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Modelling Indonesian sovereign bond yield volatility using GARCH models

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Abstract

This study examined the volatility of Indonesian government bond yields across three market periods: pre-COVID-19, the COVID-19 pandemic, and the Russia-Ukraine war. Using daily secondary data from January 2018 to December 2023, this study compared symmetric (GARCH and IGARCH) and asymmetric (GJR-GARCH and EGARCH) models across short-, medium-, and long-term maturities. It highlighted the limited evidence on how volatility persistence and asymmetric responses vary across maturities in Indonesia's sovereign bond market under changing market conditions. The results identify the EGARCH model with a generalized error distribution (GED) as the preferred specification. Volatility persistence varies across maturities, with long-term yields exhibit faster decay than short- and medium-term yields. Significant asymmetric effects are also identified for medium- and long-term yields, indicating that positive shocks increase volatility more than negative shocks in these particular segments. In addition, volatility persists longer during bearish market phases than during the pre-pandemic bullish phase. The causality tests revealed limited evidence of a causal relationship between inflation and 3-year bond yield volatility, while no significant causal relationships were found for the other macroeconomic relationships examined. These findings contribute to the maturity-specific sovereign bond risk research and offer practical guidance for volatility monitoring, portfolio allocation, and risk management during periods of heightened economic and geopolitical uncertainty.

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1. Introduction

Global economic crises can generate uncertainty in financial markets and contribute to sovereign bond yield volatility. One of the examples is the Asian financial crisis of 1997, which triggered currency depreciation, liquidity pressures, and increases in benchmark interest rates across several Asian economies, affecting sovereign bond markets throughout countries within the region, particularly in developing ASEAN countries (Trinh et al., 2020). Similarly, the 2008 global financial crisis heightened uncertainty and contributed to fluctuations in sovereign bond markets. Even more recently, the COVID-19 pandemic also disrupted economic activity and financial markets worldwide, including Indonesia, while the Russia-Ukraine war escalated in February 2022, further intensified geopolitical uncertainty and contributed to increases in commodity prices and subsequently, inflation (Roy et al., 2023). These events highlight the importance of

understanding how external shocks affect sovereign bond market dynamics. Although government bonds are commonly used for portfolio diversification and risk management, their ability to mitigate investment risk depends on prevailing market conditions and the behavior of bond yields (Yagli & Deviren, 2023).

Figures 1-3 illustrate the dynamics of Indonesian government bond yields across 3-year, 5-year, and 10-year maturities, respectively. The figures suggest that yield movements and volatility vary across maturities and change around major global events, including the COVID-19 pandemic and the Russia-Ukraine war. These variations in volatility are important because bond yields and bond prices are inversely related: an increase in yields generally corresponds to a decline in bond prices, while a decrease in yields corresponds to an increase in prices, assuming other factors remain constant. However, changes in yield levels are not necessarily equivalent to changes in yield volatility. Yield volatility reflects the magnitude and variability of yield fluctuations over time and provides an indication of uncertainty in the bond market. Accordingly, examining yield volatility across different maturities and market conditions can provide a more comprehensive insight of sovereign bond market risk, particularly in Indonesia.

Global uncertainty can influence sovereign bond yield volatility through changes in investor expectations, risk perceptions, liquidity conditions, and monetary and fiscal policy responses. Zaremba et al. (2021) identified economic uncertainty as an important factor associated with financial market instability, including fluctuations in bond markets. Government intervention through public policy may moderate these effects, by which policy responses can also alter market expectations and, in turn, yield dynamics. Furthermore, volatility in government

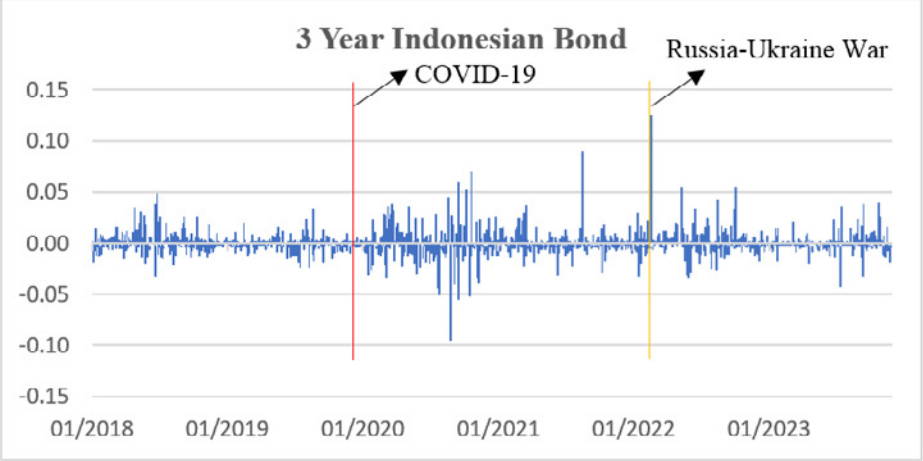


Figure 1. Indonesian government bond yields with 3-year maturity (Source: Investing.com, processed)

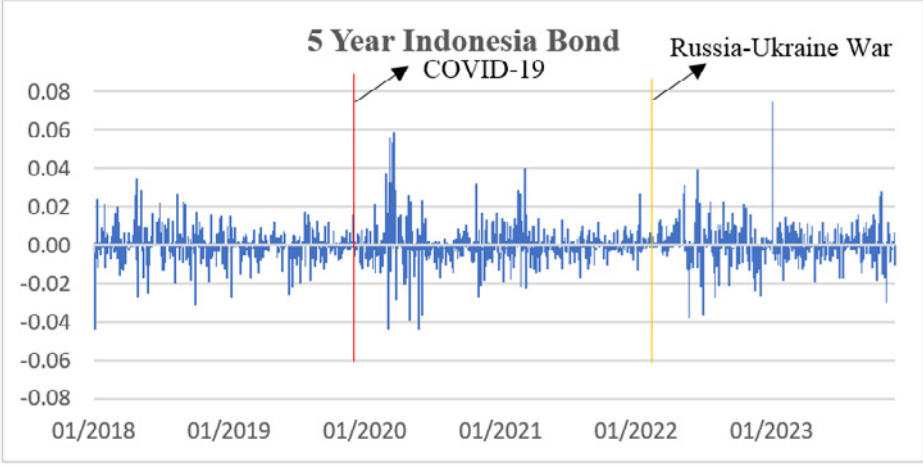


Figure 2. Indonesian government bond yields with 5-year maturity (Source: Investing.com, processed)

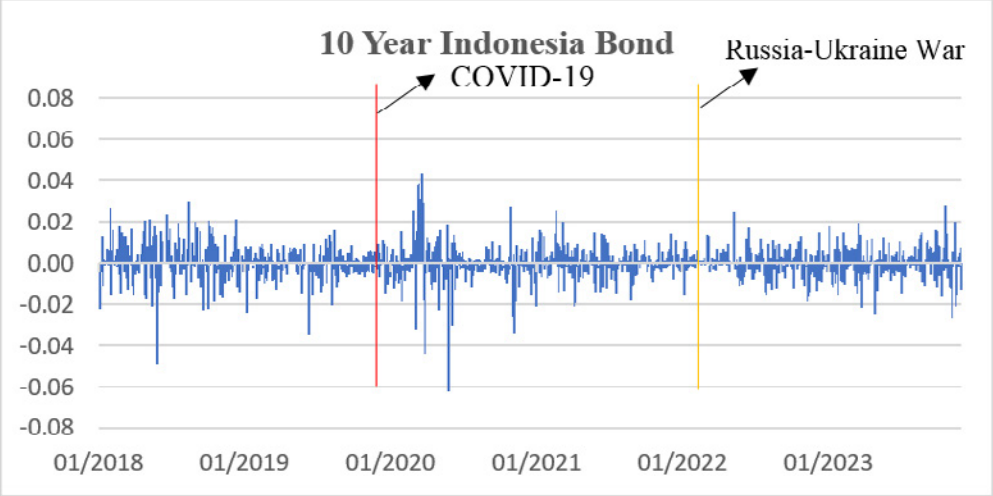


Figure 3. Indonesian government bond yields with 10-year maturity (Source: Investing.com, processed)

bond markets may affect corporate bond pricing and financial stability, reflecting the interconnectedness of sovereign and corporate debt markets (Bevilaqua et al., 2020). Monetary policy is particularly relevant since changes in benchmark interest rates influence the discount rates applied to future bond cash flows and consequently affect investors' expectations regarding future interest rates and inflation. Subramaniam (2022) discusses the role of monetary policy in responding to economic uncertainty, while Zhou (2021) highlights the relevance of fiscal policy to government bond volatility. These relationships suggest that sovereign bond yield volatility should be examined in the context of both external shocks and domestic macroeconomic conditions.

Previous studies have investigated the relationship between macroeconomic conditions and sovereign bond yield volatility (Lithin et al., 2023; Trinh et al., 2020). Existing literatures predominantly focused on developed economies, where relatively matured financial markets, established institutions, and stronger macroeconomic fundamentals provide important contexts for understanding sovereign bond market behavior (Benlagha & Hemrit, 2022; Panagiotou et al., 2022). Some studies have also examined developing economies, including India (Akram & Das, 2019; Lithin et al., 2023), Latin American countries (Martinez et al., 2013), and Vietnam (Trinh et al., 2020). However, the evidence remains limited regarding the maturity-specific dynamics of Indonesian government bond yield volatility during distinct episodes of global economic and geopolitical uncertainty. In particular, further investigation is warranted into whether volatility persistence and asymmetric responses differ between short-, medium-, and long-term maturities and between relatively stable and crisis-affected market conditions.

This study addresses these issues by examining Indonesian government bond yield volatility using symmetric and asymmetric generalized autoregressive conditional heteroskedasticity (GARCH) models. Its contribution further extends beyond applying GARCH models to Indonesian data in three ways. First, it compares volatility dynamics across 3-year, 5-year, and 10-year government bond yields to determine whether volatility persistence and asymmetric responses differ across maturity segments. Second, it examines volatility across the pre-COVID-19 period, the COVID-19 pandemic, and the Russia-Ukraine war period, distinguishing between bullish and bearish market phases to assess whether the persistence of volatility changes with market conditions. Third, it investigates whether inflation and money market conditions exhibit causal relationships with government bond yield dynamics, thereby providing evidence on the extent to which yield volatility is associated with selected domestic macroeconomic indicators. These objectives are particularly relevant to Indonesia, where understanding the interaction between domestic macroeconomic conditions and external shocks is important for evaluating sovereign bond market risk.

Inflation and money market conditions are taken into consideration since they potentially influence the uncertainty surrounding future bond cash flows and discount rates. Unanticipated inflation can change

expectations about real returns, future monetary policy, and the purchasing power of fixed-income payments. Such changes may generate revisions in investor expectations and increase fluctuations in bond yields. Similarly, changes in money market rates can affect short-term funding conditions, expectations about the policy rate, and the relative attractiveness of securities with different maturities. When inflation or money market conditions become less predictable, investors may revise their required returns more frequently, potentially increasing yield volatility. However, these relationships are not necessarily uniform across maturities or market phases, and their empirical significance must be established rather than assumed. Therefore, this study examines the causal relationships between Indonesian government bond yield dynamics and inflation and money market conditions rather than presuming that these macroeconomic variables necessarily explain yield volatility.

This study contributes to the literature by integrating maturity-specific volatility modeling, comparisons across major crisis periods, and an examination of selected macroeconomic relationships within the Indonesian sovereign bond market. By comparing symmetric and asymmetric GARCH specifications, the analysis identifies an appropriate model for capturing the persistence and potential asymmetry of yield volatility. The findings are expected to provide insights of how sovereign bond market risk evolves across maturities and market conditions. Practically, the results may inform investors and portfolio managers in assessing maturity-specific exposure and developing risk-management strategies, while also providing policymakers with evidence relevant to monitoring sovereign bond market stability during periods of economic and geopolitical uncertainty.

2. Literature Review and Hypotheses Development

Government Bond Market

Bonds are essential instruments of government financing, particularly when fiscal deficits arise (Kariyawasam & Jayasinghe, 2022; Kim, 2021). The bond market is influenced by various factors, including macroeconomic conditions, interest rates, sovereign credit ratings, and exchange rates (Kim, 2021; Martinez et al., 2013). Investors generally perceive government bonds as less risky than corporate bonds because governments are often considered more creditworthy than corporate issuers (Sulong et al., 2023). According to Lithin et al. (2023), the lower perceived risk of government bonds generally results in lower yields, whereas corporate bonds tend to offer higher yields at the same maturity. This causes a spread between the yield of government bonds and corporate bonds. Spreads also occur when comparing the same bonds with different maturities (Chen et al., 2021). Different underlying factors, therefore, determine the varying quality of bonds (Kariyawasam & Jayasinghe, 2022).

Government Bond Volatility

Volatility in government bonds is part of bond price fluctuations, which subsequently affects bond yields through various factors, especially economic and market factors (Zaremba et al., 2021). One of the critical factors in government bond volatility is interest rates, marked by a change in interest rates (Ivanovski et al., 2013). Amid bond market volatility, government bonds can provide relative stability and serve as a component of a diversified investment portfolio (Sulong et al., 2023). The existence of government bonds allows investors to mitigate portfolio risk through diversification (Mobin et al., 2022). Government bonds also provide coupons as fixed income, which makes them a potential option for investors seeking greater security, particularly during periods of significant market fluctuations from riskier assets, such as stocks (Jungherr & Schott, 2021; Kim & Lee, 2014).

Bond Maturity Effects and Economic Shocks

Bond maturity may influence the dynamics of sovereign bond yield volatility, as bonds with different maturities have varying exposures to interest rate uncertainty and shifts in market expectations. Longer-term bonds are generally more sensitive to changes in required yields and may be exposed to greater uncertainty caused by future inflation, monetary policy, and economic conditions. Rout & Mallick (2022) discuss the relationship between bond maturity and yield volatility, while Zhou (2021) explains that longer-term bonds may require higher yields as compensation for greater exposure to interest rate and other risks. Nevertheless, higher yields do not necessarily imply higher yield volatility, and the relationship between maturity and volatility should be established empirically.

During periods of economic crisis, uncertainty regarding economic conditions and investor expec-

tations may intensify the fluctuations in sovereign bond yields (Martinez et al., 2013; Mobin et al., 2022; Rout & Mallick, 2022; Siahaan & Robiyanto, 2021). Investors may also reallocate their portfolios toward assets perceived as safer, although the direction and magnitude of these adjustments depend on prevailing market conditions and the characteristics of the assets involved (Kim & Lee, 2014). Consequently, short-, medium-, and long-term government bonds may exhibit different volatility patterns in response to economic uncertainty.

These arguments suggest that the volatility dynamics of Indonesian sovereign bonds may vary across maturities. However, differences in estimated GARCH parameters reflect differences in the persistence or responsiveness of conditional volatility and do not necessarily demonstrate statistically significant differences in overall volatility levels. Accordingly, the study examines whether volatility dynamics differ across the 3-year, 5-year, and 10-year Indonesian government bond yield series. Based on the theoretical and empirical studies discussed above, Hypothesis 1 made regarding the volatility of state bond yields across maturities.

H_1: The volatility dynamics of Indonesian sovereign bond yields differ across maturities

Sovereign bonds are exposed to several sources of risk, including sovereign default risk, changes in macroeconomic fundamentals, and geopolitical uncertainty. These factors can influence investors' perceptions of a government's ability to meet its debt obligations and generate fluctuations in sovereign bond yields. Geopolitical developments may also affect global economic conditions and drive uncertainties across national financial markets (Subramaniam, 2022). One of the examples, the COVID-19 pandemic disrupted economic activity and mobility in 2020, generating uncertainty in financial markets (Rout & Mallick, 2022). Shortly thereafter, the Russia-Ukraine war further intensified geopolitical and economic uncertainty and affected sovereign bond markets in many countries. Yagli & Deviren (2023) report a significant relationship between the Russia-Ukraine war and changes in sovereign bond yields, highlighting the potential transmission of geopolitical shocks across bond markets.

The effects of economic and geopolitical shocks on bond yield volatility may be asymmetric, meaning that positive and negative shocks of comparable magnitude do not necessarily generate equal changes in conditional volatility. In this study, a positive shock refers to an unanticipated increase in sovereign bond yield returns, whereas a negative shock refers to an unanticipated decrease in sovereign bond yield returns. These definitions concern the direction of yield-return innovations rather than whether the underlying economic news is favorable or unfavorable. This distinction is important because an increase in bond yields generally corresponds to a decline in bond prices, while a decrease in yields generally corresponds to an increase in bond prices, assuming other factors remain constant.

Lithin et al. (2023) suggest that negative shocks often have substantial effects on financial market volatility, although positive news may sometimes generate a stronger response. Theoretically, positive and negative yield-return shocks may affect volatility differently because investors can revise their expectations about sovereign risk, inflation, monetary policy, and future economic conditions in response to new information. However, the direction of the stronger response cannot be established a priori because it may depend on market conditions and bond maturity. Based on these theoretical considerations, the Hypothesis 2 is proposed

H_2: Positive shocks have a greater effect on the volatility of Indonesian sovereign bond yields than negative shocks

Volatility During Bullish and Bearish Phases

A substantial body of literature has examined the implications of financial market volatility for economic and investment outcomes (Albulescu & Grecu, 2023; Nasir et al., 2023; Pagnottoni et al., 2021; Yamani, 2020; Zaremba et al., 2022). However, volatility dynamics may differ between bullish and bearish market phases (Sulong et al., 2023). Identifying these differences is important for investors because market conditions can inform investment strategies and risk-management decisions. During periods of heightened uncertainty, investors may take risk-aversion measures and adjust their portfolios in response to changing market expectations. Paule-Vianez et al. (2022) discuss the effects of the COVID-19 crisis on investor fear and investment behavior, while Coşkun (2023) reports greater volatility during bearish than bullish market conditions in the context examined.

These differences may also influence the persistence of sovereign bond yield volatility, which refers to the extent to which shocks to conditional variance continue to affect subsequent periods. Under

bearish market conditions, elevated uncertainty and sustained revisions in investor expectations may cause volatility to remain high for longer. However, the persistence of volatility may depend on bond maturity and the nature of the underlying shock. Short-, medium-, and long-term government bonds may respond differently to changes in interest rate expectations, inflation uncertainty, and risk perceptions. Therefore, greater volatility during a bearish phase does not necessarily imply that volatility persistence is longer during that phase. Based on these theoretical considerations, this study examines whether the persistence of Indonesian government bond yield volatility differs between bullish and bearish market phases. The expected relationship is expressed in the following hypothesis:

H_3: Volatility persistence in Indonesian sovereign bond yields is longer during bearish market phases than during bullish market phases

GARCH Model

Engle (1982) introduced the Autoregressive Conditional Heteroskedasticity (ARCH) model to capture time-varying conditional variance in financial time series. Bollerslev (1986) subsequently developed the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model by incorporating lagged conditional variance into the variance equation, allowing volatility persistence to be represented more parsimoniously. Although ARCH and conventional GARCH models can capture volatility clustering, their standard symmetric specifications do not distinguish between the effects of positive and negative shocks of comparable magnitude (Lithin et al., 2023). Subsequent extensions have addressed different features of financial volatility, including the Integrated GARCH (IGARCH) model developed by Engle & Bollerslev (1986), the Exponential GARCH (EGARCH) model introduced by Nelson (1991), and the Glosten-Jagannathan-Runkle GARCH (GJR-GARCH) model proposed by Glosten et al. (1993).

These models provide alternative approaches to estimating conditional volatility, but their relative suitability depends on the characteristics of the financial series under investigation. For Indonesian sovereign bond yields, differences in volatility persistence, potential asymmetric responses to shocks, and the distributional characteristics of the data may influence model performance. Therefore, the most appropriate specification cannot be determined solely from theoretical considerations and must instead be established through empirical evaluation.

This study consequently compares symmetric and asymmetric GARCH specifications to identify the model that best captures the volatility dynamics of Indonesian government bond yields across different maturities and market periods. The comparison considers information criteria, including the Akaike Information Criterion (AIC), alongside log-likelihood values and relevant diagnostic tests. These criteria provide complementary evidence regarding model fit, parsimony, and adequacy. Rather than assuming that all GARCH models are equally effective, the study uses empirical model selection to determine the specification most suitable for the observed bond yield series.

Macroeconomics and Volatility

Previous studies have examined the relationship between macroeconomic conditions and government bond markets (Dewachter et al., 2015). Among macroeconomic factors, inflation is particularly relevant because changes in the general price level can thoroughly affect the purchasing power of fixed-income payments, investors' expected real returns, and expectations regarding future monetary policy. Similarly, Zhou (2021) identifies inflation as a relevant macroeconomic factor in examining South African government bond yields. However, the empirical results are varied. Permanasari & Kurniasih (2021), for example, report no significant relationship between inflation and Indonesian government bond yields. Trinh et al. (2020) further explain that rising inflation expectations may increase government bond yields when investors anticipate debt monetization and demand greater compensation for the expected erosion of purchasing power.

These relationships provide a theoretical basis for examining whether inflation is associated with Indonesian government bond yield volatility. When inflation rises unexpectedly, investors may revise their expectations about future interest rates, monetary policy, and real returns. Such revisions can lead to changes in the required yields on government bonds and generate fluctuations in yields. A change in the level of inflation, however, does not necessarily produce greater yield volatility in every circumstance. The magnitude and direction of the relationship may depend on whether inflation is anticipated, the credibility of monetary policy, and

prevailing financial market conditions. Accordingly, this study empirically examines the relationship between inflation and Indonesian government bond yield volatility.

H_4: Inflation is significantly associated with the volatility of Indonesian government bond yields

The relationship may also operate in the opposite direction. Sovereign bond yield volatility reflects uncertainty and fluctuations in the returns required by investors to hold government debt. Greater volatility may coincide with changing expectations about monetary policy, financing conditions, and macroeconomic stability. These developments may be associated with inflation dynamics through their implications for borrowing costs, aggregate demand, and policy responses. However, the relationship is not necessarily direct or unidirectional: inflation may influence bond yield volatility, while bond market volatility may also reflect broader economic uncertainty that coincides with inflationary pressures. The direction and strength of these relationships therefore require empirical investigation rather than being assumed from theory alone.

H_5: The volatility of Indonesian government bond yields is significantly associated with inflation

Interest rates in the money market can be relevant to government bond yield dynamics because they reflect short-term financing conditions and expectations regarding monetary policy. Akram & Das (2019) discuss the relationship between interest rates and government bond yields, while changes in interest rates can influence bond prices and yields. Because bond prices and yields move inversely, an increase in required market interest rates generally reduces the prices of existing fixed-rate bonds and increases their yields. When interest rate changes are unanticipated or occur amid uncertainty about monetary policy, they may also contribute to greater fluctuations in bond yields. In Indonesia, the Jakarta Interbank Offered Rate (JIBOR) serves as a benchmark for interbank lending and borrowing rates (Handayani & Kacaribu, 2021; Herlambang et al., 2023; Sugandi, 2022). Accordingly, fluctuations in JIBOR may capture changes in money market conditions relevant to government bond market participants.

The relationship between money market volatility and government bond yield volatility can operate through changes in short-term financing costs, expectations of future policy rates, and investors' required returns. During periods of financial stress, uncertainties in monetary policy and liquidity conditions may increase fluctuations in money market rates. These developments may affect the government bond market as investors reassess interest rate expectations and the compensation required for holding bonds. Previous study also indicates that interest rate shocks can be transmitted across financial markets, including the bond market (Abbassi & Linzert, 2012). Therefore, greater volatility in the money market may be associated with greater volatility in Indonesian government bond yields. This reasoning leads to the Hypothesis 6.

H_6: Money market volatility is significantly associated with Indonesian government bond yield volatility

The relationship may also operate in the opposite direction. Substantial fluctuations in government bond yields may coincide with uncertainty about inflation expectations, future monetary policy, and broader macroeconomic conditions. Such uncertainty may be reflected in money market rate fluctuations as financial market participants revise their expectations and adjust their financing and liquidity decisions. However, this potential relationship does not necessarily imply that government bond yield volatility directly causes money market volatility; both may respond to common macroeconomic or financial shocks. Accordingly, the Hypothesis 7 is proposed.

H_7: Indonesian government bond yield volatility is significantly associated with money market volatility

3. Methodology

Sample and Data

This study employs a quantitative research design using secondary time-series data to examine the volatility dynamics of Indonesian government bond yields across three maturities: 3-year, 5-year, and 10-year bonds. The sample covers 1 January 2018 to 31 December 2023 and includes government bond yields, inflation, and money market interest rates. Government bond yield data are obtained from Investing.com website, while inflation and money market data are sourced from the official website of Bank Indonesia (bi.go.id). The Jakarta Interbank Offered Rate (JIBOR) is used as the money market benchmark as it reflects Indonesian interbank interest rate conditions and is therefore more directly relevant

to the domestic money market than an international benchmark such as the London Interbank Offered Rate (LIBOR).

The sample is divided into three subperiods to examine whether bond yield volatility dynamics differ across distinct market conditions. The first period, classified as the normal period, runs from 1 January 2018 to 1 March 2020. The second period covers 2 March 2020 to 23 February 2022 and represents the COVID-19 period. The third period, from 24 February 2022 to 31 December 2023, represents the Russia-Ukraine war period. These classifications are used to compare volatility dynamics across the selected periods and do not imply that the events defining each period were the sole determinants of market volatility.

Before estimation, the data were organized in chronological order and then checked for missing observations and consistency across the three bond maturities and the macroeconomic series. Since conventional GARCH models are designed to model conditional heteroskedasticity in a stationary time series, the transformation applied to each series is specified before estimation. For bond yields, the analysis should use the yield change, defined as "y_t = $y_t - y_{t-1}$. Inflation and JIBOR are treated according to their actual observed definitions and transformations. All series must be aligned to a common observation frequency for analyses involving more than one variable.

The GARCH models use daily changes in bond yields, define in Equation 1 (Eq. 1).

$$\Delta y_t = y_t - y_{t-1} \quad \text{(Eq. 1)}$$

Where y_t is the daily bond yield and "y_t is its daily change, typically measured in percentage points or basis points. The daily GARCH conditional variances are aggregated into a monthly volatility series (Equation 2/Eq. 2).

$$V_m = \frac{1}{N_m} \sum_{t \in m} \hat{h}_t \quad \text{(Eq. 2)}$$

Where V_m is the average estimated daily conditional variance during month m, is the daily conditional variance estimated using the GARCH model, and N_m is the number of daily observations in that month. The monthly Granger causality model may be expressed as Equation 3 (Eq. 3).

$$V_m = \sum_{i=1}^{p} a_i V_{m-i} + \sum_{j=1}^{p} b_j X_{m-j} + u_m \quad \text{(Eq. 3)}$$

Where V_m denotes monthly bond yield volatility, X_m represents a monthly inflation or JIBOR variable, p is the selected lag order, and u_m is the error term. The null hypothesis that X_m does not Granger-cause V_m is $b_1 = b_2 = ... = b_p = 0$.

GARCH Models

Generalized autoregressive conditional heteroskedasticity (GARCH) models are used to examine time-varying volatility in financial time-series data. The GARCH framework, developed by Bollerslev (1986), extends the ARCH model of Engle (1982) by incorporating both past squared innovations and lagged conditional variances. This structure enables the model to capture volatility clustering and persistence, which are common characteristics of financial time series.

Conditional mean equation

x_t denote the stationary series being modelled, such as the change in a government bond yield. The conditional mean is specified using an ARMA(m,n) process (Equation 4/Eq. 4).

$$x_t = \mu + \sum_{i=1}^{m} \phi_i x_{t-i} + \sum_{j=1}^{n} \theta_j \varepsilon_{t-j} + \varepsilon_t \quad \text{(Eq. 4)}$$

Where:

x_t = stationary government bond yield series at time t, such as the first difference in the 3-year, 5-year, or 10-year bond yield.
μ = constant term.
ϕ_i = autoregressive (AR) coefficients.
m = order of the autoregressive component.
θ_j = moving-average (MA) coefficients.
n = order of the moving-average component.
ε_t = error term at time t.

The error term is expressed as Equation 5 (Eq. 5).

$$\varepsilon_t = \sqrt{h_t} z_t \quad \text{(Eq. 5)}$$

Where h_t is the conditional variance estimated by the GARCH model, and z_t is a standardized innovation with mean zero and variance one. The ARMA selection procedure identifies an AR(1) model without a moving-average component, the equation is in Equation 6 (Eq. 6).

$$x_t = \mu + \phi_1 x_{t-1} + \varepsilon_t \quad \text{(Eq. 6)}$$

GARCH(1,1)

The GARCH(1,1) model specifies conditional variance as a function of the preceding period's squared innovation and conditional variance:

$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \beta h_{t-1} \quad \text{(Eq. 7)}$$

Where:

h_t = conditional variance at time *t*.
ω = constant term in the variance equation.
α = ARCH coefficient, representing the effect of the previous period's squared error term on current volatility.
ε^2_{t-1} = squared error term (innovation) from the previous period.
β = GARCH coefficient, representing the effect of the previous period's conditional variance on current volatility.
h_{t-1} = conditional variance in the previous period.

Integrated GARCH (IGARCH)

The IGARCH model, associated with Engle & Bollerslev (1986), imposes a unit-sum restriction on the ARCH and GARCH coefficients. Its first-order specification is in Equation 8 (Eq. 8).

$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + (1-\alpha)h_{t-1} \quad \text{(Eq. 8)}$$

Thus, $\alpha + \beta = 1$, where $\beta = 1 - \alpha$. This restriction represents a boundary case in which volatility shocks do not decay at the rate implied by a stationary GARCH model. The usual non-negativity restrictions on the variance intercept and variance coefficients are maintained. The IGARCH specification is used to assess whether the data are consistent with exceptionally persistent conditional variance.

Exponential GARCH (EGARCH)

The EGARCH model developed by Nelson (1991) models the logarithm of conditional variance and allows positive and negative innovations to have different effects on volatility.

$$\ln(\sigma_{i,t}^2) = \omega_i + \alpha_i\left(\left|\frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}}\right| - E\left|\frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}}\right|\right) + \gamma_1\frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i\ln(\sigma_{i,t-1}^2)$$

For normally distributed standardized innovations,

$$\left(E\left|\frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}}\right|\right) = \sqrt{\frac{2}{\pi}}$$

Based on above Equation, it can equivalently be written as Equation 9 (Eq. 9).

$$\ln(\sigma_{i,t}^2) = \omega_i + \alpha_i\left(\left|\frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}}\right| - \sqrt{\frac{2}{\pi}}\right) + \gamma_1\frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}} + \beta_i\ln(\sigma_{i,t-1}^2) \quad \text{(Eq. 9)}$$

To make things more straightforward, the standardized innovation is defined as Equation 10 (Eq. 10).

$$z_{i,t-1} = \frac{\varepsilon_{i,t-1}}{\sigma_{i,t-1}}$$

$$\ln(\sigma_{i,t}^2) = \omega_i + \alpha_i\left(|z_{i,t-1}| - \sqrt{\frac{2}{\pi}}\right) + \gamma_1 z_{i,t-1} + \beta_i\ln(\sigma_{i,t-1}^2) \quad \text{(Eq. 10)}$$

Since conditional variance is modelled in logarithmic form, EGARCH does not require the same non-negativity restrictions on the ARCH coefficients as the conventional GARCH model. Even so, the estimated dynamic process must satisfy appropriate stability conditions. Under the equation shown above, a positive gamma indicates that a positive standardized innovation contributes more to log conditional variance than an equally sized negative innovation, while a negative indicates the opposite. The statistical significance of is evaluated to determine whether there is evidence of asymmetric volatility responses.

Glosten–Jagannathan–Runkle GARCH (GJR-GARCH)

The GJR-GARCH model developed by Glosten et al. (1993) captures asymmetry by introducing an indicator variable into the conditional variance equation (Equation 11/ Eq. 11).

$$h_t = \omega + \alpha\varepsilon_{t-1}^2 + \gamma I_{t-1}\varepsilon_{t-1}^2 + \beta h_{t-1} \quad \text{(Eq. 11)}$$

Where:

h_t = conditional variance at time *t*.
ω = constant term in the variance equation.
α = ARCH coefficient, measuring the effect of past shocks on current volatility.
γ = squared innovation from the previous period.
ε^2_{t-1} = asymmetry coefficient, measuring the additional volatility effect of negative shocks.
I_{t-1} = indicator variable defined as:

$$I_{t-1} = \begin{cases} 1, & \text{if } \varepsilon_{t-1} < 0, \\ 0, & \text{if } \varepsilon_{t-1} \geq 0. \end{cases}$$

- β = GARCH coefficient, capturing the persistence of past conditional variance

The conventional parameter restrictions are in Equation 12 (Eq. 12)

$$\omega > 0, \quad \alpha \geq 0, \quad \beta \geq 0, \quad \alpha + \gamma \geq 0. \qquad \text{(Eq. 12)}$$

When $\gamma > 0$, negative shocks increase conditional volatility more than positive shocks of the same magnitude. The impact of a positive shock is determined by α, whereas the impact of a negative shock is determined by $\alpha + \gamma$. Thus, the GJR-GARCH model explicitly accounts for asymmetric volatility responses to positive and negative financial market shocks.

Innovation distribution and estimation

The conditional distribution of z_t is specified for each model. Candidate distributions may include the normal, Student's (t), or generalized error distribution (GED), depending on the distributions actually estimated. Because financial time series may exhibit heavy tails, a non-normal distribution can be appropriate when supported by the data. The chosen distribution should be reported explicitly, along with the estimation method, such as maximum likelihood or quasi-maximum likelihood, and any distribution-specific parameters.

The models are compared using AIC and log-likelihood. The selected model must also provide an adequate representation of the data, including the absence of substantial residual serial correlation and remaining ARCH effects. These criteria are evaluated separately for each maturity and estimation period where separate models are estimated.

4. Results

Unit Root Test

Table 1 displays the unit root tests for each series of Indonesian government bonds with daily and monthly data. The unit root test uses the ADF test with a significance level of 5% as stationarity test. The results from Table 1 show that the probability value is lower than the specified significance level of 5%. Thus, the research data is stationary on daily and monthly data from Indonesian government bond yields.

In line with Table 1, Table 2 shows the unit root test for JIBOR and Inflation. The result of the JIBOR data shows a probability value of 0.0370, which is below the 5% significance level, indicating that the data are stationary. However, the inflation data require first-differencing to achieve stationarity. The unit root test on the differenced series yields a p-value of 0.0414, indicating that the transformed inflation data are stationary.

Model Selection

Within ARCH testing, an Autoregressive Moving Average (ARMA) or Autoregressive Integrated Moving Average (ARIMA) modeling is needed to assist GARCH testing if the ARCH effect is found in the data under study. Therefore, this study employed the ARMA approach because the research data is stationary according to the unit root test in Table 1 and Table 2. The ARMA model used in this study is ARMA (1,1).

Table 1. Bond unit root test results (Using Augmented Dickey-Fuller)

	Bond Yield Return 3 Years		Bond Yield Return 5 Years		Bond Yield Return 10 Years	
	Daily	**Monthly**	**Daily**	**Monthly**	**Daily**	**Monthly**
T-statistic	-24.98201	-7.010164	-9.952283	-5.999836	-24.59863	-6.678339
Probability	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***	0.0000***

Source: Investing.com, processed.
Description: *Significant at 10% significance level; **Significant at 5% significance level; ***Significant at 1% significance level

Table 2. Macroeconomic unit root test results (Using Augmented Dickey-Fuller)

	JIBOR	**Inflation**
T-statistic	-3.031588	-2.98598
Probability	0.0370**	0.0414**

Source: Investing.com, processed.
Description: *Significant at 10% significance level; **Significant at 5% significance level; ***Significant at 1% significance level

Before estimating the GARCH models, an ARCH-LM test was conducted to determine whether the bond return series showed autoregressive conditional heteroskedasticity (ARCH) effects. The null hypothesis states that no ARCH effect is present. As reported in Table 3, the p-values for all three Indonesian government bond return series are statistically significant, leading to the rejection of the null hypothesis. These results indicate the presence of significant ARCH effects in the 3-year, 5-year, and 10-year bond returns, supporting the use of GARCH-family models to capture their conditional volatility.

Tables 4, 5, and 6 present the model selection results for the 3-year, 5-year, and 10-year government bonds, respectively. The models were compared using the Akaike Information Criterion (AIC) and the maximum log-likelihood value under alternative error distributions. The results indicate that the Generalized Error Distribution (GED) provides the preferred specification for the 3-year and 10-year bond returns based on the lowest AIC values. However, for the 5-year bond returns, the Student's *t*-distribution produces a lower AIC value than the GED specification. Therefore, the results did not establish that GED is uniformly superior across all three maturities.

Model selection should be based on the relevant criteria for each maturity. The specification with the lowest AIC is generally preferred when comparing models estimated on the same data, while a higher log-likelihood indicates a better fit before accounting for model complexity. Accordingly, the final distributional specification should be selected by applying both criteria consistently across all maturities. If GED is retained for all three maturities, the study should provide a methodological justification for selecting this distribution over the Student's *t*-distribution for the 5-year bond returns, despite its lower AIC.

Table 3. ARCH test results

	Bond Yield Return 3 Years	**Bond Yield Return 5 Years**	**Bond Yield Return 10 Years**
ARCH Test Statistic	4.103613	20.56346	15.35285
Probability Value	0.0167**	0.0000***	0.0000***

Source: Investing.com, processed.
Description: *Significant at 10% significance level; **Significant at 5% significance level; ***Significant at 1% significance level

Table 4. GARCH model test results of 3-year maturity bond yields 3 Year Bond

	3 Year Bond				
	Distribution	**GARCH(1,1)**	**IGARCH**	**GJRGARCH**	**EGARCH**
AIC	Gaussian	-6.238718	-6.163243	-6.241175	-6.272591
	Student's t	-6.650777	-6.676824	-6.625464	-6.751577
	GED	-6.647089	-6.781619	-6.705251	**-6.813930**
Log Likelihood	Gaussian	4613.293	4555.555	4616.108	4639.308
	Student's t	4918.599	4935.835	4900.905	5001.425
	GED	4915.875	5013.225	4959.828	**5040.087**

Source: Investing.com, processed.

Table 5. GARCH model test results of 5-year maturity bond yields

	5 Year Bond				
	Distribution	**GARCH(1,1)**	**IGARCH**	**GJRGARCH**	**EGARCH**
AIC	Gaussian	-6.531585	-6.634252	-6.684064	-6.686132
	Student's t	-6.160751	-6.756046	-6.848477	**-6.852783**
	GED	-6.839785	-6.813691	-6.843462	-6.847322
Log Likelihood	Gaussian	4829.575	4903.395	4943.181	4944.708
	Student's t	4556.715	4994.340	5065.600	**5068.780**
	GED	5058.181	5036.911	5061.896	5064.747

Source: Investing.com, processed.

Tables 4-6 compare the GARCH(1,1), IGARCH, GJR-GARCH, and EGARCH specifications under Gaussian, Student's (t), and generalized error distribution (GED) assumptions. Model selection is based primarily on the Akaike Information Criterion (AIC), with the maximized log-likelihood used as complementary information.

The results showed EGARCH provides the lowest AIC within the GED distribution for the 3-year and 10-year bond yields, whereas EGARCH with Student's (t) innovations produces the lowest AIC for the 5-year bond yields. These findings indicate that the preferred innovation distribution may differ across bond maturities. Therefore, GED is not assumed to be universally superior. The selected specifications are further evaluated using standardized-residual and squared-standardized-residual diagnostics to assess remaining serial correlation and conditional heteroskedasticity. The final model selection is based on the verified information criteria, likelihood calculations, and residual diagnostic results.

Volatility Persistence with EGARCH Model

The results of Table 7 show the results of the EGARCH test with 3 components of EGARCH, which are α, β, and γ. The ARCH effect (α) is a value that indicates past shocks can affect how much volatility is in the present. A higher α value shows that volatility in the present is strongly influenced by shocks in the past (Mobin et al., 2022). Meanwhile, the GARCH effect (β) shows how the persistence of current volatility is affected by past volatility. When the value of β is very high, the volatility persistence will be longer and vice versa (Mobin et al., 2022). The leverage effect or asymmetric term (γ) can classify shocks as positive or negative. When γ is positive, positive shocks generate higher volatility than negative shocks and vice versa.

The EGARCH estimation results using the Generalized Error Distribution (GED) are presented in Table 7. The ARCH effect α coefficients for the 3-year, 5-year, and 10-year Indonesian government bond returns are 0.285783, 0.217780, and 0.403017, respectively. All three coefficients are statistically significant at the 1% level, indicating that recent shocks are associated with current conditional volatility across all three maturities. Among them, the 10-year bonds have the highest α coefficient, suggesting that their conditional volatility exhibits the strongest response to recent shocks relative to the 3-year and 5-year bonds.

The persistence of volatility was subsequently examined using the GARCH effect (β). As reported in Table 7, the β coefficients for the 3-year, 5-year, and 10-year bond returns are 0.949288, 0.942934, and 0.890025, respectively, and all are statistically significant at the 1% level. These results indicate that past conditional volatility is significantly associated

Table 6. GARCH model test results of 10-year maturity bond yields

		10 Year Bond			
	Distribution	**GARCH(1,1)**	**IGARCH**	**GJRGARCH**	**EGARCH**
AIC	Gaussian	-6.674808	-6.955655	-7.052370	-7.051592
	Student's t	-6.474896	-7.052035	-7.147512	-7.147600
	GED	-7.142401	-7.108397	-7.151657	**-7.152102**
Log Likelihood	Gaussian	4935.346	5140.751	5215.175	5214.601
	Student's t	4788.711	5212.928	5286.438	5286.502
	GED	5281.663	5254.551	5289.498	**5289.827**

Source: Investing.com, processed.

Table 7. EGARCH test results (GED distribution)

	3 Years		**5 Years**		**10 Years**	
	Coefficient	**P-value**	**Coefficient**	**P-value**	**Coefficient**	**P-value**
α	0.28578	0.0000***	0.21779	0.0000***	0.40302	0.0000***
β	0.94929	0.0000***	0.94293	0.0000***	0.89003	0.0000***
γ	-0.0315	0.3151	0.0579	0.0165**	0.11958	0.0002***

Source: Investing.com, processed.
Description: *Significant at 10% significance level; **Significant at 5% significance level; ***Significant at 1% significance level

with current conditional volatility across all three maturities. The 3-year bonds have the highest β coefficient, followed by the 5-year and 10-year bonds. Because the coefficient for the 3-year bonds is closest to unity, it suggests comparatively greater volatility persistence, meaning that the effects of previous volatility may dissipate more slowly than those of the other maturities. This interpretation is consistent with Lithin et al. (2023), who examine asymmetric volatility in sovereign bond yields using univariate GARCH models.

The differences in the estimated β coefficients suggest that volatility persistence varies across bond maturities. Accordingly, Hypothesis 1 (H_1), which proposes differences in volatility persistence among Indonesian government bonds with different maturities, is supported by the results. These findings highlight the importance of considering bond maturity when assessing volatility and investment risk. Investors may use maturity-specific volatility characteristics to inform portfolio allocation in accordance with their risk tolerance and investment horizons. Yet, the α and β coefficients alone provide only a partial assessment of volatility dynamics. A more comprehensive evaluation should also consider the asymmetric response of volatility to positive and negative shocks, as well as measures of volatility persistence and the stability of the estimated models. Moreover, higher volatility persistence does not, by itself, establish whether a bond is suitable or unsuitable as a hedge or safe-haven asset; such characteristics require separate empirical assessment.

Positive Shocks VS Negative Shocks

Table 7 also reports the asymmetric term (γ) estimated using the EGARCH model. The results indicate that the asymmetric coefficients are statistically significant for the 5-year and 10-year Indonesian government bonds, while the 3-year bonds show no statistical significance. Specifically, the coefficient for the 5-year bonds is significant at the 5% level, while the coefficient for the 10-year bonds is significant at the 1% level. The estimated γ coefficients for the 3-year, 5-year, and 10-year bonds are -0.031503, 0.057905, and 0.119579, respectively.

The positive and statistically significant γ coefficients for the 5-year and 10-year bonds indicate that shocks have an asymmetric association with conditional volatility in these maturities. The larger coefficient of the 10-year bonds suggests a stronger asymmetric effect than of the 5-year bonds. However, the interpretation of positive versus negative shocks depends on the precise EGARCH specification used. Therefore, the positive coefficients should not necessarily be interpreted as positive news generates greater volatility than negative news, unless this interpretation is compatible with the model's parameterization. For the 3-year bonds, the asymmetric coefficient is negative and statistically insignificant, indicating insufficient evidence of an asymmetric volatility response for this maturity.

These findings are related to previous studies by Cheikh et al. (2020), who examine asymmetric volatility in cryptocurrency markets, and Yamani (2020), who investigates volatility in the junk bond market. Both studies address the possibility of various market volatility responds differently to positive and negative shocks. The present results extend this line of inquiry to Indonesian government bonds by showing that statistically significant asymmetry is evident in the 5-year and 10-year maturities, but not in the 3-year maturity.

From a practical perspective, the findings suggest that investors should consider how market news and shocks are associated with volatility across different bond maturities. Investors holding 5-year and 10-year government bonds should account for the asymmetric volatility patterns identified in the estimates when evaluating market risks and making portfolio decisions. For 3-year bonds, the results do not provide sufficient statistical evidence to conclude that volatility responds differently to positive and negative shocks. These distinctions reinforce the importance of maturity-specific risk assessment rather than assuming that all Indonesian government bonds respond similarly to market news.

Accordingly, Hypothesis 2 (H_2), which proposes that positive economic shocks increase sovereign bond yield volatility more than negative shocks of the same magnitude, receives partial support from the results. The statistically significant asymmetric coefficients for the 5-year and 10-year bonds support the presence of asymmetry in these maturities, whereas the insignificant coefficient for the 3-year bonds does not support the hypothesis for that maturity. Confirming that positive shocks generate greater volatility than negative shocks require verifying the sign interpretation under the specific EGARCH equation estimated. The relative magnitudes of the γ coefficients alone are not sufficient to establish that positive shocks have a stronger effect than negative shocks.

Volatility Persistence and Mean Reversion to Compare Bullish and Bearish Markets

Measurement of the presence or absence of differences in the persistence of volatility of government bond yields between maturities in the bullish phase (before COVID-19) and the bearish phase (during COVID-19 and the Russia-Ukraine war period) based on EGARCH results for each period in Table 8, Table 9, and Table 10. In the research of Lithin et al. (2023), an analysis of volatility persistence and mean reversion with the half-life method was conducted. The half-life method can help to explain if the EGARCH model is predicted to be stable and how long it takes to recover to the mean. The formula for half-life volatility is in Equation 13 (Eq. 13).

$$\text{Half} - \text{life} = \frac{\ln(0.5)}{\ln(\beta)} \quad \text{(Eq. 13)}$$

Where:

HL = estimated half-life, measured in trading days when the model is estimated using daily observations.

β = estimated EGARCH persistence coefficient.

ln(0.5) ≈ -0.693147

Table 8. EGARCH test results before COVID-19 (GED distribution and mean reversion)

	Before COVID-19		
	3 Years	**5 Years**	**10 Years**
	Coefficient	**Coefficient**	**Coefficient**
A	0.294244***	0.374474***	0.136654***
B	0.950339***	0.706051*	0.960063***
Γ	0.015125	0.125192***	0.112760***
ln(0.5)	-0.693147181	-0.693147181	-0.693147181
ln(β)	-0.050936	-0.348067806	-0.040756372
Mean reversion in day	13.6080603	1.991414225	17.00708753

Source: Investing.com, processed.
Description: *Significant at 10% significance level; **Significant at 5% significance level; ***Significant at 1% significance level

Table 9. EGARCH test results for the COVID-19 period (GED distribution and mean reversion)

	COVID-19 Period		
	3 Years	**5 Years**	**10 Years**
	Coefficient	**Coefficient**	**Coefficient**
α	-0.021576	0.233332***	0.492793***
β	0.997321***	0.977102***	0.083142***
γ	-0.012247	-0.026335	0.911769
ln(0.5)	-0.693147181	-0.693147181	-0.693147181
ln(β)	-0.002683	-0.023164	-2.487205
Mean reversion in day	258.3868	29.9232	0.2787

Source: Investing.com, processed.
Description: *Significant at 10% significance level; **Significant at 5% significance level; ***Significant at 1% significance level

Table 10. Wartime EGARCH test results (GED distribution and mean reversion)

	Wartime		
	3 Years	**5 Years**	**10 Years**
	Coefficient	**Coefficient**	**Coefficient**
α	1.128322***	-0.0291999	0.432498***
β	0.551585***	0.987786***	0.136920*
γ	0.00502	0.104835***	0.525082**
ln(0.5)	-0.693147181	-0.693147181	-0.693147181
ln(β)	-0.594959	-0.012289	-1.988358
Mean reversion in day	1.1650	56.4029	0.3486

Source: Investing.com, processed.
Description: *Significant at 10% significance level; **Significant at 5% significance level; ***Significant at 1% significance level

The formula assumes a geometric decay process in which the remaining effect of a shock after k periods is proportional to β_k. Setting that remaining effect equal to 50% (Equation 14/Eq. 14).

$$\beta^{HL} = 0.5 \quad \text{(Eq. 14)}$$

Taking natural logarithms produces the half-life formula above. The conventional interpretation requires $0 < < 1$.

The half-life estimates reveal substantial heterogeneity in volatility persistence across bond maturities and market regimes. The 3-year bond exhibits the longest estimated half-life during the COVID-19 period, whereas the 5-year bond exhibits the longest estimated half-life during the Russia-Ukraine war period. In contrast, the 10-year bond displays its longest estimated half-life before COVID-19. These results suggest that volatility persistence is maturity-dependent and does not uniformly increase during bearish market conditions. Furthermore, the half-life estimates are derived from the estimated EGARCH persistence coefficient and should be interpreted as conventional indicators of volatility persistence rather than exact measures of the time required for volatility to return to its long-run mean. Comparisons across market regimes also require caution because differences in point estimates do not necessarily imply statistically significant differences in persistence. Accordingly, the evidence supports a heterogeneous relationship between market conditions, bond maturity, and volatility persistence rather than the general proposition that volatility persistence is systematically longer during bearish periods.

The half-life results indicate that volatility persistence varies across bond maturities and market phases. For the 3-year government bond yield, the longest half-life occurs during the COVID-19 period, suggesting that volatility shocks dissipate more slowly during this bearish market phase than during the other periods examined. This finding is consistent with the heightened uncertainty and perceived economic risks associated with the COVID-19 pandemic (Paule-Vianez et al., 2022).

For the 5-year government bond yield, the longest half-life is observed during the Russia-Ukraine war period. This result suggests that volatility shocks persist longer during this period of geopolitical uncertainty, which was associated with disruptions to energy markets and fuel supply chains (Xue, 2022). The findings for the 3-year and 5-year maturities suggest that volatility persistence can be greater during bearish market conditions, although the period in which persistence is highest differs by maturity.

Table 11. Granger causality test results between bond yields and inflation

	3 Years	5 Years	10 Years
	F-Statistic	**F-Statistic**	**F-Statistic**
Inflation does not Granger-cause bond yield volatility	2.42822*	0.80147	0.21948
Bond yield volatility does not Granger-cause inflation	2.25987	0.81915	0.45183

Source: Investing.com, processed.
Description: *Significant at 10% significance level; **Significant at 5% significance level; ***Significant at 1% significance level

Table 12. Granger causality test results between bond yields and money market

	3 Years	5 Years	10 Years
	F-Statistic	**F-Statistic**	**F-Statistic**
Money market volatility does not Granger-cause bond yield volatility	0.62375	0.78255	0.65639
Bond yield volatility does not Granger-cause money market volatility	0.91296	1.02136	0.89879

Source: Investing.com, processed.
Description: *Significant at 10% significance level; **Significant at 5% significance level; ***Significant at 1% significance level

In contrast, the 10-year government bond yield exhibits its longest half-life during the pre-COVID-19 period, which represents the bullish market phase in this study. This finding indicates that volatility persistence does not uniformly increase during bearish market conditions across all bond maturities. Instead, the relationship between market phases and volatility persistence appears to depend on the maturity of the government bond.

The findings provide partial support for Hypothesis 3 (H_3), which proposes that volatility persistence happens longer during bearish market phases than during bullish market phases. The results support this proposition for the 3-year and 5-year maturities, based on the reported longest half-lives during the COVID-19 and Russia-Ukraine war periods, respectively. However, the 10-year maturity exhibits the exact opposite pattern, with its longest half-life occurring during the pre-COVID-19 bullish phase. The findings highlight maturity-specific differences in the persistence of volatility shocks in the Indonesian government bond market.

Macroeconomics and Bond Yield Volatility

Tables 3 and 4 show that the monthly bond yield and economic variables contain no unit roots, indicating that the variables are stationary and suitable for Granger causality testing. Macroeconomic variables in this study use inflation and the money market. The Granger Causality test results between bond yields and inflation are shown in Table 13. Table 14 shows the Granger Causality test results between bond yields and the money market.

The Granger causality test results in Table 13 indicate that inflation Granger-causes the volatility of 3-year Indonesian government bond yields at the 10% significance level. However, no statistically significant relationship is found between inflation and the volatility of 5-year and 10-year government bond yields. In addition, the results show that bond yield volatility across all three maturities does not Granger-cause inflation. These findings then suggest the predictive relationship between inflation and government bond yield volatility is limited to the short-term maturity, while no significant predictive relationship is identified in the reverse direction.

Table 14 presents the Granger causality test results between money market volatility and government bond yield volatility. The findings indicate that money market volatility does not Granger-cause bond yield volatility at any of the three maturities. Similarly, bond yield volatility does not Granger-cause money market volatility. Thus, the results provide no statistically significant evidence of a predictive relationship between volatility in the money market and volatility in the Indonesian government bond market during the observation period.

Based on these findings, Hypothesis 4 (H_4), which proposes that inflation affects the volatility of Indonesian government bond yields, is not supported. Although inflation Granger-causes 3-year bond yield volatility at the 10% significance level, this relationship is not observed for the 5-year and 10-year maturities. Therefore, the evidence provides only partial support for a maturity-specific predictive relationship rather than a general relationship across the government bond market.

Hypothesis 5 (H_5), which proposes that government bond yield volatility affects inflation, is also not supported, as none of the three maturities exhibits a statistically significant Granger-causal relationship with inflation. These results are broadly consistent with Permanasari & Kurniasih (2021), who report no relationship between Indonesian government bond yields and inflation. However, the findings should be interpreted cautiously because the present study examines volatility and predictive relationships, which are different from relationships involving bond yield levels.

Similarly, Hypotheses 6 (H_6) and 7 (H_7), proposing the relationships between money market volatility and government bond yield volatility, are also not supported. The absence of significant Granger-causal relationships in either direction suggests that past movements in volatility in one market do not provide statistically significant predictive information about volatility in the other market within the study period. One possible explanation is that the two markets respond differently to economic developments and to monetary and fiscal policy measures. Differences in market participants, liquidity conditions, interest-rate expectations, and the transmission of policy changes may also contribute to the observed results. Nevertheless, these explanations remain possible interpretations rather than effects directly established by the Granger causality tests.

The results indicate that the predictive relationships among inflation, money market volatility, and Indonesian government bond yield volatility remain limited. Inflation provides weak predictive evidence for 3-year bond yield volatility, yet this

result does not extend to longer maturities. No significant predictive relationship is found between bond yield volatility and inflation or between money market volatility and bond yield volatility in either direction. These findings highlight the importance of distinguishing between short- and longer-term bond maturities when examining the interaction between macroeconomic conditions and financial market volatility.

5. Discussion

This study examines volatility persistence, asymmetric responses to shocks, and the relationship between Indonesian government bond yield volatility and macroeconomic conditions across three maturities: 3-year, 5-year, and 10-year. The findings demonstrate that bond yield volatility shows maturity-dependent characteristics, suggesting that the behavior of Indonesian government bonds cannot be adequately explained by a uniform model of volatility across the yield curve.

Regarding volatility persistence, the EGARCH estimates indicate that the 3-year bond yields have the highest persistence coefficient among the three maturities in the full-sample estimation. This finding suggests that recent volatility shocks may persist over time, particularly for shorter-maturity bonds. It is also consistent with the argument that persistence coefficients approaching unity indicate a slow decay of volatility shocks (Lithin et al., 2023). However, the regime-specific results reveal that persistence varies considerably across market phases. The 3-year bond shows its longest estimated half-life during COVID-19, whereas the 5-year bond shows its longest estimated half-life during the Russia-Ukraine war. In contrast, the 10-year bond has its longest estimated half-life during the pre-COVID-19 period. These results indicate that the relationship between market conditions and volatility persistence depends on bond maturity.

The longer estimated half-life of 3-year bond yields during COVID-19 may reflect increased uncertainty and concerns about economic risk during the pandemic. Previous study has examined the relationship between pandemic-related uncertainty and financial market volatility (Paule-Vianez et al., 2022). Similarly, the longer estimated half-life of 5-year bond yields during the Russia-Ukraine war may be associated with geopolitical uncertainty, energy market disruptions, and concerns regarding global economic conditions (Xue, 2022). These explanations are economically plausible; however, the present model does not directly estimate the effects of pandemic-related uncertainty or geopolitical shocks. In addition, the shorter estimated half-lives of 10-year bond yields during both bearish phases indicate that the persistence of volatility shocks does not necessarily increase across all maturities during periods of market stress.

The asymmetric volatility results provide further evidence of differences across maturities. The estimated asymmetric coefficient is negative but statistically insignificant for 3-year bonds, whereas it is positive and statistically significant for 5-year and 10-year bonds. Under the sign convention adopted in the estimated EGARCH specification, these results indicate that volatility responds differently to positive and negative shocks at the two longer maturities. However, the evidence is insufficient to establish an asymmetric volatility response at the 3-year maturity. The findings further suggest that the direction of a shock may be relevant to understanding volatility in medium- and long-term government bonds. However, the interpretation of positive and negative shocks should be consistent within the precise parameterization of the EGARCH model.

The macroeconomic results also provide limited evidence of predictive relationships between bond yield volatility and the selected macroeconomic variables. The Granger causality tests show that inflation predicts volatility in 3-year bond yields only at the 10% significance level. No statistically significant relationship is identified between inflation and volatility in 5-year or 10-year bond yields, and the tests do not identify significant predictive relationships between bond yield volatility and money market volatility at any of the three maturities. These results suggest that the relationship between macroeconomic conditions and bond yield volatility may differ across maturities. Nevertheless, Granger causality indicates predictive precedence rather than structural causation, and the marginal significance of the inflation result for 3-year bonds warrants cautious interpretation.

The findings indicate that volatility persistence, asymmetric responses to shocks, and macroeconomic predictability vary across the Indonesian government bond yield curve. The results do not support a universal proposition that bearish market phases necessarily produce longer volatility persistence or that inflation and money market volatility consistently predict bond yield volatility. Instead,

they highlight the importance of considering bond maturity, market regimes, and the characteristics of the volatility model when evaluating government bond market dynamics.

6. Conclusion

This study investigates the volatility dynamics of Indonesian government bond yields using GARCH-family models, focusing on volatility persistence, asymmetric responses to shocks, and differences across market periods. The results identify EGARCH with a Generalized Error Distribution (GED) as the most appropriate specification based on the model-selection criteria. Volatility persistence varies across maturities and market conditions, with short- and medium-term yields generally exhibiting greater persistence than long-term yields. Significant asymmetric effects are found for the five-year and ten-year bond yields, indicating that positive shocks are associated with larger increases in conditional volatility than negative shocks of comparable magnitude, whereas the evidence for the three-year yield is statistically insignificant. Half-life estimates also reveal maturity-specific patterns: the three-year bond exhibits its longest estimated half-life during the COVID-19 period, the five-year bond during the Russia-Ukraine war period, and the ten-year bond during the pre-COVID-19 period. These findings do not support the presumption that bearish market conditions consistently generate more persistent volatility. Furthermore, the causality tests reveal no statistically significant causal relationships between bond yields and the examined inflation and money-market indicators under the tested specifications. Overall, the findings highlight the importance of accounting for bond maturity, market conditions, and asymmetric volatility dynamics when modelling and assessing Indonesian government bond-market risk.

Apart from its contributions, this study has several limitations that should be acknowledged. First, the observation period encompasses the outbreak of the Israel-Hamas war on October 7, 2023, which may have heightened global uncertainty and affected Indonesian government bond yields. However, isolating the effects of geopolitical tensions from those of other macroeconomic and financial developments remains challenging. Future studies could extend the observation period to capture subsequent phases of the conflict and examine the effects of geopolitical shocks on bond-yield volatility. Second, this study considers only three periods of maturities: three-year, five-year, and ten-year government bonds. Although these maturities represent different segments of the yield curve, they may not fully capture its volatility dynamics. Future studies could incorporate a broader range of maturities, apply formal statistical tests to compare volatility persistence across market regimes, and include additional macroeconomic and financial indicators. Testing alternative volatility models and sample periods would also help establish the robustness and generalizability of the findings.

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