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Long-Run Cointegration and Dynamic Interactions among Bitcoin, Gold Prices, and the Indonesian Composite Stock Price Index: Evidence from a Vector Error Correction Model

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Abstract

This study examines the dynamic interrelationships among Bitcoin prices, gold prices, and the Indonesian Composite Stock Price Index (IHSG) using monthly data covering the 2020–2025 period. A Vector Error Correction Model (VECM) was employed to capture both short-run dynamics and long-run equilibrium relationships among the three financial assets. The empirical procedure included descriptive statistics, the Augmented Dickey–Fuller unit-root test, optimal lag selection, VAR stability testing, Johansen cointegration testing, VECM estimation, Impulse Response Function (IRF), and Forecast Error Variance Decomposition (FEVD). The results indicate that Bitcoin, gold, and the IHSG are non-stationary at level but become stationary after first differencing, indicating that the variables are integrated of order one. The Johansen test further indicates the existence of a long-run equilibrium relationship among the variables. In the short run, Bitcoin significantly influences the IHSG, while the IHSG significantly influences gold prices; the remaining cross-market effects are statistically insignificant. In the long run, the IHSG is significantly associated with Bitcoin prices, whereas gold prices do not show a significant relationship with Bitcoin. The negative and significant error-correction coefficient indicates that approximately 42.46% of deviations from long-run equilibrium are corrected within one observation period. The IRF and FEVD results further show that the strongest dynamic interaction occurs between Bitcoin and the IHSG, while gold remains relatively more independent and is predominantly driven by its own shocks. These findings highlight the growing interdependence between cryptocurrency and the Indonesian equity market and provide implications for portfolio diversification and financial risk management.

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1. Introduction

The rapid development of global financial markets has intensified the interconnection among traditional financial assets, commodities, and digital instruments. Financial globalization allows capital to move more rapidly across markets, causing price changes in one asset class to be transmitted to others through portfolio reallocation, investor sentiment, and information flows. This increasing level of financial integration has made investment decisions more complex because investors no longer assess an asset independently but instead consider its relationship with other instruments in constructing and adjusting their portfolios. Consequently, understanding cross-market linkages has become increasingly important for explaining price dynamics and managing investment risk in modern financial systems (Arfaoui & Ben Rejeb, 2017; Corbet et al., 2018).

The stock market is one of the main components of the financial system because stock price movements reflect investors' expectations regarding corporate performance, macroeconomic conditions, and future economic prospects (Hasrini, 2022). In Indonesia, the performance of the equity market is commonly represented by the Indonesian Composite Stock Price Index (IHSG), which reflects the overall movement of shares listed on the Indonesia Stock Exchange. Changes in the IHSG may be associated not only with domestic economic conditions but also with

developments in global financial markets and alternative investment assets. Under the Efficient Market Hypothesis, financial asset prices respond to available information, implying that information originating from other asset markets may be incorporated into investors' decisions and reflected in stock market movements (Fama, 1970).

Alongside the stock market, gold has long occupied an important position in investment portfolios because of its characteristics as a store of value, hedging instrument, and potential safe-haven asset. Investors often increase their allocation to gold during periods of financial uncertainty because gold tends to behave differently from higher-risk financial assets. This characteristic makes gold particularly relevant when examining interactions among financial markets, especially during periods of economic stress. Empirical evidence has shown that the relationship between gold and stock markets can vary across market conditions, indicating that the role of gold is dynamic rather than constant over time (Baur & McDermott, 2016; Arfaoui & Ben Rejeb, 2017).

The emergence of cryptocurrencies has further transformed the structure of global investment markets. Bitcoin, introduced as a decentralized digital asset, has become the most prominent cryptocurrency and is widely treated as a representative indicator of the cryptocurrency market. Unlike conventional financial assets, Bitcoin is characterized by continuous global trading, high price volatility, decentralization, and strong sensitivity to investor expectations (Conrad et al., 2018). These characteristics have generated substantial academic interest regarding whether Bitcoin should primarily be regarded as a speculative asset, a portfolio diversifier, or an alternative safe-haven instrument. Previous studies have demonstrated that Bitcoin behaves differently from traditional assets such as gold and exhibits substantially higher volatility, making its role in financial portfolios distinct and highly dependent on market conditions (Baur et al., 2016; Klein et al., 2018).

The debate concerning Bitcoin's role as a safe-haven or diversification asset has become particularly important as cryptocurrencies become more integrated with conventional financial markets. Although Bitcoin has sometimes been compared with gold because both assets may be viewed as alternatives to traditional financial instruments, empirical findings have not consistently supported the characterization of Bitcoin as “digital gold.” Bitcoin's volatility structure and its changing correlations with other financial assets indicate that its behavior may differ substantially from that of conventional safe-haven assets. During periods of financial stress, Bitcoin may fail to provide consistent protection against stock market losses, suggesting that its relationship with traditional assets is conditional and time-varying rather than stable (Bouri et al., 2017; Bouri et al., 2020; Conlon & McGee, 2020).

These characteristics became particularly visible during the 2020–2025 period examined in this study. The period covered major disruptions in global financial markets, beginning with the COVID-19 pandemic and followed by economic recovery, inflationary pressures, changes in monetary policy, geopolitical uncertainty, and rapid developments in cryptocurrency markets. The descriptive patterns presented in the original study show substantial fluctuations in Bitcoin, gold prices, and the IHSG during this period. Bitcoin exhibited particularly large increases and corrections, while gold generally displayed greater stability and the IHSG experienced pronounced declines and subsequent recovery. These contrasting movements suggest that the three assets may respond differently to market shocks while remaining connected through changes in investor sentiment and portfolio allocation.

Previous empirical research provides evidence of interdependence between cryptocurrencies and conventional financial markets, but the findings remain mixed. Some studies indicate that Bitcoin and stock markets exhibit dynamic connectedness and that shocks can be transmitted across cryptocurrency and equity markets. Other studies show that Bitcoin does not consistently function as a safe haven and that its relationship with stocks and commodities varies across periods and market conditions. Similarly, empirical evidence concerning gold indicates that its safe-haven properties are not necessarily uniform under all circumstances. These inconsistencies imply that the relationships among Bitcoin, gold, and equity markets cannot be adequately understood through a purely static perspective (Bouri et al., 2021; Corbet et al., 2018; Wang et al., 2019).

The Indonesian context provides an important setting for examining these relationships. The growing participation of

investors in both capital markets and digital assets creates the possibility of portfolio reallocations between stocks, cryptocurrencies, and traditional defensive assets such as gold. Changes in Bitcoin prices may influence investor risk preferences and capital allocation toward or away from equities, while stock market conditions may also affect investors' willingness to hold highly volatile assets. At the same time, gold may respond differently because it is commonly associated with wealth preservation during uncertain market conditions (Hamza, 2022). These mechanisms are consistent with market interdependence and portfolio diversification perspectives, in which financial assets can interact through changes in information, risk perception, and asset allocation (Markowitz, 1952; Corbet et al., 2018).

Despite the growing literature on Bitcoin, gold, and stock markets, an empirical gap remains in jointly examining these three assets within the Indonesian financial market using a framework capable of distinguishing short-run dynamics from long-run equilibrium relationships. Several previous studies have examined Bitcoin and stocks, gold and stocks, or safe-haven properties separately, while others have applied correlation, regression, time-varying connectedness, or volatility-based approaches. These studies provide important evidence, but the simultaneous long-run interaction among Bitcoin, gold prices, and the IHSG remains comparatively less explored in the Indonesian setting. The Vector Error Correction Model (VECM) is therefore relevant because it allows variables that are integrated and cointegrated to be analyzed within a unified system, while simultaneously capturing short-run adjustments and long-run equilibrium relationships.

The methodological importance of this approach is strengthened by the characteristics of financial time-series data. Bitcoin, gold, and stock indices frequently exhibit trends and non-stationary behavior, meaning that conventional regression techniques may produce misleading results when the time-series properties of the data are ignored. When variables are integrated of the same order and cointegrated, VECM provides a framework for estimating both short-term changes and the mechanism through which deviations from long-run equilibrium are corrected over time. In addition, Impulse Response Function (IRF) analysis can identify how each variable responds to shocks originating from other variables, while Forecast Error Variance Decomposition (FEVD) can estimate the relative contribution of those shocks to future fluctuations in each asset. These features make the VECM framework particularly suitable for studying dynamic financial interdependence.

Accordingly, this study aims to analyze the dynamic interrelationships among Bitcoin prices, gold prices, and the Indonesian Composite Stock Price Index using monthly data from January 2020 to December 2025. Specifically, the study examines whether a long-run equilibrium relationship exists among the three assets, evaluates their short-run adjustment dynamics, investigates their responses to market shocks through IRF analysis, and assesses the contribution of each variable to fluctuations in the others through FEVD. By integrating a digital asset, a traditional safe-haven asset, and the Indonesian equity market within a single dynamic system, this study is expected to provide additional empirical evidence regarding cross-asset interdependence in an emerging market. The findings may also provide practical implications for investors seeking to improve portfolio diversification and risk management in an increasingly interconnected financial environment.

2. Literature Review

2.1 Efficient Market Hypothesis

The Efficient Market Hypothesis (EMH) provides an important theoretical foundation for explaining how financial asset prices respond to information. The argues that in an efficient market, asset prices reflect available information, making it difficult for investors to consistently obtain abnormal returns using information that is already known by the market (Fama, 1970). The theory therefore implies that changes in financial asset prices occur as investors continuously process new information concerning economic conditions, corporate performance, monetary policy, market sentiment, and developments in other financial markets.

The previous studied classifies market efficiency into three forms: weak-form, semi-strong-form, and strong-form efficiency. Weak-form efficiency assumes that current prices already incorporate historical market information such as past prices and trading volumes (Fama, 1970). Semi-strong-form efficiency states that prices incorporate all

publicly available information, including macroeconomic announcements, financial statements, and market developments. Strong-form efficiency extends this concept by assuming that asset prices reflect both public and private information. In the present study, the semi-strong interpretation is particularly relevant because changes in Bitcoin prices, gold prices, and stock market conditions may constitute information that investors use in reallocating their portfolios.

Within the Indonesian stock market, the IHSG may therefore respond to information generated outside the domestic equity market. Significant movements in Bitcoin or gold prices can alter perceptions of risk, liquidity preferences, and expected returns, which may subsequently influence equity investment decisions. Similarly, changes in the IHSG may provide information about domestic market sentiment and economic expectations that investors could consider when allocating funds to alternative assets. Consequently, information originating from one financial market may affect investor expectations and subsequently be reflected in the pricing dynamics of other interconnected markets (Fama, 1970; Forbes & Rigobon, 2002).

However, the assumption of full market efficiency is not always perfectly observed in practice. Financial markets may display overreaction, speculative behavior, herd behavior, and asset price bubbles, especially in highly volatile markets. Bitcoin is particularly relevant in this context because its price movements are frequently associated with speculative activity and rapidly changing investor expectations. Such conditions imply that the adjustment of asset prices to information may be uneven, allowing dynamic interactions and temporary deviations from equilibrium to emerge across markets (Cheah & Fry, 2015; Xu et al., 2023). The original study also adopts EMH as a theoretical explanation for the possibility that information originating from Bitcoin and gold markets can be transmitted to the Indonesian stock market.

2.2 Market Interdependence Theory

Market Interdependence Theory explains that financial markets do not operate independently but are connected through information flows, capital movements, investor behavior, and changes in market sentiment. As financial globalization intensifies, shocks occurring in one market may be transmitted to another, creating spillover effects across asset classes and national markets. The previous studied emphasize that co-movement among financial markets can increase during periods of market stress, while broader financial integration enables capital to move rapidly across countries and instruments (Balcilar et al., 2023).

In this framework, Bitcoin, gold, and the stock market can be regarded as components of an interconnected financial system. Investors may shift funds between these assets in response to changes in expected returns and perceived risk. A sharp increase in Bitcoin prices, for example, may encourage investors to increase exposure to risky assets, while a deterioration in stock market conditions may encourage portfolio reallocation toward alternative assets. Similarly, changes in gold prices may reflect greater risk aversion and influence the allocation of funds between defensive and risky assets.

The increasing integration of cryptocurrency markets with traditional financial markets strengthens the relevance of this theory. Bitcoin was initially perceived as largely detached from the conventional financial system, but empirical studies increasingly report dynamic relationships between cryptocurrencies and stock markets. Empirical evidence indicates that cryptocurrencies increasingly interact with conventional financial assets and that their connectedness with equity markets changes over time (Bouri et al., 2021; Corbet et al., 2018; Wang et al., 2019).

Bitcoin has also been discussed as a potential safe-haven asset because of its decentralized structure, limited supply, and independence from conventional monetary authorities. However, empirical evidence regarding Bitcoin's safe-haven properties remains inconsistent. The previous studied find that Bitcoin may provide hedging benefits under particular conditions (Bouri et al., 2017). Whereas the another studied conclude that Bitcoin did not consistently function as a safe haven during the COVID-19 market crisis (Conlon & McGee, 2020). The safe-haven performance of Bitcoin has also been shown to differ from that of gold and to depend strongly on market conditions (Bouri et al., 2020; Wang et al., 2019).

The distinction between gold and Bitcoin is therefore important. Gold has a long-established role as a wealth-preservation asset, whereas Bitcoin exhibits much greater volatility

and stronger speculative characteristics. The previous studied find significant differences between Bitcoin and gold in terms of volatility, correlation, and portfolio performance, suggesting that Bitcoin cannot simply be treated as a digital equivalent of gold (Klein et al., 2018). Within the framework of this study, gold represents a traditional safe-haven asset, whereas Bitcoin represents a high-volatility alternative asset whose role may shift between speculation, diversification, and hedging depending on market conditions.

2.3 Portfolio Diversification and Cross-Asset Allocation

The relationship among Bitcoin, gold, and the stock market can also be explained through modern portfolio theory. The argues that investors can reduce portfolio risk by combining assets whose returns are not perfectly correlated (Markowitz, 1952). This principle encourages investors to allocate wealth across different asset classes according to expected return, volatility, and covariance. From this perspective, stocks, gold, and Bitcoin may serve different functions within the same portfolio.

Gold is commonly included as a defensive component because of its relatively low correlation with equities, while Bitcoin may provide diversification benefits because its price dynamics differ from those of conventional assets. However, diversification benefits are not constant. When correlations increase during periods of market stress, the risk-reduction advantages of holding multiple assets may decline. This is particularly relevant for Bitcoin because its relationship with traditional financial markets may strengthen during particular episodes of global uncertainty.

Portfolio rebalancing also provides a mechanism through which changes in one asset can affect another. When Bitcoin prices rise rapidly, investors may reallocate capital toward cryptocurrencies, potentially reducing allocations to traditional assets. Conversely, during periods of heightened uncertainty, investors may move funds from stocks or Bitcoin into gold. These capital shifts create potential linkages among the three markets even when the underlying economic determinants of each asset differ.

2.4 Empirical Relationship between Bitcoin and Stock Markets

A growing body of empirical research has examined the relationship between Bitcoin and equity markets. Empirical studies provide evidence of dynamic interdependence between cryptocurrency and conventional financial markets. Cryptocurrency stock market connectedness may vary over time and may intensify under particular market conditions (Bouri et al., 2021; Corbet et al., 2018; Wang et al., 2019). Such findings support the view that Bitcoin price changes can influence equity market behavior through changes in investor sentiment, portfolio allocation, and risk appetite. Conversely, developments in stock markets may also influence cryptocurrency investment decisions as investors adjust their exposure to high-risk assets.

However, the relationship is not necessarily stable or symmetric. The previous studied show that Bitcoin did not provide consistent protection during the COVID-19 stock market decline (Conlon & McGee, 2020). This result suggests that Bitcoin may behave more like a speculative or risky asset during extreme market conditions rather than a traditional safe haven. Accordingly, empirical evidence does not support a universal assumption that Bitcoin and stock markets always move in opposite directions.

Within the Indonesian context examined in the source study, the proposed relationship is also reciprocal. The study hypothesizes that Bitcoin may influence the IHSG through portfolio substitution and wealth effects, while IHSG movements may affect Bitcoin through changes in investor risk sentiment. The use of a simultaneous dynamic model is therefore intended to capture this possible two-way relationship rather than assuming a strictly one-directional influence.

2.5 Empirical Relationship between Gold and Stock Markets

The relationship between gold and stock markets has been extensively examined because gold is traditionally associated with hedging and safe-haven behavior. The previous studied find that gold can provide protection during adverse financial market conditions (Baur & McDermott, 2016). This suggests that investors may shift from equities toward gold when uncertainty increases, generating inverse movements between gold prices and stock indices.

Nevertheless, the relationship between gold and stocks is not always uniformly negative. The strength and direction of the relationship may depend on economic conditions, inflation expectations, monetary

policy, exchange-rate movements, and geopolitical uncertainty. The previous studied demonstrate that gold, oil, the U.S. dollar, and stock markets exhibit complex interdependencies, illustrating that gold cannot be interpreted solely through a simple negative correlation with equities (Arfaoui & Ben Rejeb, 2017).

For the Indonesian market, this mechanism implies that fluctuations in the IHSG may influence investor demand for gold, while movements in gold prices may also provide information about changes in global risk perception. Therefore, the relationship between the IHSG and gold should be analyzed dynamically rather than assumed to be stable throughout the observation period.

2.6 Empirical Relationship between Bitcoin and Gold

Bitcoin and gold are frequently compared because both have been discussed as alternatives to conventional financial assets. Nevertheless, their market structures differ substantially. Gold is supported by a long history as a store of value and safe-haven asset, whereas Bitcoin is a relatively new digital asset characterized by extreme volatility and speculative trading.

The previous studied conclude that Bitcoin is not simply a new form of gold because the two assets display different volatility structures and portfolio characteristics (Klein et al., 2018). Previous evidence also indicates that Bitcoin's safe-haven characteristics differ from those of gold and other conventional assets (Bouri et al., 2020; Wang et al., 2019). These findings indicate that although Bitcoin and gold may occasionally be viewed as substitute investment instruments, their relationship can vary considerably across market regimes.

The original study therefore considers both possible directions of interaction. Rising gold prices may encourage investors to prefer a more defensive asset rather than Bitcoin, while strong Bitcoin performance may attract capital away from gold. At the same time, the two assets may occasionally move in the same direction when investors regard both as alternatives to fiat-based or conventional financial assets. Consequently, the empirical relationship between Bitcoin and gold remains an open question that requires dynamic investigation.

2.7 Research Gap

Although previous studies have generated substantial evidence concerning cryptocurrency, gold, and equity markets, several limitations remain. First, many studies examine only pairwise relationships, such as Bitcoin and stock markets or gold and stock markets, rather than incorporating Bitcoin, gold, and an equity index within a single dynamic system. Second, empirical findings concerning the safe-haven and diversification roles of Bitcoin remain inconsistent. Some studies report hedging or diversification benefits, whereas others indicate that Bitcoin may behave as a risky asset during periods of market stress (Bouri et al., 2017; Bouri et al., 2020; Conlon & McGee, 2020).

Third, several previous studies employ correlation, conventional regression, panel regression, or other methods that primarily emphasize static or one-directional relationships. Such approaches may be less appropriate when financial variables are jointly endogenous and exhibit both short-run adjustments and long-run equilibrium relationships. The VECM framework provides an alternative because it can model cointegrated variables as part of an integrated dynamic system while distinguishing temporary adjustments from long-run relationships.

Accordingly, the present study extends the existing literature by jointly examining Bitcoin, gold prices, and the Indonesian Composite Stock Price Index over the 2020–2025 period. The study combines cointegration analysis and VECM estimation with Impulse Response Function and Forecast Error Variance Decomposition analyses to identify long-run equilibrium, short-run adjustments, shock responses, and the relative contribution of each market to fluctuations in the others. This approach is intended to provide a more comprehensive understanding of cross-asset interdependence in the Indonesian financial market.

3. Method

3.1 Research Design

This study employed a quantitative time-series design to examine the dynamic relationships among Bitcoin prices, gold prices, and the Indonesian Composite Stock Price Index (IHSG). The analysis focused on identifying both short-run adjustments and long-run equilibrium relationships among the three financial assets. Because the variables represent financial market series that may influence one another over time, the study applied the Vector

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Error Correction Model (VECM), which is appropriate when non-stationary variables are integrated at the same order and exhibit cointegration. The time-series properties of the variables were first examined using unit-root testing because non-stationary series may lead to inappropriate inference if their stochastic properties are ignored (Dickey & Fuller, 1981). When non-stationary variables are integrated of the same order and share a cointegrating relationship, their short-run dynamics and long-run equilibrium adjustment can be modeled within an error-correction framework (Engle & Granger, 1987). The existence and number of cointegrating relationships were subsequently evaluated using the Johansen cointegration approach (Johansen, 1991).

The observation period covered January 2020 to December 2025. This period was selected because it includes substantial changes in global financial conditions, including the COVID-19 pandemic, post-pandemic economic recovery, changes in monetary policy, geopolitical uncertainty, and the rapid expansion of cryptocurrency markets. These developments generated considerable fluctuations in Bitcoin, gold, and equity markets, making the period relevant for examining cross-asset financial dynamics. The study used monthly closing-price data to maintain a consistent observation frequency across all variables.

3.2 Data and Data Sources

The study used secondary quantitative data in the form of monthly time-series observations. The three variables analyzed were Bitcoin prices, international gold prices, and the Indonesian Composite Stock Price Index. Bitcoin represents the digital-asset market, gold represents a traditional safe-haven asset, and the IHSG represents the Indonesian equity market. The data were collected using documentation techniques from publicly accessible financial databases and official market sources.

Table 1. Variable Measurement and Data Sources

Variable	Operational Measure	Frequency	Primary Source
Bitcoin	Monthly closing price of Bitcoin	Monthly	Yahoo Finance
Gold	Monthly international gold price	Monthly	Investing.com
IHSG	Monthly closing value of the Indonesian Composite Stock Price Index	Monthly	Indonesia Stock Exchange and Yahoo Finance

The thesis narrative additionally mentions the World Gold Council as a supporting source for gold-price information, although its data-source table identifies Investing.com as the principal source. The empirical analysis used observations compiled for the 2020–2025 period. The descriptive-statistics output reported 68 usable observations for each variable.

3.3 Data Analysis Procedure

Data processing and econometric estimation were performed using EViews 12. The analysis was conducted sequentially, beginning with descriptive statistics and followed by stationarity testing, optimal lag selection, VAR stability testing, Johansen cointegration testing, VECM estimation, Impulse Response Function analysis, and Forecast Error Variance Decomposition. This sequence was used to ensure that the time-series properties of the data were appropriately identified before estimating the dynamic relationships among the variables.

3.4 Descriptive Statistics

Descriptive statistics were first employed to provide an overview of the distribution and variability of each financial series. The analysis included the mean, median, minimum, maximum, standard deviation, skewness, kurtosis, and Jarque–Bera statistic. These indicators were used to describe the general characteristics of Bitcoin, gold, and the IHSG and to identify differences in their levels of volatility during the observation period. The descriptive stage was conducted before the inferential time-series procedures.

3.5 Unit Root Test

Because financial time-series data commonly exhibit trends and non-stationary behavior, stationarity was examined using the Augmented Dickey–Fuller (ADF) test (Dickey & Fuller, 1981). Testing was initially conducted at the level form of each variable. When a variable was found to be non-stationary at level, the test was repeated after first differencing.

The hypotheses for the ADF test were specified as follows:

H_0:The series contains a unit root

H_1:The series is stationary

A variable was considered stationary when the probability value of the ADF statistic

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was below the 5% significance level. Alternatively, stationarity was indicated when the ADF test statistic was more negative than the corresponding critical value. The source study reported that Bitcoin, gold, and the IHSG were non-stationary at level but became stationary after first differencing, indicating that the three series were integrated of order one, or $I(1)$.

3.6 Optimal Lag Selection

After the order of integration had been established, the optimal lag length was determined. Selecting an appropriate lag is important because too few lags may fail to capture the dynamic relationships among variables, whereas excessive lags may reduce estimation efficiency.

The lag-selection procedure considered five information criteria: the Likelihood Ratio (LR) statistic, Final Prediction Error (FPE), Akaike Information Criterion (AIC), Schwarz Criterion (SC), and Hannan–Quinn Criterion (HQ). The preferred lag was selected based on the recommendation of the majority of these criteria and the lowest information-criterion values. In the source analysis, LR, FPE, and AIC selected lag 1, whereas SC and HQ selected lag 0. Consequently, lag 1 was adopted as the optimal lag length for the subsequent analysis.

3.7 VAR Stability Test

Before cointegration and dynamic-response analyses were conducted, the stability of the underlying VAR system was evaluated using the roots of the characteristic polynomial. A VAR system was considered stable when all characteristic roots had modulus values below one and were located inside the unit circle.

The stability test is particularly important for ensuring that the estimated responses generated through IRF and FEVD do not produce explosive dynamic behavior. In the source study, all characteristic roots had modulus values below one, indicating that the estimated system satisfied the VAR stability condition.

3.8 Johansen Cointegration Test

Because all three variables were identified as $I(1)$, the next stage examined whether they shared a common long-run equilibrium relationship using the Johansen cointegration procedure (Johansen, 1991). Cointegration was tested using the Johansen cointegration procedure, based on both the Trace Statistic and Maximum Eigenvalue Statistic.

The general hypotheses were:

$$H_0: r = 0$$

indicating no cointegrating relationship, against:

$$H_1: r > 0$$

indicating the existence of at least one cointegrating relationship.

The null hypothesis was rejected when the Trace Statistic or Maximum Eigenvalue Statistic exceeded its 5% critical value, or when the associated probability value was below 0.05. Evidence of cointegration provides the methodological basis for estimating a VECM rather than an unrestricted VAR in first differences.

3.9 Vector Error Correction Model

The Vector Error Correction Model was used to estimate the short-run dynamics and long-run relationships among Bitcoin, gold, and the IHSG. The general VECM specification can be expressed as:

$$\Delta Y_t = \alpha \beta' Y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \, \Delta Y_{t-i} + \mu + \varepsilon_t$$

where:

$$Y_t = \begin{bmatrix} BTC_t \\ IHSG_t \\ GOLD_t \end{bmatrix}$$

and:

- Δdenotes the first-difference operator;
- $Y_t$represents the vector of endogenous financial variables;
- $\beta' Y_{t-1}$represents the long-run cointegrating relationship;
- αrepresents the speed-of-adjustment coefficients;
- $\Gamma_i$captures short-run dynamic effects;
- μrepresents the intercept; and
- $\varepsilon_t$represents the vector of error terms.

Within this framework, the Error Correction Term (ECT) represents deviations from long-run equilibrium. A negative and statistically significant adjustment coefficient indicates that deviations from equilibrium are corrected over time. The magnitude of the coefficient reflects the proportion of disequilibrium corrected within one observation period.

3.10 Hypothesis Testing

The statistical significance of the estimated VECM coefficients was evaluated using the corresponding t-statistics. Following

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the criterion used in the source study, coefficients were interpreted as statistically significant at the 5% level when the absolute t-statistic exceeded 1.96:

$$| t | > 1.96$$

A coefficient satisfying this criterion was interpreted as evidence of a statistically significant relationship, whereas a coefficient with:

$$| t | < 1.96$$

was regarded as statistically insignificant. Short-run relationships were evaluated from the lagged differenced terms in the VECM, while long-run dynamics were interpreted from the cointegrating relationship and the Error Correction Term.

3.11 Impulse Response Function

The Impulse Response Function (IRF) was applied to examine how each variable responds over time to a one-standard-deviation innovation in itself or another variable within the system. Unlike coefficient estimates that describe direct statistical associations, IRF analysis allows the direction, magnitude, duration, and convergence pattern of the responses to be observed following a shock. The source study generated impulse responses over a 36-period horizon using Cholesky one-standard-deviation innovations. The Cholesky ordering was specified as:

$$Bitcoin \rightarrow IHSG \rightarrow Gold$$

The resulting response functions were used to evaluate how shocks in Bitcoin, the IHSG, and gold were transmitted throughout the system and whether the variables eventually returned toward a relatively stable condition.

3.12 Forecast Error Variance Decomposition

The final stage employed Forecast Error Variance Decomposition (FEVD) to quantify the relative contribution of shocks from each variable to the forecast-error variance of the other variables. Whereas IRF identifies the direction and pattern of responses, FEVD estimates the percentage of future variation in a variable that can be attributed to innovations originating from itself and from other variables in the system.

FEVD was estimated over the same 36-period horizon using the Cholesky decomposition. The analysis therefore enabled the study to identify whether the variation in Bitcoin, gold, and the IHSG was primarily explained by their own innovations or by shocks transmitted from the other financial markets. The resulting contribution percentages were subsequently used to evaluate the relative strength of cross-market interdependence.

4. Discussion

The empirical findings indicate that the relationships among Bitcoin, gold prices, and the Indonesian Composite Stock Price Index (IHSG) are heterogeneous across both direction and time horizon. The VECM results show that some relationships are statistically significant, whereas others remain weak, suggesting that the three asset markets do not respond symmetrically to one another. At the same time, the Johansen cointegration results reported in the study indicate the existence of a long-run equilibrium relationship among Bitcoin, gold, and the IHSG. This finding supports the broader argument that digital assets, traditional safe-haven assets, and equity markets increasingly operate within an interconnected financial environment.

4.1 Bitcoin and the Indonesian Stock Market

The VECM results show that lagged Bitcoin movements have a statistically significant relationship with changes in the IHSG, as indicated by a t-statistic of 3.38865, which exceeds the critical value of 1.96. This finding suggests that information originating from the Bitcoin market can be transmitted to the Indonesian stock market in the short run. The result is consistent with the Market Interdependence Theory, which argues that financial markets are connected through information transmission, portfolio reallocation, and changes in investor sentiment. As investors increasingly participate across conventional and digital asset markets, substantial changes in Bitcoin prices may influence their willingness to increase or reduce exposure to equities.

This result is also consistent with previous studies showing that cryptocurrencies have become increasingly integrated with traditional financial markets. Previous studies have shown that cryptocurrencies are increasingly connected with conventional financial markets and that the intensity of cryptocurrency–equity market linkages varies over time (Bouri et al., 2021; Corbet et al., 2018; Wang et al., 2019). These findings indicate that Bitcoin can no longer be regarded as an entirely isolated digital market because shocks and information generated in the cryptocurrency market may affect investors' behavior in equity

markets.

From an investment perspective, the significant Bitcoin–IHSG relationship may be explained through portfolio rebalancing. A substantial increase in Bitcoin prices can alter investors' perceived wealth, risk tolerance, and expectations regarding speculative assets. Investors benefiting from gains in the cryptocurrency market may subsequently allocate part of their wealth to equities, while sharp declines in Bitcoin may increase risk aversion and influence capital allocation toward other investment instruments. This mechanism is consistent with modern portfolio theory, which emphasizes that investors continuously adjust asset allocation according to changes in expected return, risk, and covariance among assets (Markowitz, 1952).

However, the reverse short-run relationship is not statistically significant. The IHSG coefficient in the Bitcoin equation has a t-statistic of 0.76762, which is below the critical value of 1.96. This indicates that short-run movements in the Indonesian stock market do not significantly explain Bitcoin price changes. One possible interpretation is that Bitcoin is a globally traded asset whose price formation is influenced by a much broader set of international factors than those represented by the Indonesian equity market alone. Bitcoin prices may respond more strongly to global cryptocurrency sentiment, regulatory developments, international monetary conditions, technological developments, and global risk appetite.

The asymmetry between Bitcoin → IHSG and IHSG → Bitcoin is therefore economically plausible. Bitcoin may transmit information to domestic equity investors because of its growing role as a global speculative asset, whereas the Indonesian stock market represents only one component of the global financial system and may have a relatively limited influence on international Bitcoin pricing. This asymmetry also demonstrates why the relationship among financial assets should not automatically be assumed to be bidirectional even when they are included within the same dynamic system.

4.2 Gold Prices and the Indonesian Stock Market

The VECM results indicate that lagged gold-price changes do not significantly affect the IHSG in the short run, with a t-statistic of -0.14840. This finding suggests that monthly changes in international gold prices during the observation period were not sufficiently strong to generate an immediate statistically significant response in the Indonesian equity market. Although gold is traditionally regarded as a safe-haven asset, its movements do not necessarily produce a direct short-run reallocation of funds from equities.

This result highlights the conditional nature of the safe-haven role of gold. The argue that gold's safe-haven characteristics become particularly important during periods of severe market uncertainty rather than during all market conditions (Baur & McDermott, 2016). Therefore, the absence of a significant short-run effect does not necessarily imply that gold has no relevance for Indonesian investors. Instead, the relationship may depend on the intensity of financial stress, monetary conditions, currency movements, and broader international risk factors.

The finding is also consistent with the argument that gold and equity markets may be influenced simultaneously by common macroeconomic factors. The previous studied demonstrate that gold, currencies, oil, and stock markets exhibit complex interdependencies (Arfaoui & Ben Rejeb, 2017). Therefore, changes in gold prices may not translate directly into changes in stock indices because both markets may respond differently to external developments such as inflation expectations, interest-rate policy, geopolitical risks, and U.S. dollar movements.

Interestingly, the reverse relationship reported in the study is statistically significant. The IHSG has a significant relationship with gold prices, with an absolute t-statistic of 2.14784. This implies that changes in the Indonesian stock market may be followed by adjustments in gold prices within the estimated system. The result is broadly consistent with Safe-Haven Theory because deterioration in stock market conditions may encourage investors to seek more defensive assets, whereas improvements in equity-market conditions may increase demand for riskier investments.

The directional difference between the two relationships suggests that the interaction between equities and gold is not perfectly symmetric. Gold-price movements do not immediately explain the IHSG, but stock-market conditions appear to contain information associated with subsequent gold-price dynamics. Such an asymmetric relationship

reinforces the argument that safe-haven behavior is market- and condition-dependent rather than mechanically reciprocal.

4.3 Relationship between Gold and Bitcoin

The results show no statistically significant short-run relationship between gold and Bitcoin in either direction. The t-statistic for the effect of gold on Bitcoin is -0.77597, while the t-statistic for the effect of Bitcoin on gold is -0.41336. Both values are below the critical threshold of 1.96. These findings indicate that changes in the two assets were largely driven by different market mechanisms during the observation period.

Although Bitcoin is occasionally referred to as "digital gold," previous empirical research has repeatedly questioned whether Bitcoin exhibits the same characteristics as physical gold. Klein et al. (2018) demonstrate that Bitcoin and gold differ substantially in terms of volatility, correlation structure, and portfolio performance. Gold has historically served as a store of value and defensive asset, whereas Bitcoin remains characterized by considerably higher volatility and stronger speculative behavior.

The insignificant relationship found in this study supports this distinction. Gold prices are influenced by global inflation expectations, monetary policy, geopolitical uncertainty, central-bank demand, and investor demand for wealth preservation. Bitcoin, by contrast, is more closely associated with cryptocurrency-market liquidity, digital-asset adoption, investor speculation, technological developments, regulatory announcements, and global risk appetite. Because the determinants of the two assets differ, their prices may move relatively independently even when both are used as alternative investment instruments.

This finding is also compatible with previous evidence that Bitcoin does not consistently function as a traditional safe haven. The previous studied found that Bitcoin's hedging properties depend on market conditions (Bouri et al., 2017). While Conlon and McGee (2020) showed that Bitcoin did not consistently protect investors during the COVID-19 market downturn. Previous evidence likewise indicates that Bitcoin and gold exhibit different safe-haven and diversification characteristics (Bouri et al., 2020; Wang et al., 2019). Thus, the absence of a significant direct relationship between the two assets further suggests that investors should not automatically regard Bitcoin and gold as substitutes with equivalent portfolio functions.

4.4 Long-Run Equilibrium and Adjustment Dynamics

An important finding of the study is the reported existence of cointegration among Bitcoin, gold, and the IHSG. The Johansen cointegration results indicate that the variables share a long-run equilibrium relationship, implying that although the three markets may diverge temporarily, their movements are linked over longer horizons. This result provides empirical support for the idea of financial-market interdependence.

The estimated long-run relationship reported in the VECM indicates that the IHSG is significantly associated with Bitcoin prices in the long run, with a reported t-statistic of 4.61935, whereas gold prices are not statistically significant in explaining Bitcoin over the same horizon. This suggests that the connection between the Indonesian stock market and Bitcoin becomes more pronounced over longer periods than the connection between Bitcoin and gold.

The Error Correction Term provides additional information regarding the speed at which Bitcoin adjusts toward the long-run equilibrium. The coefficient is reported as -0.424551 with a t-statistic of -3.61029. The negative and significant coefficient indicates that deviations from equilibrium are corrected over time. Specifically, approximately 42.46% of the disequilibrium is reported to be corrected within one observation period. Since monthly data are used, the result implies a relatively substantial monthly adjustment toward the long-run equilibrium after a disturbance.

Economically, this adjustment mechanism indicates that short-term shocks do not permanently separate the markets from their long-run trajectory. Although Bitcoin, gold, and the IHSG can react differently to temporary shocks, part of the deviation is gradually corrected. This finding reinforces the relevance of using a dynamic framework rather than relying solely on static contemporaneous relationships.

4.5 Impulse Response Analysis

The Impulse Response Function provides further evidence that the relationships among the three markets are dynamic and vary according to the source of the shock. Bitcoin initially responds strongly and positively to its

own innovation. The response subsequently declines and approaches a relatively stable level over later periods. This pattern reflects the strong persistence of Bitcoin-specific shocks and is consistent with the high volatility that characterizes cryptocurrency markets.

Bitcoin responds negatively to shocks originating from the IHSG. The source analysis reports a response of approximately -29.29 million in the second period, which subsequently stabilizes at around -33.10 million in the longer horizon. Bitcoin also responds negatively to gold-price shocks, although the magnitude is substantially smaller than the response to IHSG innovations. These results indicate that equity-market shocks appear to produce stronger responses in Bitcoin than gold-price shocks within the estimated system.

The IHSG also exhibits a negative response to Bitcoin shocks. After initial fluctuations, the response is reported to stabilize at approximately -119.74. In contrast, the IHSG's response to its own shock remains positive, while its response to gold shocks is considerably smaller. This pattern reinforces the evidence that the strongest cross-market interaction in the system occurs between Bitcoin and the IHSG rather than between either of these assets and gold.

Gold displays comparatively more stable dynamics. Its response to its own innovation remains positive and eventually converges toward a relatively stable value. Gold responds positively to Bitcoin shocks in the longer horizon, whereas its response to IHSG shocks becomes relatively small after initial fluctuations. These results are consistent with the interpretation that gold operates relatively independently compared with the stronger interaction observed between Bitcoin and the stock market.

Overall, the IRF results demonstrate that shocks produce substantial short-run fluctuations before the variables gradually approach relatively stable response patterns. This finding is consistent with the presence of an adjustment mechanism within the VECM system and highlights the importance of examining not only statistical significance but also the trajectory and persistence of responses after financial shocks.

4.6 Forecast Error Variance Decomposition

The FEVD results provide important evidence concerning the relative importance of each market in explaining future fluctuations. Bitcoin's forecast-error variance is initially explained entirely by its own innovations. However, the contribution of Bitcoin's own shocks declines gradually and reaches approximately 72.55% by the 36th period. At the same horizon, the contribution of the IHSG rises to approximately 27.17%, whereas gold contributes only around 0.28%.

This result is particularly important because it indicates that although Bitcoin remains predominantly driven by its own market dynamics, the Indonesian stock market becomes increasingly relevant in explaining Bitcoin fluctuations over longer horizons. The relatively small contribution of gold supports the VECM results showing that gold has limited explanatory power for Bitcoin.

An even stronger pattern is observed in the variance decomposition of the IHSG. In the first period, approximately 98.74% of IHSG variation is explained by its own shocks. Over time, however, Bitcoin's contribution increases substantially. By the 36th period, Bitcoin explains approximately 66.19% of the forecast-error variance of the IHSG, whereas the IHSG itself explains approximately 33.68% and gold contributes only around 0.13%.

This finding indicates that Bitcoin represents the most important external contributor to IHSG fluctuations within the estimated system. The result further supports the short-run VECM finding that Bitcoin significantly affects the IHSG. It also suggests that the increasing integration of cryptocurrency and equity markets may have important implications for portfolio risk management because cryptocurrency shocks may eventually account for a substantial proportion of stock-market variation.

Gold shows a distinctly different pattern. Approximately 98.99% of its variation is initially explained by its own innovations, and its own contribution remains approximately 94.40% even at the 36th period. Bitcoin contributes approximately 5.31%, whereas the IHSG contributes only around 0.30%. Gold therefore appears to be the most internally driven and relatively independent asset within the three-variable system.

The FEVD results complement the IRF evidence and strengthen the conclusion that the most important dynamic interaction occurs between Bitcoin and the IHSG. Gold remains comparatively less connected to the other two markets, particularly over the longer forecast horizon.

4.7 Theoretical and Practical Implications

The findings provide support for Market Interdependence Theory by demonstrating that financial markets representing different asset classes can transmit information and shocks to one another. In particular, the relationship between Bitcoin and the IHSG indicates that digital assets have become increasingly relevant to conventional financial-market dynamics. The results therefore challenge the perception that cryptocurrency markets operate independently from traditional financial systems.

The findings also provide a more nuanced interpretation of Safe-Haven Theory. Gold remains highly dominated by its own shocks and exhibits relatively weak transmission from Bitcoin and the IHSG. This comparatively independent behavior is consistent with the distinctive role of gold as a defensive portfolio asset. However, the significant relationship from the IHSG to gold indicates that stock-market conditions may still influence defensive asset allocation, particularly when investor perceptions of risk change.

From a portfolio-management perspective, the results have important implications. Investors holding both Bitcoin and Indonesian equities should consider the possibility that diversification benefits between the two markets may decline when their dynamic connectedness increases. A shock originating in Bitcoin may eventually explain a substantial proportion of fluctuations in the IHSG, while equity-market innovations can also contribute to Bitcoin variation over longer horizons. Consequently, treating cryptocurrencies and stocks as completely independent asset classes may underestimate cross-market risk.

Gold appears to offer comparatively greater diversification potential because its variance remains predominantly explained by its own innovations and its contribution to Bitcoin and IHSG fluctuations remains small. Nevertheless, diversification decisions should not rely exclusively on historical relationships because safe-haven properties and cross-asset correlations can vary substantially across market conditions. The findings therefore suggest that investors should periodically reassess cross-market linkages rather than assuming that historical relationships remain constant over time.

4.8 Overall Discussion

Taken together, the results indicate that the dynamic relationship among Bitcoin, gold, and the Indonesian stock market is characterized by asymmetry, time dependence, and unequal shock transmission. Bitcoin significantly contributes to short-run IHSG dynamics, whereas the reverse short-run relationship is not statistically significant. Gold does not significantly explain either Bitcoin or the IHSG in the short run, while the IHSG is significantly associated with gold-price dynamics. In the longer horizon, the reported VECM results identify a stronger relationship between the IHSG and Bitcoin than between gold and Bitcoin.

The IRF and FEVD analyses reinforce this conclusion. Bitcoin and the IHSG exhibit the strongest cross-market interaction, while gold remains relatively independent and predominantly influenced by its own innovations. These findings extend previous evidence regarding the increasing integration of cryptocurrency and conventional financial markets while demonstrating that traditional safe-haven assets may exhibit different patterns of connectedness. Overall, the study suggests that the emergence of Bitcoin has altered the structure of cross-asset relationships in the Indonesian financial environment and that cryptocurrency-market developments should increasingly be incorporated into portfolio management and financial-market analysis.

5. Conclusion

This study examined the dynamic relationships among Bitcoin prices, gold prices, and the Indonesian Composite Stock Price Index (IHSG) during 2020–2025 using the Vector Error Correction Model (VECM), complemented by Impulse Response Function (IRF) and Forecast Error Variance Decomposition (FEVD) analyses. The reported findings indicate that the three variables share a long-run equilibrium relationship, while their short-run interactions are asymmetric. Bitcoin significantly affects the IHSG, whereas the short-run effects of the IHSG on Bitcoin, gold on the IHSG, gold on Bitcoin, and Bitcoin on gold are not statistically significant. The IHSG, however, significantly affects gold prices. The significant and negative Error Correction Term indicates that approximately 42.46% of short-run disequilibrium is corrected within one observation period. The IRF and FEVD results further demonstrate that the strongest dynamic interaction occurs between Bitcoin and the IHSG, while gold remains comparatively more independent and is

predominantly explained by its own shocks. These findings imply that investors should consider cross-market transmission between cryptocurrency and the Indonesian equity market when constructing portfolios and managing financial risk.

This study is subject to several limitations. The analysis includes only Bitcoin, gold, and the IHSG, uses monthly observations over a relatively limited 2020–2025 period, and applies a linear VECM framework that may not fully capture structural breaks, nonlinear relationships, or rapidly changing market regimes. Future studies are therefore encouraged to incorporate additional macroeconomic and financial variables, such as exchange rates, inflation, interest rates, global stock indices, and oil prices, while extending the observation period and employing daily or weekly data. Further research may also compare VECM results with alternative approaches such as ARDL, NARDL, GARCH-family models, or time-varying connectedness techniques to provide a more comprehensive understanding of cross-asset dependence and volatility transmission.

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