymakers often focus on the bilateral relationship between assets, comparing the domestic equity market with global safe-haven assets. Studying the pairwise correlation and relationship between two assets offered clear economic insights into risk and optimal asset allocation. In practice, simple pairs trading, which involves only two highly correlated assets is popular (Ko et al., 2023; Miao & Laws, 2016; Nair, 2021). Therefore, the use of a two-asset framework remains both theoretically and practically justified.

Table 2. Descriptive statistics of variables.

Variables	Mean	Min.	Max.	σ	Skewness	Kurtosis	JB Test (p-value)
BTC	0.00	-0.52	0.25	0.04	-0.95	17.07	0.00***
BCH	-0.00	-0.60	0.41	0.07	0.03	12.54	0.00***
ADA	0.00	-0.53	0.88	0.07	2.35	30.91	0.00***
LINK	0.00	-0.68	0.49	0.07	-0.01	11.33	0.00***
DOGE	0.00	-0.50	1.47	0.08	4.23	68.29	0.00***
ETH	0.00	-0.60	0.35	0.06	-0.78	14.24	0.00***
XRP	0.00	-0.54	0.62	0.07	1.25	20.96	0.00***
TRX	0.00	-0.57	0.97	0.07	2.66	39.93	0.00***
G	0.00	-0.05	0.05	0.01	-0.31	7.01	0.00***
JKSE	-0.00	-0.10	0.11	0.01	-0.58	15.64	0.00***
KLCI	-0.00	-0.06	0.06	0.01	-0.13	9.90	0.00***
STI	0.00	-0.08	0.09	0.01	-0.22	18.08	0.00***

Variables	Mean	Min.	Max.	σ	Skewness	Kurtosis	JB Test (p-value)
SETI	-0.00	-0.12	0.07	0.01	-1.43	21.39	0.00***
VN	0.00	-0.07	0.05	0.01	-0.99	7.38	0.00***
SSEC	0.00	-0.09	0.08	0.01	-0.37	9.40	0.00***
IMOEX	-0.00	-0.45	0.19	0.02	-3.97	76.25	0.00***
FCHI	0.00	-0.14	0.09	0.01	-0.66	14.56	0.00***
GDAXI	0.00	-0.14	0.11	0.01	-0.42	15.12	0.00***
N225	0.00	-0.12	0.10	0.01	-0.38	11.39	0.00***
FTSE	0.00	-0.13	0.10	0.01	-0.94	18.97	0.00***
SPX	0.00	-0.13	0.09	0.01	-0.84	18.35	0.00***

Note: *** indicates statistically significance at 5% level, BTC-Bitcoin, BCH-Bitcoin Cash, ADA-Cardano, LINK-Chainlink, DOGE-Dogecoin, ETH-Ethereum, XRP-Ripple, TRX-Tron, G-Gold, JKSE-Indonesia, KLCI-Malaysia, STI-Singapore, SETI-Thailand, VN-Vietnam, SSEC-China, IMOEX-Russia, FCHI-France, GDAXI-Germany, N225-Japan, FTSE-United Kingdom & SPX-United States & JB test refers to Jarque-Bera test.

4. RESULTS AND DISCUSSIONS

4.1. Descriptive Statistics and Diagnostic Tests

Table 2 shows the descriptive statistics of variables used in this study. Overall, the standard deviation of gold is lower than that of cryptocurrencies, indicating that gold is less volatile than cryptocurrencies. Additionally, the normality assumption of variables is violated, as the distribution of stock return is consistently deviated from normal in real-world data (Cevik, Cevik, & Dibooglu, 2020), often accompanied by extreme prices due to shocks. Excluding these extreme values under the normality assumption may underestimate the risk and volatility inherent in stock prices (Chen, Liu, & Zhao, 2021). Likewise, applying multivariate DCC-GJR-GARCH modelling in this study does not require a normality assumption for the underlying return distribution (Engle & Sheppard, 2001).

Table 3. Diagnostics Test of Variables.

Variables	ADF		PP		LB		LM	
	Statistics	P-value	Statistics	P-value	Statistics	P-value	Statistics	P-value
BTC	-10.97	0.01***	-2023.50	0.01***	38.83	0.00***	32.80	0.00***
BCH	-11.75	0.01***	-1975.10	0.01***	139.51	0.00***	97.24	0.00***
ADA	-9.73	0.01***	-2036.30	0.01***	178.54	0.00***	151.17	0.00***
LINK	-11.25	0.01***	-2019.00	0.01***	125.18	0.00***	94.00	0.00***
DOGE	-11.17	0.01***	-1729.40	0.01***	53.04	0.00***	46.37	0.00***
ETH	-10.81	0.01***	-2055.20	0.01***	54.54	0.00***	43.18	0.00***
XRP	-10.43	0.01***	-1978.40	0.01***	159.16	0.00***	111.75	0.00***
TRX	-9.85	0.01***	-1974.10	0.01***	353.58	0.00***	274.11	0.00***
G	-11.85	0.01***	-1817.60	0.01***	257.63	0.00***	145.58	0.00***
JKSE	-11.55	0.01***	-1924.70	0.01***	1602.80	0.00***	566.37	0.00***
KLCI	-11.49	0.01***	-2017.10	0.01***	1028.20	0.00***	432.66	0.00***
STI	-11.85	0.01***	-2078.80	0.01***	1316.10	0.00***	465.96	0.00***
SETI	-10.35	0.01***	-2115.40	0.01***	804.78	0.00***	389.00	0.00***
VN	-11.87	0.01***	-1939.30	0.01***	425.87	0.00***	204.12	0.00***
SSEC	-12.50	0.01***	-1961.80	0.01***	123.14	0.00***	87.97	0.00***
IMOEX	-12.39	0.01***	-2371.90	0.01***	339.98	0.00***	196.78	0.00***
FCHI	-12.39	0.01***	-1924.70	0.01***	651.76	0.00***	346.53	0.00***
GDAXI	-12.11	0.01***	-1965.20	0.01***	523.57	0.00***	342.95	0.00***
N225	-12.26	0.01***	-1974.50	0.01***	455.56	0.00***	334.44	0.00***
FTSE	-12.22	0.01***	-1893.90	0.01***	804.58	0.00***	420.65	0.00***
SPX	-12.32	0.01***	-2195.20	0.01***	2345.90	0.00***	718.82	0.00***

Note: *** indicates statistically significance at 5% level, BTC-Bitcoin, BCH-Bitcoin Cash, ADA-Cardano, LINK-Chainlink, DOGE-Dogecoin, ETH-Ethereum, XRP-Ripple, TRX-Tron, G-Gold, JKSE-Indonesia, KLCI-Malaysia, STI-Singapore, SETI-Thailand, VN-Vietnam, SSEC-China, IMOEX-Russia, FCHI-France, GDAXI-Germany, N225-Japan, FTSE-United Kingdom & SPX-United States. ADF refers to Augmented Dickey Fuller test, PP refers to Phillips Perron test, LB denotes Ljung-Box test & LM denotes Lagrange Multiplier test.

Referring to Table 3, all the variables are found to reject the null hypothesis in both ADF and PP tests, concluding that the variables are stationary at the level in which they behave consistently over time, enabling better statistical inferences. In LB and LM tests, all the p-values of variables are also rejected at the 5% significance level,

inferring that there is autocorrelation in the residual up to lag 10 and the presence of heteroskedasticity in the residuals of each series, respectively. Hence, the application of the DCC-GJR-GARCH model is appropriate.

Table 4. Estimation Results of Optimal Weight (w), Hedge Ratio (HR) & Hedge Effectiveness (HE) of Cryptocurrencies & Gold in Δ Stock Markets (%).

Stock markets	(w)	HR	HE
Bitcoin			
ASEAN+2			
Indonesia (JKSE)	5.17	1.89	3.90
Malaysia (KLCI)	2.76	1.24	1.96
Singapore (STI)	2.69	1.69	2.05
Thailand (SETI)	3.84	2.52	2.45
Vietnam (VN)	6.69	1.98	5.30
China (SSEC)	6.56	2.06	5.37
Russia (IMOEX)	15.07	6.34	11.84
G5			
France (FCHI)	4.06	5.67	2.23
Germany (GDAXI)	4.33	5.76	2.38
Japan (N225)	7.50	1.57	6.49
United Kingdom (FTSE)	2.95	4.87	1.57
United States (SPX)	2.30	6.10	1.71
Bitcoin Cash			
ASEAN+2			
Indonesia (JKSE)	1.96	1.60	1.21
Malaysia (KLCI)	1.02	0.94	0.58
Singapore (STI)	1.17	1.11	1.92
Thailand (SETI)	1.57	1.54	0.90
Vietnam (VN)	2.51	1.86	1.58
China (SSEC)	2.53	1.55	1.66
Russia (IMOEX)	8.41	3.44	6.69
G5			
France (FCHI)	1.62	3.40	0.90
Germany (GDAXI)	1.78	3.35	1.06
Japan (N225)	3.32	1.16	2.52
United Kingdom (FTSE)	1.06	3.17	0.59
United States (SPX)	0.90	3.72	0.64
Cardano			
ASEAN+2			
Indonesia (JKSE)	1.79	1.64	1.03
Malaysia (KLCI)	0.01	1.07	0.44
Singapore (STI)	0.69	1.58	0.35
Thailand (SETI)	0.89	2.35	0.38
Vietnam (VN)	2.75	1.62	1.84
China (SSEC)	2.22	2.08	1.28
Russia (IMOEX)	7.69	4.68	5.59
G5			
France (FCHI)	1.00	4.26	0.38
Germany (GDAXI)	1.00	4.43	0.37
Japan (N225)	2.96	1.83	1.93
United Kingdom (FTSE)	0.59	3.73	0.22
United States (SPX)	0.57	4.47	0.31
Chainlink			
ASEAN+2			
Indonesia (JKSE)	1.46	1.28	0.86
Malaysia (KLCI)	0.92	0.61	0.69
Singapore (STI)	0.73	0.96	0.43
Thailand (SETI)	0.63	1.97	0.26
Vietnam (VN)	2.07	1.36	1.34
China (SSEC)	2.01	1.31	1.30
Russia (IMOEX)	6.35	4.40	4.66
G5			
France (FCHI)	0.70	3.65	0.28
Germany (GDAXI)	0.71	3.78	0.27
Japan (N225)	2.53	1.12	1.81
United Kingdom (FTSE)	0.49	3.05	0.27
United States (SPX)	0.39	3.69	0.21

Stock markets	(w)	HR	HE
Dogecoin			
ASEAN+2			
Indonesia (JKSE)	2.82	1.16	2.10
Malaysia (KLCI)	1.31	0.90	0.84
Singapore (STI)	1.25	1.36	0.78
Thailand (SETI)	1.85	1.86	1.08
Vietnam (VN)	3.13	1.42	2.26
China (SSEC)	3.13	1.40	2.26
Russia (IMOEX)	8.94	3.96	6.95
G5			
France (FCHI)	2.41	3.64	1.28
Germany (GDAXI)	2.62	3.54	1.46
Japan (N225)	3.96	1.10	3.17
United Kingdom (FTSE)	1.71	3.14	0.85
United States (SPX)	1.47	3.93	0.80
Ethereum			
ASEAN+2			
Indonesia (JKSE)	2.68	1.73	1.70
Malaysia (KLCI)	1.35	1.12	0.77
Singapore (STI)	1.03	1.76	0.59
Thailand (SETI)	1.55	2.70	0.86
Vietnam (VN)	3.70	2.08	2.51
China (SSEC)	3.23	2.57	1.98
Russia (IMOEX)	9.72	5.91	7.30
G5			
France (FCHI)	1.56	5.17	0.73
Germany (GDAXI)	1.61	5.22	0.77
Japan (N225)	4.24	1.88	3.03
United Kingdom (FTSE)	0.99	4.35	0.45
United States (SPX)	0.95	5.18	0.67
Ripple			
ASEAN+2			
Indonesia (JKSE)	2.56	1.57	1.73
Malaysia (KLCI)	0.95	1.33	0.48
Singapore (STI)	0.86	2.04	0.51
Thailand (SETI)	1.26	2.50	0.61
Vietnam (VN)	3.43	1.46	2.50
China (SSEC)	2.62	2.21	1.61
Russia (IMOEX)	8.55	4.97	6.35
G5			
France (FCHI)	1.76	4.05	0.80
Germany (GDAXI)	1.67	4.40	0.74
Japan (N225)	3.84	1.38	2.90
United Kingdom (FTSE)	0.99	3.94	0.42
United States (SPX)	1.05	4.49	0.53
Tron			
ASEAN+2			
Indonesia (JKSE)	4.93	1.69	3.81
Malaysia (KLCI)	3.26	0.74	2.70
Singapore (STI)	2.71	1.54	1.92
Thailand (SETI)	3.95	2.61	2.63
Vietnam (VN)	7.22	1.42	6.20
China (SSEC)	6.43	2.25	5.04
Russia (IMOEX)	15.10	5.72	12.74
G5			
France (FCHI)	5.72	4.28	3.70
Germany (GDAXI)	5.59	4.68	3.50
Japan (N225)	7.66	2.21	6.23
United Kingdom (FTSE)	3.81	4.02	2.21
United States (SPX)	3.37	4.45	2.00
Gold			
ASEAN+2			
Indonesia (JKSE)	59.42	15.55	53.52
Malaysia (KLCI)	45.31	11.52	39.52
Singapore (STI)	44.81	14.05	38.58
Thailand (SETI)	58.25	29.38	45.60

Stock markets	(w)	HR	HE
Vietnam (VN)	62.14	-1.25	62.60
China (SSEC)	64.61	23.08	56.77
Russia (IMOEX)	78.23	12.06	75.54
G5			
France (FCHI)	64.83	18.40	58.65
Germany (GDAXI)	66.06	20.17	59.50
Japan (N225)	67.37	16.83	62.07
United Kingdom (FTSE)	59.86	20.04	52.13
United States (SPX)	54.84	3.72	53.42

Note: JKSE – Jakarta Stock Exchange Composite Index; KLCI – FTSE Bursa Malaysia KLCI Index; STI – Straits Times Index; SETI – Stock Exchange of Thailand Index; VN – Vietnam Index; SSEC – Shanghai Stock Exchange Composite Index; IMOEX – MOEX Russia Index; FCHI – CAC 40 Index; GDAXI– Deutscher Aktienindex Index; N225 – Nikkei 225 Index; FTSE – Financial Times Stock Exchange Index; SPX – Standard & Poor 500 Index.

4.2. Optimal Weight (w), Optimal Hedge Ratio (HR) and Hedge Effectiveness (HE)

Table 4 displayed the average optimal weight (w), average optimal hedge ratio (HR) and average hedge effectiveness (HE) of cryptocurrencies and gold with stocks. Most cryptocurrencies show a low average optimal weight of at most 10%. Yet, there is a notable exception in Russia, where the average optimal weight of Bitcoin and Tron is 15.07% and 15.10%, respectively. However, gold showed a relatively higher average optimal weight of more than 44% in all the stock markets consistent with the finding from Yousaf, Bouri, Ali, and Azoury (2021). Similarly, Naeem, Hasan, Arif, and Shahzad (2020) also discovered that although a higher allocation of gold is needed, it still reduces portfolio risk significantly.

Besides, the average optimal hedge ratio of cryptocurrencies and gold varies across different stock markets. Again, the optimal hedge ratio of cryptocurrencies and gold remains positive except for the gold-Vietnam pair. This implies that a similar position should be taken in both hedged and hedging assets to minimize risk since there is a negative relationship. In general, optimal weight and hedge ratio both rely on different constraints. The optimal weight allows only long positions, with the weight constrained to lie between 0 and 1; in contrast, the hedge ratio can take positive or negative values, representing either long or short positions.

Notably, past studies found negative hedge ratios for gold, which contradict our study, revealing a positive hedge ratio in most countries. This is because these past findings are not universal and differ across the asset class, period of study, and markets. Studies from both Yun, Choi, and Kim (2023) and Yousaf et al. (2021) confirm these findings. Yet, our findings are still consistent with those from Chemkha, BenSaïda, Ghorbel, and Tayachi (2021) and Yousaf et al. (2021), which revealed a positive hedge ratio for gold in the equity market. Even if gold and stocks are moving in the same direction, an appropriately scaled position of gold can still reduce the overall risks significantly. This aligns with the hedge concept from Baur and Lucey (2010), which does not require a persistent negative correlation but only a negative or no correlation with another assets.

Additionally, gold is found to show the highest hedge effectiveness, with more than 38% in all stock markets, while cryptocurrencies showed lower hedge effectiveness, not exceeding 13% across all markets. Cryptocurrencies only demonstrated notable hedge effectiveness in Russia, where Tron showed the highest hedge effectiveness against the Russian stock market, with 11.84% and 12.74%, respectively, followed by Bitcoin. Among all cryptocurrencies, Tron exhibited the highest hedge effectiveness in all stock markets except for Singapore, China, and Japan. Bitcoin only showed the highest hedge in Singapore, China, and Japan. Overall, gold demonstrated relatively higher hedge effectiveness against the stock markets of ASEAN+2 and G5, ranging from 38.58% to 75.54%, suggesting that gold is a superior hedge, consistent with findings from Yousaf et al. (2021) and Naeem et al. (2020).

Table 5. Estimation Results of Modified Value at Risk (MVaR) & Modified Conditional Value at Risk (MCVaR) (%).

Portfolios	MVaR						MCVaR					
	$\alpha = 0.01$			$\alpha = 0.05$			$\alpha = 0.01$			$\alpha = 0.05$		
	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}
Bitcoin	$MVaR_{99} = 11.70, MVaR_{95} = 6.39$						$MCVaR_{99} = 14.92, MCVaR_{95} = 9.51$					
ASEAN+2												
Indonesia (JKSE)	3.12	6.08	2.90	1.75	3.35	1.67	3.65	7.67	3.54	2.66	5.00	2.48
Malaysia (KLCI)	2.14	6.06	2.09	1.27	3.32	1.25	2.82	7.44	2.75	1.80	5.01	1.76
Singapore (STI)	2.18	5.97	2.08	1.29	3.33	1.26	2.85	7.62	2.73	1.85	4.93	1.76
Thailand (SETI)	2.62	6.15	2.48	1.57	3.40	1.50	3.45	7.64	3.23	2.21	5.10	2.08
Vietnam (VN)	4.02	5.70	3.64	2.12	3.32	1.98	4.02	7.66	3.68	3.56	4.74	3.21
China (SSEC)	2.99	5.91	2.93	1.78	3.41	1.74	3.97	7.01	3.90	2.51	4.95	2.46
Russia (IMOEX)	7.53	6.94	5.58	5.48	5.81	4.57	7.53	8.64	5.58	5.48	5.81	4.57
G5												
France (FCHI)	3.63	6.20	3.61	1.99	3.53	1.96	4.16	8.10	4.15	3.06	5.16	3.01
Germany (GDAXI)	3.71	6.28	3.60	2.03	3.54	2.00	4.22	8.17	4.20	3.13	5.19	3.06
Japan (N225)	3.31	5.95	3.13	2.00	3.37	1.90	4.20	7.69	3.98	2.84	4.94	2.70
United Kingdom (FTSE)	3.40	6.15	3.32	1.80	3.48	1.77	3.49	8.00	3.58	2.87	5.10	2.77
United States (SPX)	3.47	6.32	3.24	1.81	3.53	1.77	3.47	8.07	3.51	2.96	5.24	2.80
Bitcoin Cash	$MVaR_{99} = 20.62, MVaR_{95} = 9.67$						$MCVaR_{99} = 23.80, MCVaR_{95} = 13.35$					
ASEAN+2												
Indonesia (JKSE)	3.12	10.65	2.89	1.75	4.98	1.70	3.65	11.67	3.60	2.66	7.00	2.48
Malaysia (KLCI)	2.14	10.74	2.12	1.27	4.95	1.27	2.82	10.83	2.78	1.80	7.02	1.79
Singapore (STI)	2.18	10.40	2.05	1.29	4.94	1.27	2.85	12.08	2.65	1.85	6.92	1.76
Thailand (SETI)	2.62	10.46	2.56	1.57	5.01	1.54	3.45	12.04	3.40	2.21	7.11	2.16
Vietnam (VN)	4.02	10.38	3.89	2.12	5.01	2.07	4.02	12.26	3.89	3.56	7.10	3.45
China (SSEC)	2.99	10.15	2.97	1.78	5.02	1.77	3.97	13.01	3.98	2.51	7.05	2.49
Russia (IMOEX)	7.53	10.45	5.99	3.16	5.41	2.95	7.53	13.63	5.99	5.48	7.78	4.93
G5												
France (FCHI)	3.63	10.16	3.55	1.99	5.10	1.98	4.16	13.50	4.14	3.06	7.15	3.02
Germany (GDAXI)	3.71	10.22	3.56	2.03	5.12	2.01	4.22	13.33	4.20	3.13	7.23	3.05
Japan (N225)	3.31	10.60	3.18	2.00	5.01	1.96	4.20	7.69	3.98	2.84	4.94	2.70
United Kingdom (FTSE)	3.40	10.41	3.35	1.80	5.07	1.78	3.49	13.00	3.52	2.87	7.10	2.82
United States (SPX)	3.47	10.38	3.34	1.81	5.16	1.79	3.47	12.87	3.45	2.96	7.41	2.87
Cardano	$MVaR_{99} = 16.89, MVaR_{95} = 9.36$						$MCVaR_{99} = 28.04, MCVaR_{95} = 12.20$					
ASEAN+2												
Indonesia (JKSE)	3.12	8.97	3.00	1.75	4.84	1.71	3.65	14.70	3.69	2.66	6.38	2.54
Malaysia (KLCI)	2.14	8.94	2.15	1.27	4.80	1.27	2.82	14.38	2.83	1.80	6.40	1.81

Portfolios	MVaR						MCVaR					
	$\alpha = 0.01$			$\alpha = 0.05$			$\alpha = 0.01$			$\alpha = 0.05$		
	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}
Singapore (STI)	2.18	8.81	2.14	1.29	4.83	1.28	2.85	14.44	2.81	1.85	6.36	1.81
Thailand (SETI)	2.62	9.12	2.57	1.57	4.90	1.55	3.45	14.77	3.43	2.21	6.50	2.16
Vietnam (VN)	4.02	8.97	3.85	2.12	4.83	2.05	4.02	14.81	3.85	3.56	6.36	3.40
China (SSEC)	2.99	8.75	3.03	1.78	4.90	1.79	3.97	14.16	3.95	2.51	6.46	2.56
Russia (IMOEX)	7.53	9.36	5.90	3.16	5.26	2.98	7.53	14.81	5.90	5.48	7.03	4.89
G5												
France (FCHI)	3.63	8.93	3.63	1.99	4.99	1.98	4.16	14.53	4.18	3.06	6.58	3.05
Germany (GDAXI)	3.71	8.95	3.65	2.03	5.01	2.03	4.22	14.45	4.24	3.13	6.63	3.10
Japan (N225)	3.31	8.97	3.21	2.00	4.89	1.96	4.20	14.46	4.06	2.84	6.51	2.77
United Kingdom (FTSE)	3.40	8.98	3.31	1.80	4.94	1.79	3.49	14.91	3.61	2.87	6.45	2.80
United States (SPX)	3.47	9.29	3.35	1.81	5.03	1.80	3.47	14.92	3.46	2.96	6.73	2.89
Chainlink	$MVaR_{99} = 18.15, MVaR_{95} = 10.58$						$MCVaR_{99} = 26.20, MCVaR_{95} = 14.61$					
ASEAN+2												
Indonesia (JKSE)	3.12	9.35	2.98	1.75	5.43	1.70	3.65	13.33	3.67	2.66	7.56	2.54
Malaysia (KLCI)	2.14	9.27	2.16	1.27	5.36	1.27	2.82	13.24	2.84	1.80	7.48	1.81
Singapore (STI)	2.18	9.17	2.18	1.29	5.38	1.28	2.85	13.11	2.85	1.85	7.44	1.84
Thailand (SETI)	2.62	9.33	2.58	1.57	5.47	1.55	3.45	13.17	3.43	2.21	7.61	2.17
Vietnam (VN)	4.02	9.15	3.95	2.12	5.42	2.09	4.02	13.06	3.95	3.56	7.44	3.50
China (SSEC)	2.99	9.22	3.03	1.78	5.44	1.77	3.97	13.24	3.99	2.51	7.46	2.54
Russia (IMOEX)	7.53	10.12	6.19	3.16	5.87	3.05	7.53	14.32	6.19	5.48	8.20	5.22
G5												
France (FCHI)	3.63	9.37	3.71	1.99	5.58	2.00	4.16	13.16	4.14	3.06	7.69	3.08
Germany (GDAXI)	3.71	9.42	3.70	2.03	5.59	2.03	4.22	13.20	4.28	3.13	7.74	3.12
Japan (N225)	3.31	9.23	3.21	2.00	5.42	1.96	4.20	13.10	4.07	2.84	7.52	2.77
United Kingdom (FTSE)	3.40	9.44	3.39	1.80	5.55	1.80	3.49	13.34	3.52	2.87	7.70	2.85
United States (SPX)	3.47	9.67	3.36	1.81	5.59	1.79	3.47	13.74	3.45	2.96	7.82	2.87
Dogecoin	$MVaR_{99} = 21.10, MVaR_{95} = 8.95$						$MCVaR_{99} = 34.98, MCVaR_{95} = 8.95$					
ASEAN+2												
Indonesia (JKSE)	3.12	9.93	2.90	1.75	4.71	1.68	3.65	17.07	3.61	2.66	5.56	2.47
Malaysia (KLCI)	2.14	10.57	2.10	1.27	4.58	1.26	2.82	17.24	2.80	1.80	4.68	1.77
Singapore (STI)	2.18	10.77	2.15	1.29	4.63	1.27	2.85	17.19	2.84	1.85	4.67	1.81
Thailand (SETI)	2.62	10.64	2.52	1.57	4.72	1.53	3.45	16.87	3.34	2.21	5.19	2.13
Vietnam (VN)	4.02	11.34	3.84	2.12	4.65	2.05	4.02	15.99	3.84	3.56	4.65	3.38
China (SSEC)	2.99	10.48	3.13	1.78	4.67	1.78	3.97	18.06	4.13	2.51	4.91	2.58
Russia (IMOEX)	7.53	11.04	5.55	3.16	5.14	2.90	7.53	17.68	5.55	5.48	6.14	4.66

Portfolios	MVaR						MCVaR					
	$\alpha = 0.01$			$\alpha = 0.05$			$\alpha = 0.01$			$\alpha = 0.05$		
	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}
G5												
France (FCHI)	3.63	10.39	3.54	1.99	4.80	1.96	4.16	18.40	4.18	3.06	5.35	2.98
Germany (GDAXI)	3.71	10.31	3.55	2.03	4.81	1.99	4.22	18.44	4.21	3.13	5.43	3.02
Japan (N225)	3.31	10.41	3.23	2.00	4.68	1.94	4.20	17.16	4.15	2.84	5.16	2.76
United Kingdom (FTSE)	3.40	10.41	3.27	1.80	4.77	1.75	3.49	18.23	3.69	2.87	5.28	2.71
United States (SPX)	3.47	10.37	3.17	1.81	4.87	1.75	3.47	17.56	3.55	2.96	5.74	2.73
Ethereum	$MVaR_{99} = 14.91, MVaR_{95} = 8.19$						$MCVaR_{99} = 18.89, MCVaR_{95} = 12.18$					
ASEAN+2												
Indonesia (JKSE)	3.12	8.02	3.00	1.75	4.27	1.70	3.65	9.21	3.62	2.66	6.58	2.55
Malaysia (KLCI)	2.14	7.69	2.14	1.27	4.21	1.27	2.82	9.31	2.81	1.80	3.37	1.80
Singapore (STI)	2.18	7.80	2.12	1.29	4.24	1.27	2.85	9.56	2.78	1.85	6.39	1.79
Thailand (SETI)	2.62	8.04	2.50	1.57	4.34	1.53	3.45	9.40	3.33	2.21	6.65	2.11
Vietnam (VN)	4.02	7.80	3.85	2.12	4.25	2.05	4.02	9.76	3.85	3.56	6.36	3.40
China (SSEC)	2.99	7.90	2.96	1.78	4.34	1.77	3.97	9.83	3.94	2.51	6.49	2.49
Russia (IMOEX)	7.53	8.81	5.69	3.16	4.81	2.90	7.53	10.44	5.69	5.48	7.33	4.79
G5												
France (FCHI)	3.63	8.22	3.63	1.99	4.47	1.98	4.16	9.97	4.17	3.06	6.76	3.05
Germany (GDAXI)	3.71	8.19	3.65	2.03	4.48	2.03	4.22	10.01	4.22	3.13	6.76	3.11
Japan (N225)	3.31	7.90	3.26	2.00	4.31	1.96	4.20	9.57	4.12	2.84	6.52	2.81
United Kingdom (FTSE)	3.40	8.26	3.31	1.80	4.43	1.78	3.49	9.77	3.61	2.87	6.75	2.78
United States (SPX)	3.47	8.38	3.35	1.81	4.49	1.80	3.47	9.80	3.45	2.96	6.90	2.89
Ripple	$MVaR_{99} = 18.42, MVaR_{95} = 8.59$						$MCVaR_{99} = 25.95, MCVaR_{95} = 10.87$					
ASEAN+2												
Indonesia (JKSE)	3.12	9.73	2.92	1.75	4.50	1.70	3.65	11.66	3.58	2.66	6.05	2.51
Malaysia (KLCI)	2.14	9.58	2.12	1.27	4.41	1.27	2.82	12.02	2.82	1.80	5.78	1.79
Singapore (STI)	2.18	9.65	2.09	1.29	4.47	1.27	2.85	12.60	2.75	1.85	5.80	1.78
Thailand (SETI)	2.62	9.79	2.52	1.57	4.54	1.54	3.45	12.00	3.37	2.21	6.08	2.13
Vietnam (VN)	4.02	9.68	3.87	2.12	4.47	2.05	4.02	12.20	3.87	3.56	5.87	3.42
China (SSEC)	2.99	9.57	2.93	1.78	4.52	1.77	3.97	13.29	3.85	2.51	5.85	2.48
Russia (IMOEX)	7.53	10.10	5.58	3.16	4.95	2.82	7.53	13.84	5.58	5.48	6.74	4.50
G5												
France (FCHI)	3.63	9.53	3.55	1.99	4.62	1.96	4.16	13.57	4.17	3.06	6.13	2.99
Germany (GDAXI)	3.71	9.50	3.61	2.03	4.64	2.00	4.22	13.62	4.20	3.13	6.18	3.06
Japan (N225)	3.31	9.78	3.15	2.00	4.52	1.93	4.20	11.73	4.02	2.84	6.09	2.71
United Kingdom (FTSE)	3.40	9.56	3.29	1.80	4.58	1.76	3.49	13.50	3.61	2.87	6.01	2.75

Portfolios	MVaR						MCVaR					
	$\alpha = 0.01$			$\alpha = 0.05$			$\alpha = 0.01$			$\alpha = 0.05$		
	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}	S	CS_{EW}	CS_{OW}
United States (SPX)	3.47	9.88	3.28	1.81	4.69	1.77	3.47	12.58	3.49	2.96	6.40	2.82
Tron	$MVaR_{99} = 19.56, MVaR_{95} = 8.96$						$MCVaR_{99} = 19.56,\ MCVaR_{95} = 12.96$					
ASEAN+2												
Indonesia (JKSE)	3.12	10.46	2.92	1.75	4.65	1.68	3.65	10.46	3.60	2.66	6.91	2.49
Malaysia (KLCI)	2.14	10.08	2.12	1.27	4.60	1.25	2.82	10.08	2.80	1.80	6.95	1.78
Singapore (STI)	2.18	10.35	2.08	1.29	4.62	1.27	2.85	10.35	2.72	1.85	6.78	1.77
Thailand (SETI)	2.62	10.46	2.55	1.57	4.68	1.51	3.45	10.46	3.43	2.21	6.91	2.13
Vietnam (VN)	4.02	10.30	3.66	2.12	4.65	1.97	4.02	10.30	3.66	3.56	6.89	3.22
China (SSEC)	2.99	9.88	2.95	1.78	4.67	1.75	3.97	10.46	3.89	2.51	6.86	2.49
Russia (IMOEX)	7.53	10.49	5.71	3.16	5.09	2.78	7.53	11.57	5.71	5.48	7.56	4.73
G5												
France (FCHI)	3.63	10.01	3.54	1.99	4.76	1.95	4.16	10.38	4.06	3.06	7.11	3.01
Germany (GDAXI)	3.71	10.03	3.51	2.03	4.79	1.95	4.22	10.32	4.13	3.13	7.21	3.02
Japan (N225)	3.31	10.03	3.18	2.00	4.67	1.91	4.20	10.03	4.06	2.84	6.97	2.73
United Kingdom (FTSE)	3.40	9.95	3.33	1.80	4.72	1.78	3.49	10.35	3.47	2.87	7.02	2.84
United States (SPX)	3.47	10.50	3.49	1.81	4.76	1.80	3.47	10.50	3.49	2.96	7.02	2.99
Gold	$MVaR_{99} = 2.22, MVaR_{95} = 1.32$						$MCVaR_{99} = 2.92,\ MCVaR_{95} = 1.88$					
ASEAN+2												
Indonesia (JKSE)	3.12	1.98	1.84	1.75	1.15	1.08	3.65	2.56	2.41	2.66	1.67	1.55
Malaysia (KLCI)	2.14	1.56	1.51	1.27	0.96	0.93	2.82	2.03	2.03	1.80	1.33	1.28
Singapore (STI)	2.18	1.65	1.52	1.29	0.98	0.92	2.85	2.21	2.07	1.85	1.39	1.27
Thailand (SETI)	2.62	1.87	1.82	1.57	1.14	1.12	3.45	2.47	2.40	2.21	1.59	1.55
Vietnam (VN)	4.02	2.15	1.76	2.12	1.25	1.06	4.02	2.56	2.23	3.56	1.88	1.52
China (SSEC)	2.99	1.97	1.85	1.78	1.21	1.10	3.97	2.56	2.44	2.51	1.69	1.56
Russia (IMOEX)	7.53	3.93	2.06	3.16	1.80	1.22	7.53	3.93	2.70	5.48	3.14	1.75
G5												
France (FCHI)	3.63	2.18	1.87	1.99	1.25	1.12	4.16	2.74	2.46	3.06	1.84	1.58
Germany (GDAXI)	3.71	2.14	1.89	2.03	1.25	1.12	4.22	2.72	2.48	3.13	1.82	1.60
Japan (N225)	3.31	2.07	1.92	2.00	1.25	1.15	4.20	2.71	2.50	2.84	1.76	1.64
United Kingdom (FTSE)	3.40	2.09	1.86	1.80	1.18	1.10	3.49	2.57	2.44	2.87	1.76	1.58
United States (SPX)	3.47	2.02	1.76	2.96	1.72	1.50	3.47	2.42	2.21	2.96	1.72	1.50

Note: C denotes the cryptocurrency or gold; S denotes the stock; CS denotes the portfolio of cryptocurrency or gold with stock; EW denotes the equal weighting; OW denotes the optimal weighting; JKSE – Jakarta Stock Exchange Composite Index; KLCI – FTSE Bursa Malaysia KLCI Index; STI – Straits Times Index; SETI – Stock Exchange of Thailand Index; VN – Vietnam Index; SSEC – Shanghai Stock Exchange Composite Index; IMOEX – MOEX Russia Index; FCHI – CAC 40 Index; GDAXI– Deutscher Aktienindex Index; N225 – Nikkei 225 Index; FTSE – Financial Times Stock Exchange Index; SPX – Standard & Poor 500 Index.

Comparing across the ASEAN+2 and G5, this study observed that all the cryptocurrencies showed the highest hedge effectiveness in the Russian stock market, ranging from 4.66% to 12.74%. As the hedge effectiveness of cryptocurrencies is considerably low, it is concluded that cryptocurrencies do not provide superior hedging efficiency in well-developed financial markets such as G5 countries. Our findings contradict previous literature such as Fakhfekh and Ben Salem (2024); Tan et al. (2023), Jiang et al. (2021), and Kang et al. (2020), which support the hedging ability of cryptocurrencies. Also, gold demonstrates a greater hedge efficiency on average, with 57.15% in G5, higher than ASEAN+2 with 53.17%. This suggests that gold performs better as a hedge in advanced financial markets such as those in G5 countries. Also, this study revealed that despite a notably low hedge efficiency by cryptocurrencies, the average hedge effectiveness by all the cryptocurrencies in ASEAN+2 is greater than that of the G5 countries. Consequently, this suggested that cryptocurrencies showed lower correlations with the ASEAN+2 stock market.

4.3. Modified Value at Risk (MVaR) and Modified Conditional Value at Risk (MCVaR)

Table 5 shows the MVaR and MCVaR of cryptocurrency-stock and gold-stock pairs at 99% and 95% confidence levels through equal weighting and optimal weighting. The MVaR provides insight into the loss threshold, while MCVaR refers to the average loss beyond the threshold. This study found that only optimally weighted cryptocurrencies can reduce the downside risks of stock portfolios in ASEAN+2 and G5. Nevertheless, the degree of reduction is relatively minimal. More downside risk reduction by optimally weighted cryptocurrencies was observed only in the Russian stock market. Therefore, only optimally weighted cryptocurrencies could substantially reduce downside risks in ASEAN+2 and G5 stock portfolios.

Notably, there are certain cryptocurrency-stock pairs that fail to reduce downside risk even when an optimal weighting is assigned. For instance, Cardano-Malaysia, Cardano-China, Chainlink-Malaysia, Chainlink-China, Chainlink-France, Dogecoin-China, and Tron-United States fail to reduce the MVaR at a 99% confidence level, while Bitcoin-United Kingdom, Bitcoin-United States, Bitcoin Cash-China, Bitcoin Cash-United Kingdom, Cardano-Indonesia, Cardano-Malaysia, Cardano-France, Cardano-Germany, Cardano-United Kingdom, Chainlink-Indonesia, Chainlink-Malaysia, Chainlink-Singapore, Chainlink-Germany, Chainlink-China, Chainlink-United Kingdom, Dogecoin-China, Dogecoin-France, Dogecoin-United Kingdom, Dogecoin-United States, Ethereum-France, Ethereum-United Kingdom, Ripple-France, Ripple-United Kingdom, Ripple-United States, and Tron-United States fail to reduce the MCVaR at a 99% confidence interval. Therefore, it can be inferred that these cryptocurrency-stock pairs are unable to mitigate extreme tail risks. Additionally, the optimal weighted portfolio of Cardano-China, Chainlink-France, and Dogecoin-China fails to reduce the MVaR at a 95% confidence level. Furthermore, the portfolio of Cardano-Malaysia, Cardano-China, Chainlink-Malaysia, Chainlink-China, Chainlink-France, Dogecoin-China, and Tron-United States fails to reduce the MCVaR at a 99% confidence level. These pairs fail to protect against moderate tail risk.

Remarkably, gold showed a substantial reduction in both the MVaR and MCVaR metrics at 99% and 95% confidence levels, regardless of whether optimal weighting or equal weighting was assigned. This suggests that gold effectively reduces both the loss threshold and average loss beyond the threshold in moderate and extreme tail risks, consistent with the studies by Sadorsky (2024), Echaust and Just (2022), Masset and Maurer (2021), and Ali et al. (2021), which revealed that gold reduces downside risk in stocks. Comparatively, optimally weighted gold showed a greater reduction in downside risk than equal-weighted gold. Additionally, gold exhibits the highest downside risk reduction in the Russian stock market, implying it reduces downside risk more effectively in that market.

Comparing across the ASEAN+2 and G5, both cryptocurrencies and gold showed greater risk reduction in the Russian stock market. This infers that greater risk reduction by both cryptocurrencies and gold is not limited to well-developed financial markets. However, a good hedge must not be weight sensitive; thus, it was concluded that only gold offered better tail risk reduction in the stock market of ASEAN+2 and G5. Likewise, on average, optimal weighted gold showed a higher absolute downside risk reduction in extreme tail risk for ASEAN+2 (MVAR: 1.75%,

CVaR: 1.72%) than G5 (MVaR: 1.64%, MCVaR: 1.49%). Therefore, this study concluded that gold protects the ASEAN+2 stock portfolio more effectively than the G5 against extreme events.

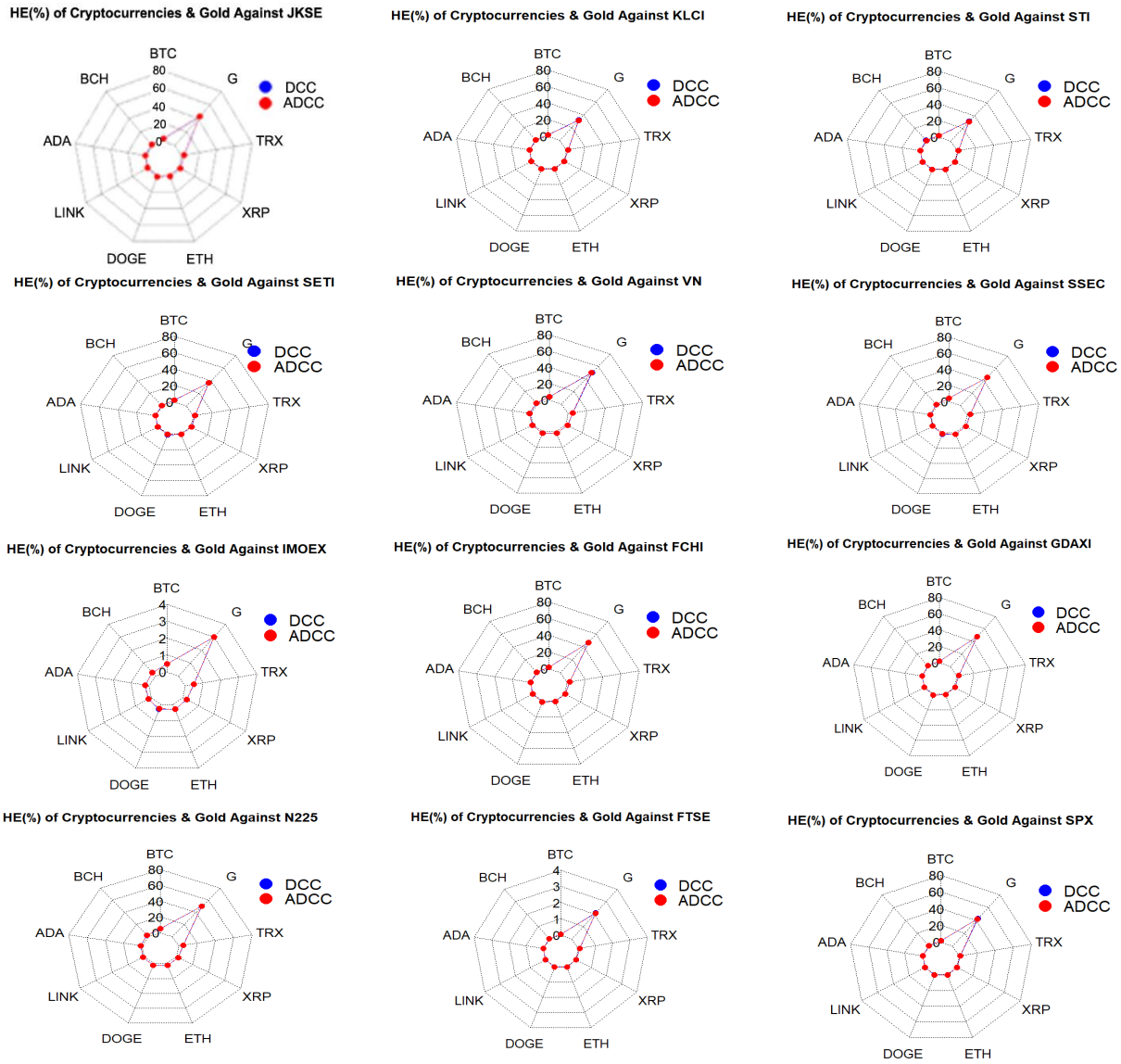

Figure 1. Radar Chart of Hedge Effectiveness (HE) from DCC-GJR-GARCH and ADCC-GJR-GARCH.

Note: BTC-Bitcoin, BCH-Bitcoin Cash, ADA-Cardano, LINK-Chainlink, DOGE-Dogecoin, ETH-Ethereum, XRP-Ripple, TRX-Tron, G-Gold, JKSE-Indonesia, KLCI-Malaysia, STI-Singapore, SETI-Thailand, VN-Vietnam, SSEC-China, IMOEX-Russia, FCHI-France, GDAXI-Germany, N225-Japan, FTSE-United Kingdom & SPX-United States.

4.4. Robustness Tests

Figure 1 illustrates the radar chart of HE for cryptocurrencies and gold against stock markets, resulting from different modeling approaches, the DCC-GJR-GARCH and ADCC-GJR-GARCH. Overall, there is no significant difference between the HE resulting from the two models. Thus, it was concluded that the HE generated by DCC-GJR-GARCH is insensitive to changes in model specifications. Additionally, Appendix A shows that increasing the allocation weight of cryptocurrencies raises both the MVaR and MCVaR metrics, but the opposite is true for gold. Therefore, it was concluded that an optimal weight is essential to ensure cryptocurrencies effectively reduce downside risk. The result aligns with our previous findings.

5. CONCLUSIONS

To sum up, this paper aims to explore the hedge and safe haven properties of various cryptocurrencies Bitcoin, Bitcoin Cash, Cardano, Chainlink, Dogecoin, Ethereum, Ripple, and Tron and gold against the stock markets of ASEAN+2: Indonesia, Malaysia, Singapore, Thailand, Vietnam, China, and Russia, as well as G5: France, Germany, Japan, the United Kingdom, and the United States, from 2017 to 2024. The results have yielded several key insights. Firstly, the study found that the proportion of gold in a stock portfolio is suggested to be more than 44% on average, while the optimal weight for cryptocurrencies should be less than 15%. The optimal weight selection is market-dependent. Thus, it is recommended that investors hold a minimum of 44% of gold in their bivariate portfolio to minimize overall portfolio risks when holding the equity of ASEAN+2 and G5.

Secondly, gold and cryptocurrencies showed a positive hedge ratio in most cases except for Vietnam. Hence, investors should hold either gold or cryptocurrencies simultaneously in opposite positions with the stock of ASEAN+2 and G5 to provide diversification benefits as they tend to move in the same direction. Except for Vietnam, where a negative hedge ratio indicated that gold offered a hedging role against the stock market of Vietnam, resulting from its unique market characteristics and weaker integration with global stock markets.

Thirdly, gold is found to show higher hedge effectiveness than cryptocurrencies in all the stock markets. The hedge effectiveness of gold is over 38%, while cryptocurrencies show a relatively low hedge effectiveness of no more than 13%. The tremendous discrepancy in hedge effectiveness implies that gold is still the best hedging instrument. Therefore, it is recommended to the government and policymakers to encourage the public to seek gold as a hedging instrument against the stock market. The low hedge effectiveness of cryptocurrencies further emphasizes the need for crypto issuers to reevaluate cryptocurrencies, as they may face pressures to ensure cryptocurrencies provide stability during normal market conditions.

Fourthly, this study also revealed that gold reduces downside risk substantially at both extreme tail risk and moderate tail risk, regardless of whether equal weighting or optimal weighting has been assigned. However, minimal risk reduction is observed only when optimal weight is assigned to cryptocurrencies, and this reduction is both conditional and context-dependent. Generally, a favorable hedge must not be weight-sensitive. Thus, it was concluded that merely incorporating cryptocurrency without careful examination is problematic. Investors are recommended not to rely on cryptocurrency as a reliable hedge. Since, in the real world, we cannot continuously rebalance portfolios, and frequent optimization is costly. Given the low hedge effectiveness, investors should not use cryptocurrencies for risk reduction. Policymakers should inform the public of the risks inherent in cryptocurrency investment to improve investor understanding.

Lastly, comparing across the ASEAN+2 and G5, this study revealed that gold showed the highest hedge effectiveness in the Russian stock market. Furthermore, gold showed a better hedge in G5 compared to ASEAN+2. For cryptocurrencies, although their effectiveness is far lower than that of gold, a relatively higher average hedge effectiveness is observed in ASEAN+2 relative to G5. Thus, it is inferred that cryptocurrencies are less correlated with the stock market in ASEAN+2. Likewise, gold showed higher absolute downside risk reduction in ASEAN+2 than in G5 countries. Hence, it is recommended that central banks and policymakers consider gold reserves for stabilizing the financial market during economic turbulence in both emerging and developed financial markets. Furthermore, the hedge effectiveness of gold is relatively high in countries with emerging financial markets such as Vietnam and Russia. Gold is therefore more essential in reducing risk in emerging stock markets, although it remains statistically significant in developed financial markets like the G5.

Overall, this study concluded that gold is still the best hedging instrument since it showed the highest hedge effectiveness and reduced downside risks substantially. Cryptocurrencies are still far from being a digital gold, and gold remains the most effective hedge and safe haven against stock markets due to its low volatility and low extreme tail risk. Provided cryptocurrencies become less volatile, they are not far from being considered digital gold.

Considering cryptocurrencies a digital mirage, policymakers and investors should create stricter transparency and risk warnings to reduce excessive speculative activities.

Besides, empirical findings showed that the downside risk reduction may be effective for moderate tail risk but not in extreme tail risk, suggesting that the correlation between assets is regime-dependent. This finding addresses the limitations of modern portfolio theory in capturing the dynamics of tail risk. Likewise, gold showed an effective hedge against the stock markets of ASEAN+2 and G5, which reflects that the markets are not perfectly efficient in the real world. The price does not fully reflect information since returns are predictable. Moreover, the massive and sudden deviations from fair value challenge the principles of the efficient market hypothesis, making hedging crucial to managing shocks. Gold's capacity to diminish portfolio variance illustrates its efficiency as a hedge, offering a stabilizing buffer amid heightened stock market volatility. Lastly, sector-specific research should be taken into consideration in future studies, as various sectors are heterogeneous and different in structures, and cryptocurrencies and gold may serve distinct roles in different sectors.

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REFERENCES

Abdelmalek, W. (2024). Cryptocurrencies and portfolio diversification before and during COVID-19. *EuroMed Journal of Business*, *19*(4), 1084-1120. https://doi.org/10.1108/EMJB-10-2022-0182

Abdelmalek, W., & Benlagha, N. (2023). On the safe-haven and hedging properties of Bitcoin: New evidence from COVID-19 pandemic. *The Journal of Risk Finance*, *24*(2), 145-168. https://doi.org/10.1108/JRF-06-2022-0153

Akhtaruzzaman, M., Boubaker, S., Lucey, B. M., & Sensoy, A. (2021). Is gold a hedge or a safe-haven asset in the COVID–19 crisis? *Economic Modelling*, *102*, 105588. https://doi.org/10.1016/j.econmod.2021.105588

Ali, F., Jiang, Y., & Sensoy, A. (2021). Downside risk in Dow Jones Islamic equity indices: Precious metals and portfolio diversification before and after the COVID-19 bear market. *Research in International Business and Finance*, *58*, 101502. https://doi.org/10.1016/j.ribaf.2021.101502

Ampountolas, A. (2023). The effect of COVID-19 on cryptocurrencies and the stock market volatility: A two-stage DCC-EGARCH model analysis. *Journal of Risk and Financial Management*, *16*(1), 25. https://doi.org/10.3390/jrfm16010025

Antar, M. (2025). Quantile analysis of Bitcoin returns: Uncovering market dynamics. *The Journal of Risk Finance*, *26*(1), 122-146. https://doi.org/10.1108/JRF-05-2024-0154

Arnone, G. (2024). *Navigating the world of cryptocurrencies: Technology, economics, regulations, and future trends.* Cham, Switzerland: Springer Nature Switzerland.

Bahloul, S., Mroua, M., & Naifar, N. (2023). Re-evaluating the hedge and safe-haven properties of Islamic indexes, gold and Bitcoin: Evidence from DCC–GARCH and quantile models. *Journal of Islamic Accounting and Business Research*, *14*(8), 1167-1181. https://doi.org/10.1108/JIABR-03-2022-0076

Bányai, A., Tatay, T., Thalmeiner, G., & Pataki, L. (2024). Optimising portfolio risk by involving crypto assets in a volatile macroeconomic environment. *Risks*, *12*(4), 68. https://doi.org/10.3390/risks12040068

Baur, D. G., Karlsen, J. R., Smales, L. A., & Trench, A. (2024). Digging deeper—Is Bitcoin digital gold? A mining perspective. *Journal of Commodity Markets*, *34*, 100406. https://doi.org/10.1016/j.jcomm.2024.100406

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

Belguith, R., Alnafisah, H., Snene Manzli, Y., & Jeribi, A. (2025). Can Bitcoin and gold have dynamic hedging and safe haven capabilities against the BRICS plus stock market indices during global crises? An evidence from a time-varying copula approach. *Emerging Markets Finance and Trade*, *61*(12), 3634–3657. https://doi.org/10.1080/1540496X.2025.2486677

Belhassine, O., & Riahi, M. (2025). Searching for safe haven assets against American and European stocks during the Russo-Ukrainian War. *Studies in Economics and Finance*, *42*(2), 352-372. https://doi.org/10.1108/SEF-01-2024-0056

Ben Brayek, A., Ameur, H. B., & Alharbi, F. M. (2024). The importance of Bitcoin and commodities as investment diversifiers in OPEC and non-OPEC countries. *Economies*, *12*(12), 351. https://doi.org/10.3390/economies12120351

Bouri, E., Molnár, P., Azzi, G., Roubaud, D., & Hagfors, L. I. (2017). 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

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

Bredin, D., Conlon, T., & Potì, V. (2017). The price of shelter—Downside risk reduction with precious metals. *International Review of Financial Analysis*, *49*, 48-58. https://doi.org/10.1016/j.irfa.2016.12.005

Cevik, N. K., Cevik, E. I., & Dibooglu, S. (2020). Oil prices, stock market returns and volatility spillovers: Evidence from Turkey. *Journal of Policy Modeling*, *42*(3), 597-614. https://doi.org/10.1016/j.jpolmod.2020.01.006

Chemkha, R., BenSaïda, A., Ghorbel, A., & Tayachi, T. (2021). Hedge and safe haven properties during COVID-19: Evidence from Bitcoin and gold. *The Quarterly Review of Economics and Finance*, *82*, 71-85. https://doi.org/10.1016/j.qref.2021.07.006

Chen, C., Liu, L., & Zhao, N. (2021). Fear sentiment, uncertainty, and bitcoin price dynamics: The case of COVID-19, Research on pandemics. In (pp. 166-177). UK: Routledge.

Chkili, W. (2026). The risk transmission from the COVID-19 to MENA stock markets: What is the best safe haven asset during the pandemic? *EuroMed Journal of Business*, *21*(1), 283–317. https://doi.org/10.1108/EMJB-11-2023-0307

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

Dutta, A., Das, D., Jana, R. K., & Vo, X. V. (2020). COVID-19 and oil market crash: Revisiting the safe haven property of gold and Bitcoin. *Resources Policy*, *69*, 101816. https://doi.org/10.1016/j.resourpol.2020.101816

Echaust, K., & Just, M. (2022). Is gold still a safe haven for stock markets? New insights through the tail thickness of portfolio return distributions. *Research in International Business and Finance*, *63*, 101788. https://doi.org/10.1016/j.ribaf.2022.101788

Echaust, K., Just, M., & Kliber, A. (2024). To hedge or not to hedge? Cryptocurrencies, gold and oil against stock market risk. *International Review of Financial Analysis*, *94*, 103292. https://doi.org/10.1016/j.irfa.2024.103292

Engle, R. F., & Sheppard, K. (2001). *Theoretical and empirical properties of dynamic conditional correlation multivariate GARCH*. NBER Working Paper No. 8554. Cambridge, MA: National Bureau of Economic Research.

Fakhfekh, M., & Ben Salem, M. (2024). Hedge, safe haven, and diversification for US and China stock markets during COVID-19 outbreak: Volatile versus stable cryptocurrencies. *Iranian Economic Review*, *28*(2), 338-367. https://doi.org/10.22059/ier.2024.342047.1007434

Fama, E. F. (1970). Efficient capital markets: A review of theory and empirical work. *The Journal of Finance*, *25*(2), 383-417. https://doi.org/10.2307/2325486

Garcia-Jorcano, L., & 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*, *54*, 101300. https://doi.org/10.1016/j.ribaf.2020.101300

Härdle, W. K., Harvey, C. R., & Reule, R. C. G. (2020). Understanding cryptocurrencies. *Journal of Financial Econometrics*, *18*(2), 181–208. https://doi.org/10.1093/jjfinec/nbz033

Hossain, M. J., Ismail, M. T., Akter, S., & Hossain, M. R. (2020). *Which will serve better as a hedge or diversifier Gold or Bitcoin?* Paper presented at the 2020 International Conference on Decision Aid Sciences and Application (DASA), IEEE.

Jana, S., & Sahu, T. N. (2025). A wavelet analysis of investing in cryptocurrencies in the Indian stock market. *International Journal of Emerging Markets*, *20*(8), 3229-3251. https://doi.org/10.1108/IJOEM-05-2023-0698

Jiang, Y., Lie, J., Wang, J., & Mu, J. (2021). Revisiting the roles of cryptocurrencies in stock markets: A quantile coherency perspective. *Economic Modelling*, *95*, 21-34. https://doi.org/10.1016/j.econmod.2020.12.002

Kakinuma, Y. (2022). Nexus between Southeast Asian stock markets, Bitcoin and gold: Spillover effect before and during the COVID-19 pandemic. *Journal of Asia Business Studies*, *16*(4), 693-711. https://doi.org/10.1108/JABS-02-2021-0050

Kang, S. H., Yoon, S.-M., Bekiros, S., & Uddin, G. S. (2020). Bitcoin as hedge or safe haven: Evidence from stock, currency, bond and derivatives markets. *Computational Economics*, *56*(2), 529-545. https://doi.org/10.1007/s10614-019-09935-6

Kliber, A., Marszałek, P., Musiałkowska, I., & 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*, *524*, 246-257. https://doi.org/10.1016/j.physa.2019.04.145

Klose, J. (2022). Comparing cryptocurrencies and gold-a system-GARCH-approach. *Eurasian Economic Review*, *12*(4), 653-679. https://doi.org/10.1007/s40822-022-00218-4

Ko, P.-C., Lin, P.-C., Do, H.-T., Kuo, Y.-H., Huang, Y.-F., & Chen, W.-H. (2023). Pairs trading strategies in cryptocurrency markets: A comparative study between statistical methods and evolutionary algorithms. *Engineering Proceedings*, *38*(1), 74. https://doi.org/10.3390/engproc2023038074

Korsah, D., Mensah, L., Osei, K. A., & Amewu, G. (2026). Dynamic connectedness, hedge and safe-haven effects: Cryptocurrencies, precious metals and African stock markets. *International Journal of Emerging Markets*, *21*(1), 147-169. https://doi.org/10.1108/IJOEM-06-2024-1090

Kruse, L. C., & Tumbas, S. (2016). *Digital ethnography: At the crossroads of mirage, mosaic, and mirror*. Paper presented at the Proceedings of the 37th International Conference on Information Systems (ICIS 2016), Association for Information Systems.

Kumar, A. S., Mohan, M., & Niveditha, P. S. (2025). Assessing Bitcoin and gold as safe havens amid global uncertainties: A rolling window DCC-GARCH analysis. *NMIMS Management Review*, *33*(1), 7-17. https://doi.org/10.1177/09711023251322578

Ma, Y., Ahmad, F., Liu, M., & Wang, Z. (2020). Portfolio optimization in the era of digital financialization using cryptocurrencies. *Technological Forecasting and Social Change*, *161*, 120265. https://doi.org/10.1016/j.techfore.2020.120265

Maitra, D., Rehman, M. U., Dash, S. R., & Kang, S. H. (2022). Do cryptocurrencies provide better hedging? Evidence from major equity markets during COVID-19 pandemic. *The North American Journal of Economics and Finance*, *62*, 101776. https://doi.org/10.1016/j.najef.2022.101776

Majumder, S. B. (2022). Searching for hedging and safe haven assets for Indian equity market–a comparison between gold, cryptocurrency and commodities. *Indian Growth and Development Review*, *15*(1), 60-84. https://doi.org/10.1108/IGDR-10-2021-0131

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

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

Masset, P., & Maurer, F. (2021). Mitigating downside risk of portfolio diversification: Wine versus other tangible assets. *Economic Modelling*, *102*, 105579. https://doi.org/10.1016/j.econmod.2021.105579

Matharu, A. (2019). *Understanding cryptocurrencies: The money of the future*. United States: Business Expert Press.

Miao, J., & Laws, J. (2016). Profitability of a simple pairs trading strategy: Recent evidences from a global context. *International Journal of Theoretical and Applied Finance*, *19*(4), 1650023. https://doi.org/10.1142/S0219024916500230

Naeem, M. A., Hasan, M., Arif, M., & Shahzad, S. J. H. (2020). Can Bitcoin glitter more than gold for investment styles? *Sage Open*, *10*(2), 2158244020926508. https://doi.org/10.1177/2158244020926508

Nair, S. T. G. (2021). Pairs trading in cryptocurrency market: A long-short story. *Investment Management and Financial Innovations*, *18*(3), 127–141. https://doi.org/10.21511/imfi.18(3).2021.12

Ngene, G. M., Mungai, A. N., & Hassan, M. K. (2026). Hedging with gold, correlation cycles and risk aversion: Evidence from global economic sectors. *International Journal of Finance & Economics*. *31*(2), 1606–1626. https://doi.org/10.1002/ijfe.70006

Nguyen, B. K. Q., & Pham, D. T. N. (2025). Investing during a Fintech revolution: The hedge and safe haven properties of Bitcoin and Ethereum. *Research in International Business and Finance*, *73*, 102599. https://doi.org/10.1016/j.ribaf.2024.102599

Sadorsky, P. (2024). Using precious metals to reduce the downside risk of FinTech stocks. *FinTech*, *3*(4), 537-550. https://doi.org/10.3390/fintech3040028

Shahzad, M. F., Xu, S., Lim, W. M., Hasnain, M. F., & Nusrat, S. (2024). Cryptocurrency awareness, acceptance, and adoption: The role of trust as a cornerstone. *Humanities and Social Sciences Communications*, *11*(1), 4. https://doi.org/10.1057/s41599-023-02528-7

Stensås, A., Nygaard, M. F., Kyaw, K., & Treepongkaruna, S. (2019). Can Bitcoin be a diversifier, hedge or safe haven tool? *Cogent Economics & Finance*, *7*(1), 1593072. https://doi.org/10.1080/23322039.2019.1593072

Tan, C.-C., Ling, P.-S., Sim, S.-L., & Ming, K. L. Y. (2023). Hedge and safe-haven properties of cryptocurrencies: Evidence in East Asia-5 market. *Cogent Economics & Finance*, *11*(1), 2183640. https://doi.org/10.1080/23322039.2023.2183640

Tarchella, S., Khalfaoui, R., & Hammoudeh, S. (2024). The safe haven, hedging, and diversification properties of oil, gold, and cryptocurrency for the G7 equity markets: Evidence from the pre- and post-COVID-19 periods. *Research in International Business and Finance*, *67*, 102125. https://doi.org/10.1016/j.ribaf.2023.102125

Thuy, L. T. V., Oanh, T. T. K., & Ha, N. T. H. (2024). The roles of gold, US dollar, and bitcoin as safe-haven assets in times of crisis. *Cogent Economics & Finance*, *12*(1), 2322876. https://doi.org/10.1080/23322039.2024.2322876

Tronzano, M. (2023). Safe-haven currencies as defensive assets in global stocks portfolios: A reassessment of the empirical evidence (1999–2022). *Journal of Risk and Financial Management*, *16*(5), 273. https://doi.org/10.3390/jrfm16050273

Ustaoglu, E. (2023). Diversification, hedge, and safe-haven properties of gold and bitcoin with portfolio implications during the Russia–Ukraine war. *Resources Policy*, *84*, 103791. https://doi.org/10.1016/j.resourpol.2023.103791

Vashisth, A., Salako, K., & Pinto, P. (2024). Digital assets valuation and financial reporting. Aghili, S. (Ed.), Leveraging blockchain technology. In (pp. 93-114). United States: CRC Press.

Vasudeva, S. (2023). Cryptocurrency as an investment or speculation: A bibliometric review study. *Business Analyst Journal*, *44*(1), 34-50. https://doi.org/10.1108/BAJ-07-2022-0008

Vieira, D. S., De Carvalho, P. V., Curto, J. D., & Laureano, L. (2023). Gold's hedging and safe haven properties for European stock and bond markets. *Resources Policy*, *85*, 103817. https://doi.org/10.1016/j.resourpol.2023.103817

Wang, Y. (2024). Do cryptocurrency investors in the UK need more protection? *Journal of Financial Regulation and Compliance*, *32*(2), 230-249. https://doi.org/10.1108/JFRC-03-2023-0036

Watters, C. (2023). Digital gold or digital security? Unravelling the legal fabric of decentralised digital assets. *Commodities*, *2*(4), 355-366. https://doi.org/10.3390/commodities2040020

Widarto, A. R., Muharam, H., Wahyudi, S., & Pangestuti, I. R. D. (2022). ASEAN-5 and crypto hedge fund: Dynamic portfolio approach. *Sage Open*, *12*(2), 21582440221094612. https://doi.org/10.1177/21582440221094612

Yousaf, I., Bouri, E., Ali, S., & Azoury, N. (2021). Gold against Asian stock markets during the COVID-19 outbreak. *Journal of Risk and Financial Management*, *14*(4), 186. https://doi.org/10.3390/jrfm14040186

Yun, S.-J., Choi, S.-Y., & Kim, Y. S. (2023). Examining the hedge performance of US dollar, VIX, and gold during the coronavirus pandemic: Is US dollar a better hedge asset? *PLoS One*, *18*(10), e0291684. https://doi.org/10.1371/journal.pone.0291684

Appendix A. Relative MVaR (99%) by Cryptocurrency Allocation Weight in Stock Portfolios.

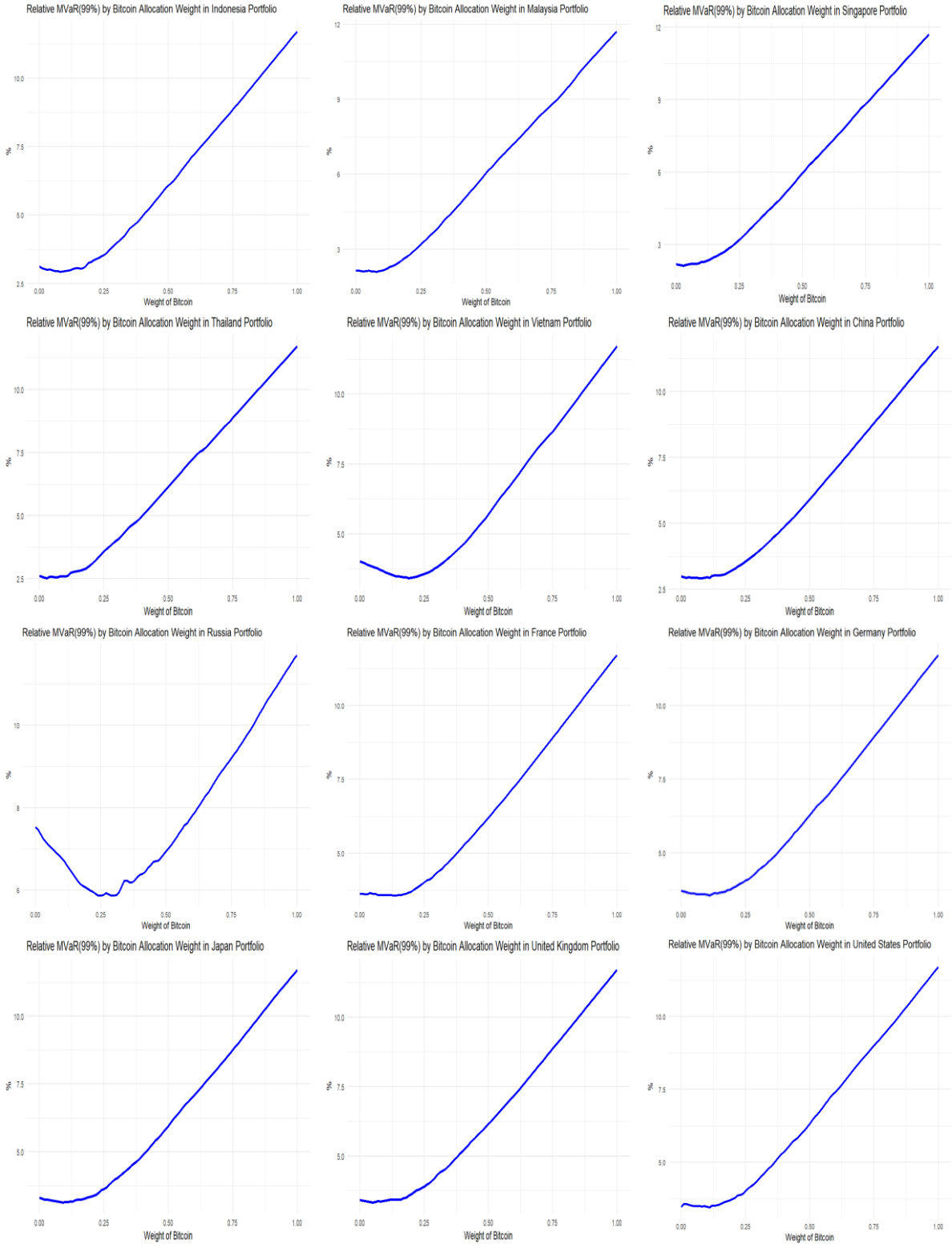

Figure A1. Relative MVaR (99%) by Bitcoin Allocation Weight in Stock Portfolios.

Figure A1 represents the relative MVaR (99%) by Bitcoin allocation weight in stock portfolios.

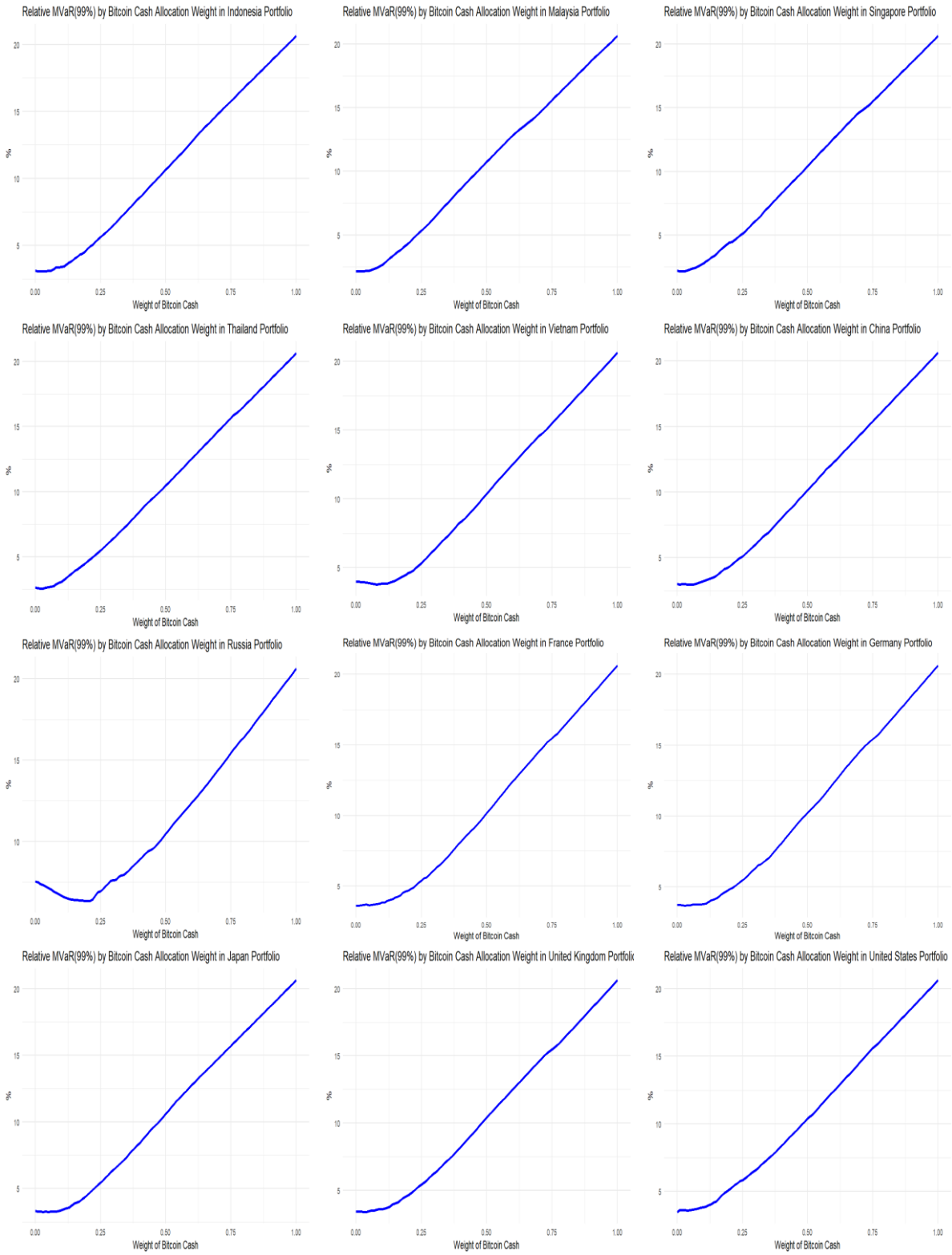

Figure A2. Relative MVaR (99%) by Bitcoin Cash Allocation Weight in Stock Portfolios.

Figure A2 represents the relative MVaR (99%) by Bitcoin Cash allocation weight in stock portfolios.

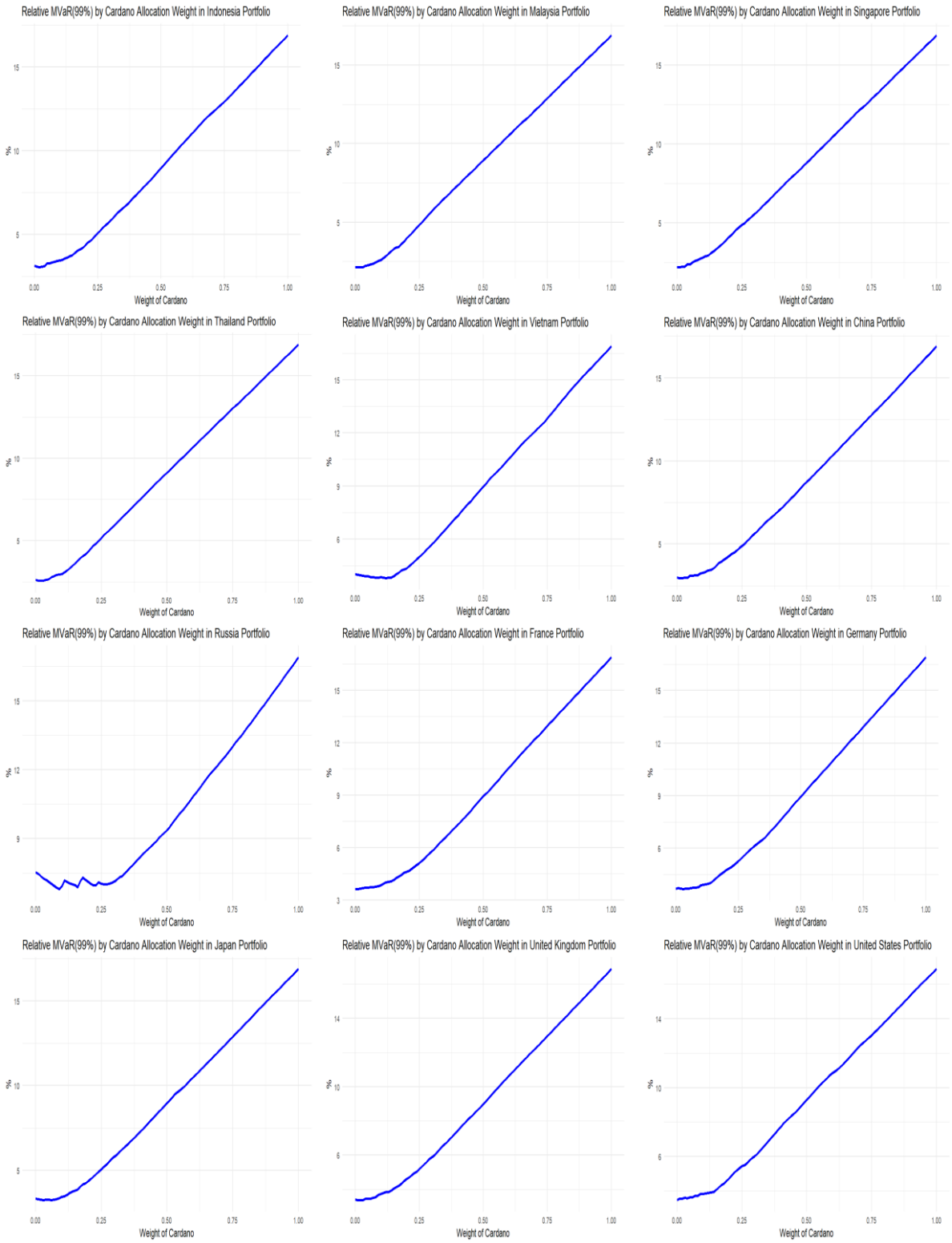

Figure A3. Relative MVaR (99%) by Cardano Allocation Weight in Stock Portfolios.

Figure A3 represents the relative MVaR (99%) by Cardano allocation weight in stock portfolios.

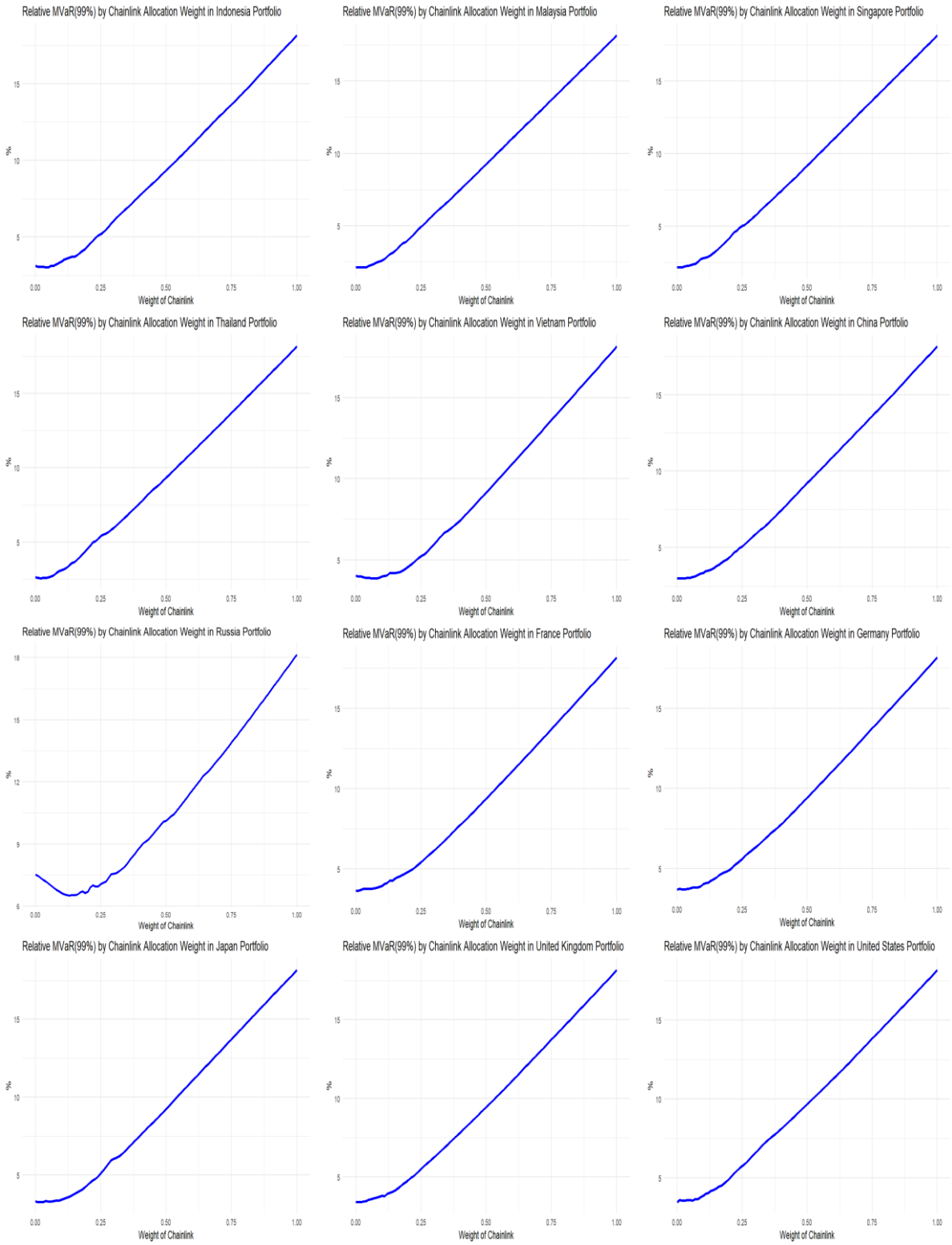

Figure A4. Relative MVaR (99%) by Chainlink Allocation Weight in Stock Portfolios.

Figure A4 represents the relative MVaR (99%) by Chainlink allocation weight in stock portfolios.

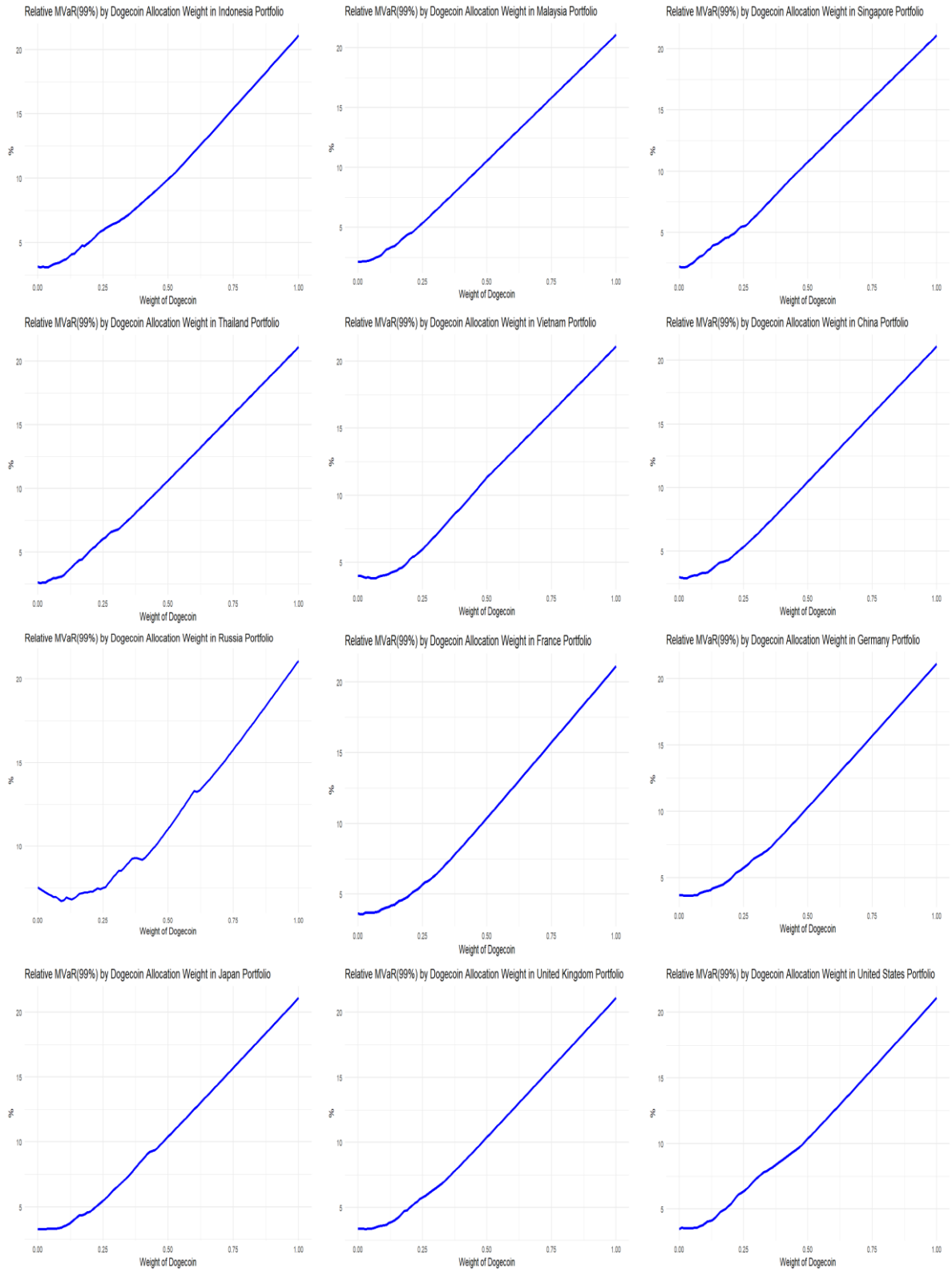

Figure A5. Relative MVaR (99%) by Dogecoin Allocation Weight in Stock Portfolios.

Figure A5 represents the relative MVaR (99%) by Dogecoin allocation weight in stock portfolios.

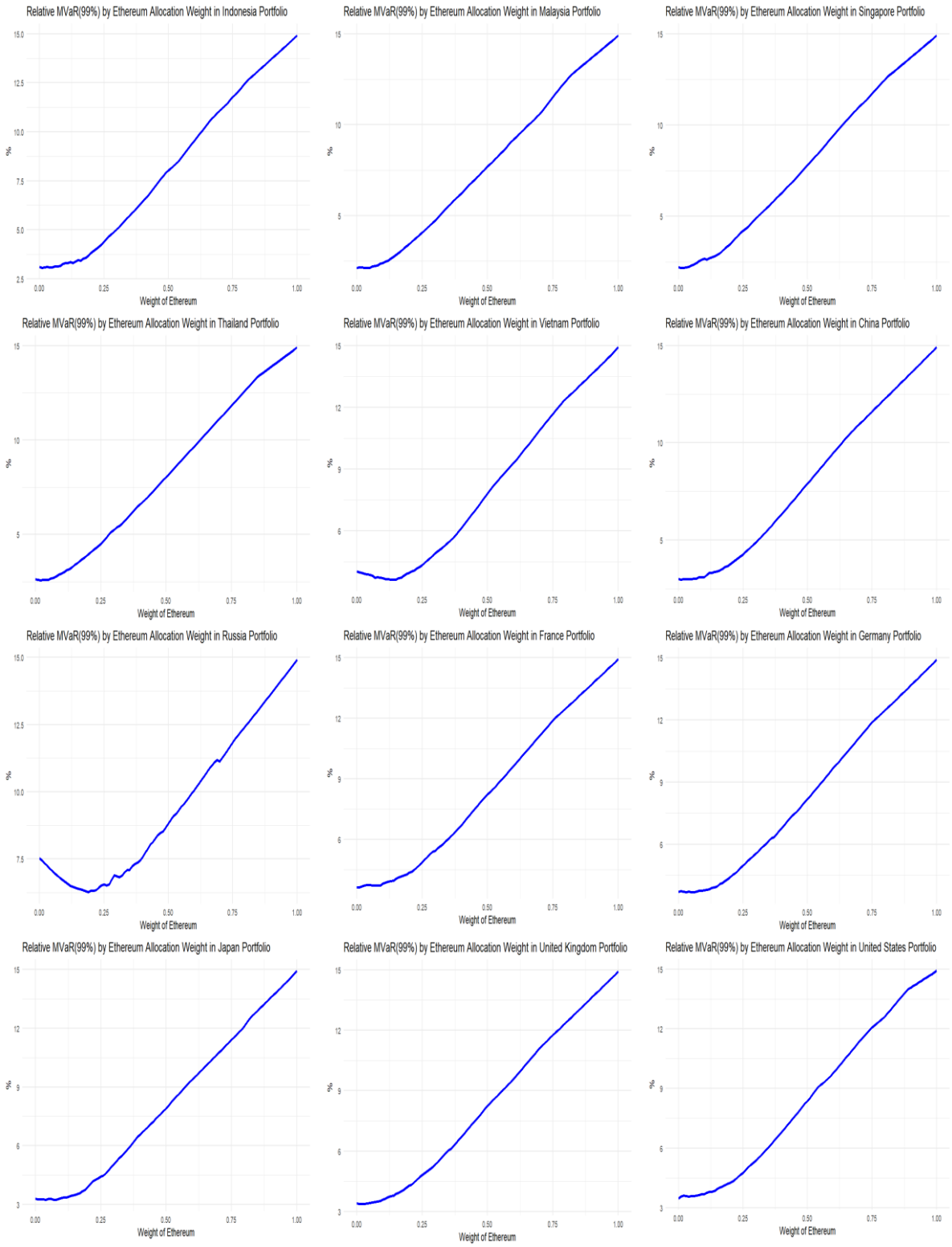

Figure A6. Relative MVaR (99%) by Ethereum Allocation Weight in Stock Portfolios.

Figure A6 represents the relative MVaR (99%) by Ethereum allocation weight in stock portfolios.

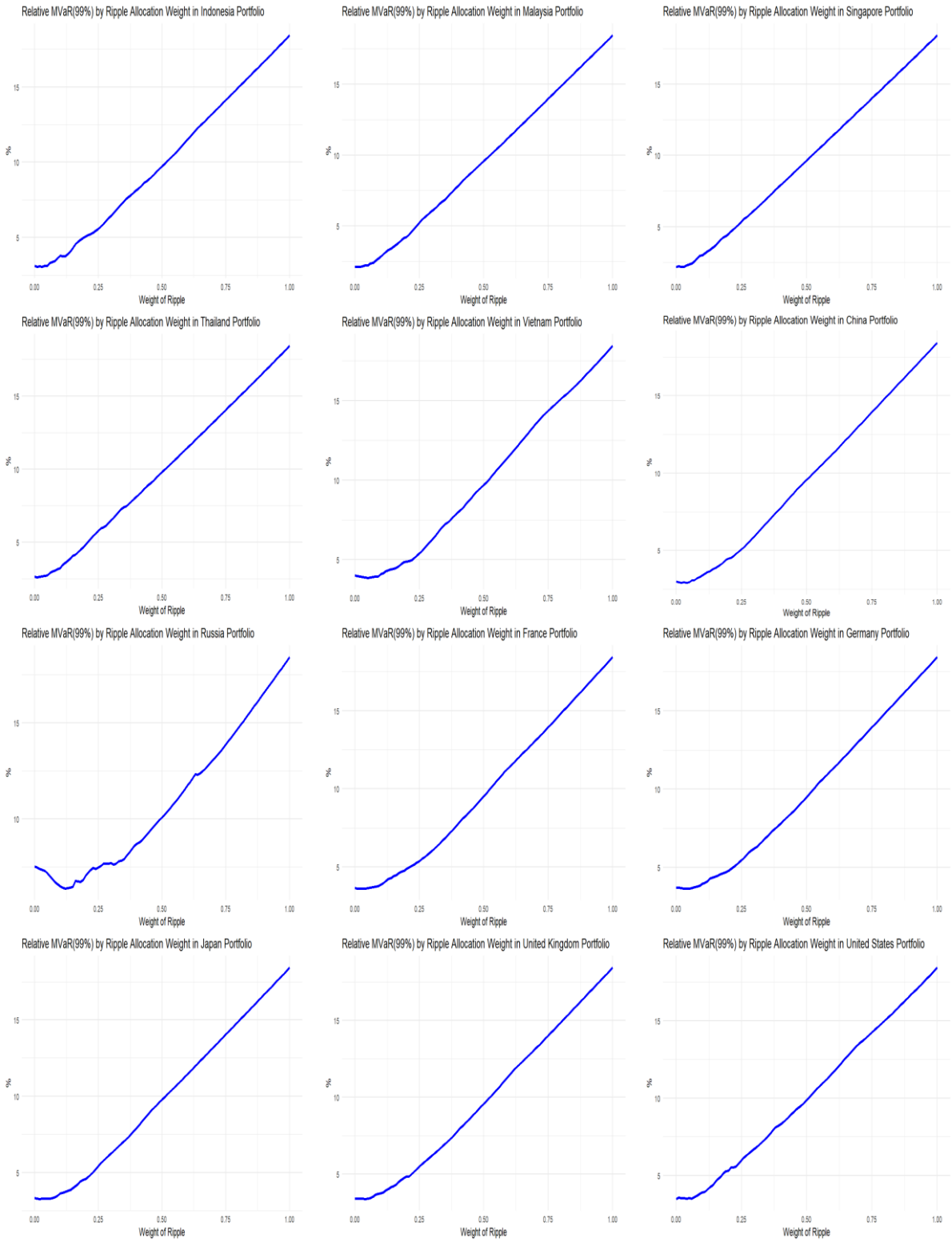

Figure A7. Relative MVaR (99%) by Ripple Allocation Weight in Stock Portfolios.

Figure A7 represents the relative MVaR (99%) by Ripple allocation weight in stock portfolios.

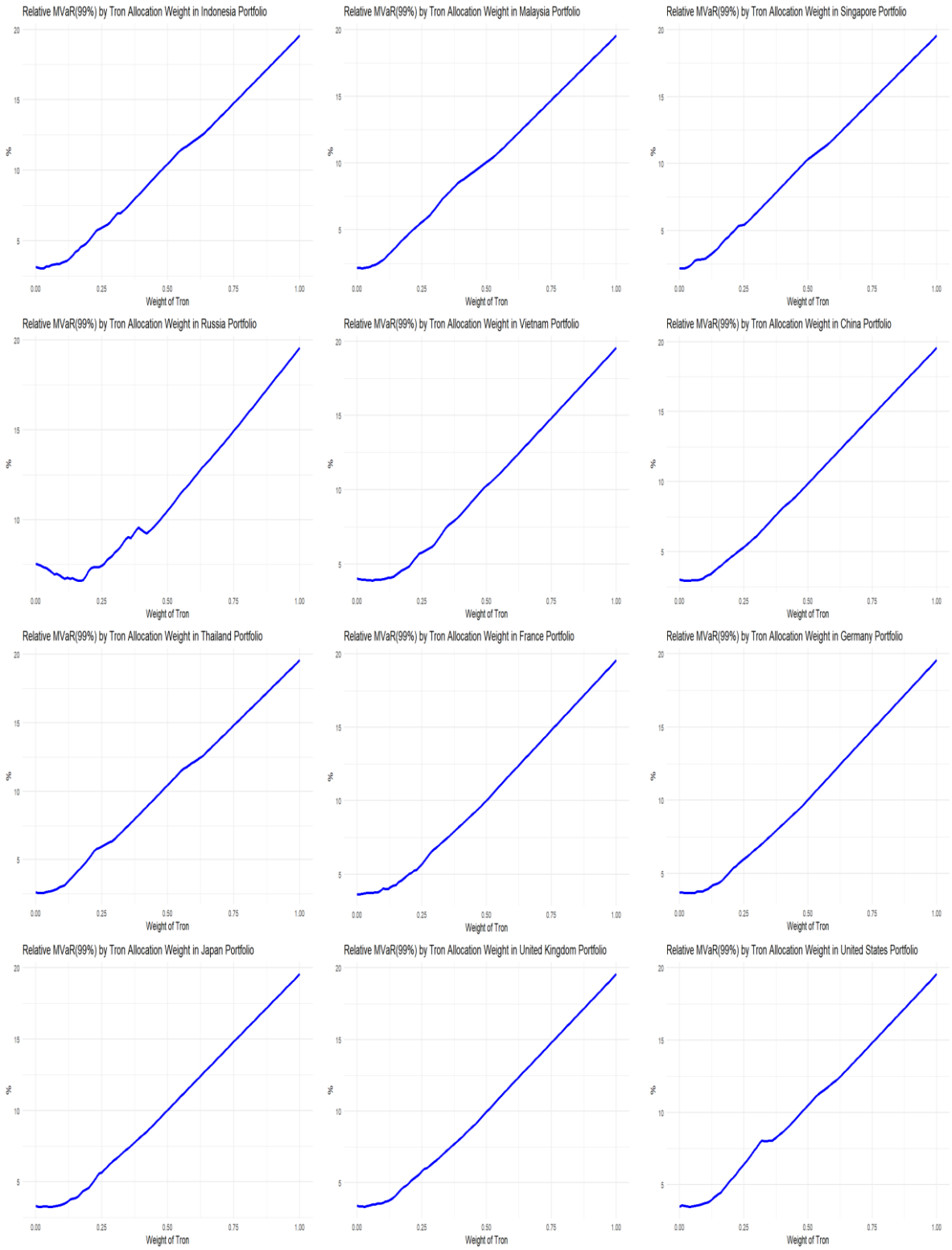

Figure A8. Relative MVaR (99%) by Tron Allocation Weight in Stock Portfolios.

Figure A8 represents the relative MVaR (99%) by Tron allocation weight in stock portfolios.

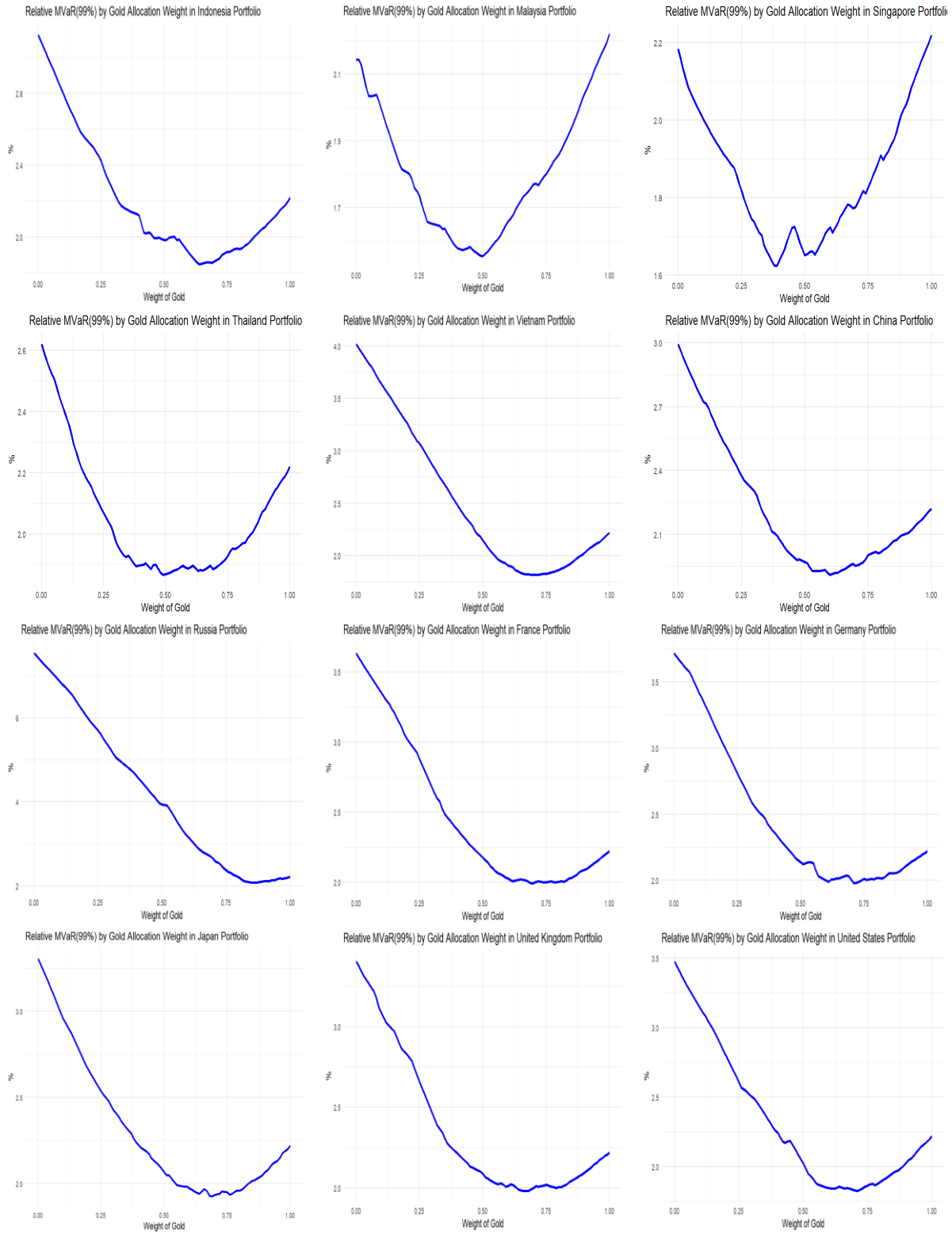

Figure A9. Relative MVaR (99%) by Gold Allocation Weight in Stock Portfolios.

Note: Indonesia – Jakarta Stock Exchange Composite Index (JKSE); Malaysia – FTSE Bursa Malaysia KLCI Index (KLCI); Singapore – Straits Times Index (STI); Thailand – Stock Exchange of Thailand Index (SETI); Vietnam – Vietnam Index (VN); China – Shanghai Stock Exchange Composite Index (SSEC), Russia – MOEX Russia Index (IMOEX); France – CAC 40 Index (FCHI); Germany – Deutscher Aktienindex Index (GDAXI); Japan – Nikkei 225 Index (N225); United Kingdom – Financial Times Stock Exchange Index (FTSE); United States – Standard & Poor 500 Index (SPX).

Figure A9 represents the relative MVaR (99%) by Gold allocation weight in stock portfolios.