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Asymmetric thresholds of macroeconomic volatility's impact on stock volatility in developing economies: a study in Vietnam

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Abstract

Purpose – This paper examines the impact of macroeconomic volatility on stock volatility, both under normal conditions and during the COVID-19 pandemic in Vietnam.

Design/methodology/approach – We extend the existing Exponential Generalized Autoregressive Conditional Heteroskedasticity model by adding a new component: the thresholds – the levels of macroeconomic volatility at which the market may respond differently. These thresholds are estimated for both positive and negative volatility.

Findings – The impact of macroeconomic volatility on stock volatility is asymmetric: there are thresholds of macroeconomic volatility at which its pattern changes. These thresholds are higher in the case of positive volatility compared with negative volatility. The thresholds were also higher during the COVID-19 pandemic. Macroeconomic variables influence stock volatility differently depending on market conditions. While GDP is more significant in normal periods, interest rates affect it in both normal and unstable phases.

Research limitations/implications – Our models consider only two variables representing macroeconomic variables: interest rate and GDP. Furthermore, only one lag period of the variables is included in the analysis. In the future, more macrovariables and longer lags could be included when computational techniques advance.

Practical implications – Policymakers should consider the impact of macroeconomic volatility on the stock market when designing policies, especially at thresholds. Similarly, investors should pay more attention to macroeconomic volatility when constructing and managing their portfolios, particularly when such volatility is close to thresholds.

Originality/value – The inclusion of thresholds as parameters to be estimated into the model provides more insights into the impact of macroeconomic variables on stock volatility.

Keywords Asymmetric threshold, COVID-19 pandemic, EGARCH, Macroeconomic volatility, Stock market volatility

Paper type Research paper

1. Introduction

Stock volatility plays a crucial role in financial asset valuation and the implementation of risk management strategies. Volatility provides insights into a stock's risk and is an essential input for calculating various quantitative measures. It finds applications in different contexts, such as calculating the Sharpe ratio to evaluate investment performance (Sharpe, 1966), determining the Value-at-Risk (VaR) and Conditional Value-at-Risk (CVaR)

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(Rockafellar and Uryasev, 2000), as well as assessing the probability of default of listed companies (Merton, 1973). Numerous studies have been conducted to identify the determinants of stock volatility, among which macroeconomic variables are significant.

The role of macroeconomic variables as determinants of stock volatility is theoretically well-founded. The theory of investment and firm valuation, proposed by Gordon (1962), pointed out the role of interest rates in determining stock prices. It is based on the present value of dividend expectations discounted by interest rates. Since interest rates reflect discount rates and the opportunity cost of investing capital in stocks, they significantly affect changes in stock prices. In addition, the Arbitrage Pricing Theory (Ross, 1976) has shown that changes in Gross Domestic Product (GDP) can directly impact the expected profits of businesses. Therefore, GDP and interest rates directly affect stock prices, thereby causing stock volatility over time.

The impact of macroeconomic variables is also said to be asymmetric. For instance, behavioral finance theory (Kahneman and Tversky, 2013) suggests that negative information from macroeconomic variables has an asymmetric impact on the volatility of stock prices. Investors tend to perceive losses more intensely than gains of the same magnitude. Therefore, they tend to overreact to negative information in the market, such as an interest rate hike, leading to an asymmetric rather than a linear impact on the volatility of stock prices. This idea is also supported by Peters (1994), who argues that the simplification of the impact of macroeconomic variables on stock volatility turns out to be incorrect. It can involve non-linearity, complexity and even asymmetry. Many recent papers have found empirical evidence supporting this asymmetry (Amendola *et al.*, 2019; Hashmi and Chang, 2023).

In recent years, empirical studies on the asymmetric impact of macroeconomic variables on stock volatility have paid more attention to the impact at some specific thresholds, namely at the 90th and 10th percentiles of the volatility of macroeconomic variables (Amendola *et al.*, 2019). These studies examine the changes in the direction and magnitude of the impact at those fixed thresholds. However, in reality, thresholds may vary depending on various factors such as the level of economic development, market conditions and the risk aversion of each nation.

Our paper aims to contribute to the existing literature in three main points: First, we consider asymmetric thresholds as parameters to be estimated, rather than being fixed at arbitrary values as in existing studies. To achieve this, we extend the existing Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model by adding thresholds as a new component to the model. Second, we investigate these thresholds in two separate market conditions: a normal period and an unstable period caused by the COVID-19 pandemic, a pandemic considered to have a significant impact on stock markets (Ghosh, 2022). We argue that the role of each macroeconomic variable may vary depending on market conditions. Thus, the COVID-19 pandemic provides us with an opportunity to examine this hypothesis. Finally, we consider the above issues for both positive and negative macroeconomic volatility.

The structure of the paper is as follows: Section 2 presents a literature review; Section 3 introduces the research method and data used. Section 4 presents detailed experimental results and discussion. Conclusions and recommendations are presented in Section 5.

2. Literature review

Recent studies have examined the impact of macroeconomic variables on the volatility of the stock market, taking into consideration the non-linear relationship. Specifically, the findings indicate that interest rates and GDP are two crucial variables in various countries, encompassing both developed, emerging and developing markets (Schwert, 1989; Beltratti and Morana, 2006; Amendola *et al.*, 2019; Hashmi and Chang, 2023; Ma *et al.*, 2023).

In developed markets, researchers commonly utilize extended GARCH models to examine the role of macroeconomic variables. For example, Lobo (2000) conducted a notable study investigating the impact of currency shocks on the American stock market in the 1990s. Employing the ASAR-EGARCH model and Federal Reserve fund rates, the study revealed that stock volatility increased due to risk concerns triggered by negative news, such as interest rate hikes. Moreover, the findings highlighted the market's tendency to overreact to negative news and pointed to a shift in volatility from before to after the change in interest rates. Furthermore, Amendola *et al.* (2019) investigated the asymmetric effects of macroeconomic volatility by analyzing both positive and negative macroeconomic volatility using the GJR-A-GARCH-MIDAS model in the American stock market. The findings indicated differential impacts of positive and negative volatility of the IP index on stock volatility. Specifically, the positive volatility of the IP index increased stock volatility, while the negative volatility of this index reduced it.

Some studies have also examined the role of macroeconomic variables at fixed asymmetric thresholds in developed markets. Wang *et al.* (2020) researched to examine asymmetric thresholds at the 10th and 90th percentiles of stock volatility. The study utilized the Dow Jones Industrial Average (DJIA) index data from 1928 to 2018. It demonstrated that extreme events, such as major financial crises or monetary policy shocks, can significantly increase market volatility. Negative extreme shocks were found to lead to higher stock volatility compared with positive shocks. Another study by Brown *et al.* (1988) established a 2.5% threshold for positive and negative shocks. Their study focused on 200 companies within the Standard and Poor's 500 index (S&P 500) in the American stock market. The findings indicated that stock prices react more strongly to negative shocks than to positive ones. Similarly, Himmelmann *et al.* (2012) researched the European stock market from 1999 to 2003 and utilized a threshold at the 20th percentile. This study emphasized the importance of differentiating abnormal cases across different analytical frameworks.

For emerging and developing markets, several studies have examined the asymmetric impact of macroeconomic variables. Hashmi and Chang (2023) utilized data from July 2001 to April 2019 in the stock markets of emerging 7 (E7) countries and various macroeconomic indicators, including the IP index, interest rates and others. Their study employed the IP index as a proxy for GDP, utilizing autoregressive distributed lag (ARDL) and quantile ARDL techniques. The results indicated that macroeconomic variables asymmetrically influenced stock prices in developing markets, except for the IP index. The findings are consistent with those of Lobo (2000) and Amendola *et al.* (2019) regarding the asymmetric impact of macroeconomic variables.

In another study focusing on the Chinese developing market, Guo *et al.* (2013) utilized the MSVAR-EGARCH model in the data spanning from 2005 to 2011 to analyze the asymmetric impact of monetary policy on stock volatility. The results demonstrate the significant influence of the change in monetary policy on stock price volatility despite the primary objective of the policy being the maintenance of stock market stability. Thus, research to determine the thresholds of macroeconomic volatility on stock prices in developing countries is still needed.

Thus, empirical studies have addressed the asymmetric influence of macroeconomic variables on stock market volatility. However, in these studies, the thresholds are set fixed at some specific values. As such, the chosen thresholds may not be the accurate thresholds. Furthermore, the coefficients of interest might need to be accurately estimated due to the model specification in which the thresholds are set arbitrarily fixed, as the asymmetric thresholds may differ in different markets. This motivates our study to add the thresholds into the EGARCH model as parameters to be estimated. We propose the following two hypotheses:

H1. The impact of macroeconomic volatility on stock volatility is asymmetric and changes its pattern at certain thresholds.

H2. The role of macroeconomic variables and threshold levels differ between normal and unstable market periods.

3. Research methodology

In this section, we extend the EGARCH model (Nelson, 1991) by adding thresholds for macroeconomic variables. This inclusion helps capture the asymmetric impact of macroeconomic volatility on the volatility of stock prices. Furthermore, the impact of positive and negative macroeconomic volatility is distinguished in the model.

3.1 EGARCH model

The EGARCH model is widely used in analyzing stock volatility due to its advantages, as Diebold and Yilmaz (2008) highlighted, such as not requiring constraints on the model's coefficients to be non-negative. The standard EGARCH model consists of the mean Equation (1) and the variance Equation (2):

$$\begin{cases} r_{i,t} = \mu + \sigma_{i,t}\varepsilon_{i,t}\,\forall i = 1, 2, \ldots, N_t & (1) \\ log\left(\sigma_{i,t}^2\right) = \omega + \beta log\left(\sigma_{i-1,t}^2\right) + \alpha\dfrac{|r_{i-1,t} - \mu|}{\sqrt{\sigma_{i-1,t}^2}} + \gamma\dfrac{r_{i-1,t} - \mu}{\sqrt{\sigma_{i-1,t}^2}} & (2) \end{cases}$$

where $r_{i,t}$ is the log-return of the stock market index on day i in month t.

μ and $\sigma_{i,t}^2$ represent the mean and conditional variance of $r_{i,t}$, respectively.

N_t is the number of trading days in month t.

$\varepsilon_{i,t}$ is the random error term, assumed to be independent and identically distributed normal distribution as N (0,1).

The EGARCH model, with its practical implications, offers an advantage in its capability to analyze asymmetry in volatility behavior, as illustrated in Equation (2), where non-zero γ indicates the presence of asymmetric effects in the stock market: the market's response changes as the return r exceeds μ.

Several extensions of this model have been employed to evaluate the asymmetric impact of macroeconomic variables. As demonstrated by Lobo (2000), the mean Equation (1) and the variance Equation (2) are extended as follows:

$$\begin{cases} r_{i,t} = \mu + [\alpha_1 + \beta_1 \mathrm{D}_1 + \gamma_2 \mathrm{D}_2]\, R_{i,t-1}^{+} + [\alpha_2 + \beta_2 \mathrm{D}_1 + \gamma_2 \mathrm{D}_2]\, R_{i,t-1}^{-} + \delta_1 \Delta \mathrm{TB}_t + \delta_2 \Delta \mathrm{SPD}_t + \sigma_{i,t}\varepsilon_{i,t} \\ log\left(\sigma_{i,t}^2\right) = \omega + \beta log\left(\sigma_{i-1,t}^2\right) + \alpha\dfrac{|r_{i-1,t} - \mu|}{\sqrt{\sigma_{i-1,t}^2}} + \gamma\dfrac{r_{i-1,t} - \mu}{\sqrt{\sigma_{i-1,t}^2}} + \omega_1 \mathrm{D}_1 + \omega_2 \mathrm{D}_2 \end{cases} \quad (3)$$

where $R_{i,t-1}^{+}$ and $R_{i,t-1}^{-}$ are lagged positive and negative returns at day i in month t.

ΔTB and $\Delta \mathrm{SPD}_t$ represent for the future interest rate changes in the 3-month T-Bill yield; and the spread of yields between the 10-year T-Bond and 3-month T-Bill, respectively.

D_1 and D_2 are five-day windows before and after a change in the federal funds rate.

Nevertheless, Equation (3) does not consider the asymmetric impact of macroeconomic variables at different thresholds. Therefore, we adjust and extend it by adding new components to the variance equation to estimate the thresholds of macroeconomic variables.

3.2 Extended EGARCH model with asymmetric thresholds

In this section, we extend the EGARCH model by incorporating thresholds into the model. Furthermore, we examine the impact of macroeconomic variables in two scenarios: when the macroeconomic volatility is positive and when it is negative. The EGARCH model will be extended as follows:

$$\begin{cases} r_{i,t} = \mu + \sigma_{i,t}\varepsilon_{i,t} \quad \forall i = 1, 2, \ldots, N_t \\ \log \sigma_{i,t}^2 = \omega + \beta \log \sigma_{i-1,t}^2 + \alpha \dfrac{|r_{i-1,t} - \mu|}{\sqrt{\sigma_{i-1,t}^2}} + \gamma \dfrac{r_{i-1,t} - \mu}{\sqrt{\sigma_{i-1,t}^2}} + s^+ \left| X_{t-1}^+ - \xi^+ \right| \\ \quad + \mathrm{a}^+ \left(X_{t-1}^+ - \xi^+ \right) + s^- \left| X_{t-1}^- - \xi^- \right| + \mathrm{a}^- \left(X_{t-1}^- - \xi^- \right) \end{cases} \tag{4}$$

where X_{t-1}^+ represents the first-order lag of positive volatility X_t^+ and ξ^+ denotes the threshold associated with this positive volatility.

X_{t-1}^- represents the first-order lag of negative volatility X_t^- and ξ^- denotes the threshold associated with this negative volatility.

By definition, the volatility of a variable indicates the disparity between its values and equilibrium and can be measured using various methodologies. A common measure of volatility is conditional variance (Bollerslev, 1986). Alternatively, volatility can be quantified as the absolute value of the error term in a regression model, where the error terms represent deviations of the dependent variable from its equilibrium. The latter methodology is frequently employed in the measurement of macroeconomic volatility (Lensink and Morrissey, 2006; Schwert, 1989). In our study, we actively chose to follow the regression approach proposed by Schwert (1989) due to its relevance to our research.

Specifically, we conduct a 12th-order autoregressive analysis on the monthly macroeconomic variable X_t, as described in Model (5).

$$X_t = \sum_{j=1}^{12} \varphi_j D_{jt} + \sum_{p=1}^{12} \delta_p X_{t-p} + \upsilon_t \tag{5}$$

In which X_t is the macroeconomic variable in month t

X_{t-p} represents the p^{th} order lag for the macroeconomic variable X_t.

D_{jt} is a monthly dummy variable of t^{th} month, with j = 1, . . ., 12. Specifically, D_{jt} equals 1 if the month t is j^{th} month of the year and 0 otherwise.

The residuals from Model (5) will be used in the following:

$$|\upsilon_t| = \sum_{j=1}^{12} \rho_j D_{jt} + \sum_{q=1}^{12} \gamma_q |\upsilon_{t-q}| + u_t \tag{6}$$

The estimated value of the regressand $|\upsilon_t|$ from Model (6), denoted as $\widehat{|\upsilon_t|}$, will be defined as the volatility of the macroeconomic variable X_t in month t, based on available information up to month t.

It is crucial to emphasize that the impact of this volatility on stock volatility can differ depending on the sign of υ_t. For instance, the impact of GDP volatility on the stock market would be preferable when GDP surpasses its equilibrium, whereas the reverse holds otherwise. To account for this distinction, we categorize the volatility of macroeconomic variables into two cases:

We define positive volatility as the disparity observed when a macroeconomic variable increases beyond its equilibrium value ($\upsilon_t \geq 0$), determined as follows:

$$X_t^+ = \widehat{|\upsilon_t|} \tag{7}$$

Negative volatility is defined as the disparity observed if a macroeconomic variable decreases below its equilibrium value ($\upsilon_t < 0$), as described below:

$$X_t^- = -\widehat{|\upsilon_t|} \tag{8}$$

The extended EGARCH model offers asymmetry in the impact of macroeconomic volatility behavior, as illustrated in Equation (4). In more detail, a non-zero a^+ denotes the presence of an asymmetric effect in the positive volatility: the response of stock prices changes as the positive volatility X_{t-1}^+ exceeds the threshold ξ^+. Similarly, a non-zero a^- indicates the presence of an asymmetric effect in the negative volatility: the response of stock prices changes as the negative volatility X_{t-1}^- exceeds the threshold ξ^-.

The extended EGARCH model is estimated using the maximum likelihood estimation method. The log likelihood function (LLF) is computed as follows:

$$LLF(\omega, \alpha, \beta, \gamma, \xi^+, \xi^-, s^+, a^+, s^-, a^-) = T^{-1} \sum_{t=1}^{T} \sum_{i=1}^{N} \left[-\frac{1}{2} \log \sigma_{i,t}^2 - \frac{1}{2} \varepsilon_t^2 \sigma_{i,t}^{2\ -1} \right]$$

For each pair values of ξ^+ and ξ^-, the parameters $(\omega, \alpha, \beta, \gamma, \xi^+, \xi^-, s^+, a^+, s^-, a^-)$ are chosen on the grid to maximize the LLF over a period T.

The estimation process is conducted as follows:

(1) First, we estimate Equations (5) and (6) and then use their residuals to form positive and negative volatility for each macroeconomic variable using Equations (7) and (8), respectively.

(2) Then, we estimated the model in Equation (4) that includes both positive and negative volatility for two macroeconomic variables: the IP index and interest rates.

(3) The above process is repeated for each period.

3.3 Data description

We utilize the daily closed prices of the VN-Index in the Vietnamese stock market, spanning from January 2, 2013, to December 31, 2022. The dataset is divided into two periods: the first period, from January 2, 2013, to December 31, 2018, reflects a phase of stability in the stock market, and the second period, from January 2, 2019, to December 30, 2022, represents an unstable period influenced by the COVID-19 pandemic.

Studies in this field commonly employ GDP and interest rates to represent macroeconomic variables (Amendola *et al.*, 2019; Hashmi and Chang, 2023). In this study, we utilize the IP index as a proxy for GDP (Engle *et al.*, 2013; Guo *et al.*, 2013). The interbank interest rates (IRATE) are represented by interest rates in the monetary market (Lobo, 2000).

Table 1 provides the summary statistics of analyzed variables and the *t*-test results regarding the differences in means and standard deviations between the two periods.

Table 1 illustrates significant differences in the means and standard deviations of analyzed variables between stable and unstable periods. Specifically, the daily returns of the VN-Index decreased from 0.05% in the 2013–2018 period to 0.01% in 2019–2022. These returns exhibited statistically higher volatility in 2019–2022, with a difference in the standard deviation of 0.26% per day. Additionally, notable differences in the means and standard

deviations of the monthly IP index stand at 50.53 and 18.77%, respectively. Conversely, average interest rates declined from 3.46% to 2.86%, while the standard deviation of these rates increased from 0.86% to 1.5% between the periods 2013–2018 and 2019–2022. The result indicates significant fluctuations in the monthly GDP and changes in Vietnam's monetary policy.

The realized volatility of the VN-Index returns from January 2, 2013, to December 31, 2022, is presented in Figure 1.

From Figure 1, it can be seen that the realized volatility of VN-Index returns differs significantly across the two periods. This observed pattern indicates the characteristics of Vietnam's emerging and developing stock markets. Particularly, noteworthy is the heightened volatility of VN-Index returns during the COVID-19 pandemic. The results underscore the necessity of partitioning the dataset into two distinct periods for our study. Moreover, the distribution of VN-Index returns exhibited fat tails and left skewness in both periods. Consequently, we employ the EGARCH model to address the asymmetric effect in the Vietnamese stock market. The results are consistent with the study by Diebold and Yilmaz (2008).

4. Results and discussion

4.1 Empirical results

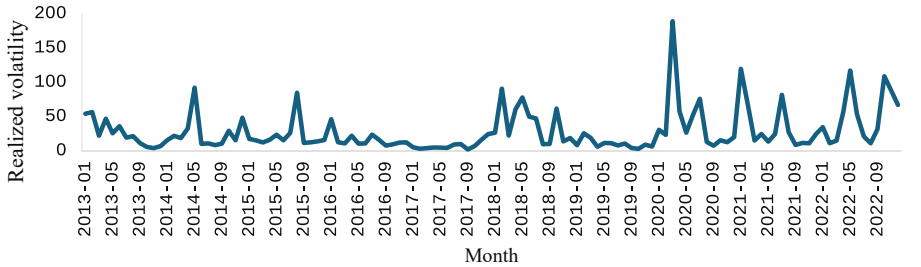
The results of the stationarity test indicate that the VN-Index returns are stationary series, with a significance level of 1% in both periods. Table 2 presents the estimated parameters in Model (4), extended with the positive and negative volatility of the IRATE and IP variables.

Table 2 reveals that the estimated coefficients of, β, γ, s^+, s^-, a^+ and a^- are almost statistically significant. The findings suggest several findings on the impact of macroeconomic variables on stock volatility in Vietnam as follows:

Variable	Period	Summary statistics Mean	Summary statistics Standard deviation	Differences of two periods Mean	Differences of two periods Standard deviation
Return of VN-Index	2013–2018	0.05	1.05	−0.04	0.26***
	2019–2022	0.01	1.31		
IP	2013–2018	86.26	12.72	50.53***	18.77***
	2019–2022	136.79	31.49		
IRATE	2013–2018	3.46	0.86	−0.6***	0.64***
	2019–2022	2.86	1.5		

Note(s): (***) indicates significance at the 1% level
Source(s): Researchers' own computations

Table 1.
Descriptive statistics and *t*-test



Source(s): Researchers' own computations

Figure 1.
Realized volatility of VN-Index returns

Period	2013–2018		2019–2022	
Macro variable	IP	IRATE	IP	IRATE
Column	[A]	[B]	[C]	[D]
μ	0.052**	0.052***	0.003	0.00001
α	−0.109***	−0.132***	−0.179***	−0.112***
β	0.933***	0.913***	0.888***	0.948***
γ	0.217***	0.206***	0.244***	0.217***
s^+	0.036***	0.606***	−0.009	0.378***
a^+	−0.029**	−0.497***	0.008***	0.194***
s^-	0.106**	0.405***	0.023*	0.286**
a^-	0.105**	0.159**	−0.005	0.204*
ξ^+	70%	60%	90%	90%
ξ^-	50%	60%	80%	50%
LLF	−1978.925	−1972.427	−1460.876	−1465.287

Note(s): (***), (**) and (*) indicate significance at 1%, 5% and 10% levels, respectively
Source(s): Researchers' own computations

Table 2. Estimated parameters for the extended EGARCH model with asymmetric thresholds

4.1.1 In the period from 2013 to 2018. The findings in Column A confirm Hypothesis 1 of our study. The estimated coefficients a^+ and a^- are −0.029 and 0.105, respectively. The findings align with the study by Amendola *et al.* (2019) in the American stock market but differ from Lobo (2000). Thus, the impact of the IP index volatility on Vietnamese stock volatility is asymmetric, exhibiting different patterns at thresholds. The threshold ξ^+ for positive volatility of the IP index is 70%, while the threshold ξ^- for the negative volatility of the IP index is lower, reaching 50%. These thresholds of positive and negative volatility of the IP index are lower than those of the studies of Wang *et al.* (2020) and Himmelmann *et al.* (2012) in the developed market. The results contribute to the scope of analysis of the relationship between the IP index and the stock market in the developing country of Vietnam.

More concretely, if the volatility of the IP index exceeds these thresholds, the changes in the stock price volatility might be sharp. Accordingly, the change in the stock volatility resulting from a 1% increment in positive volatility of the IP index can be calculated $e^{\{s^+ + a^+\}} - 1 = e^{\{0.036 - 0.029\}} - 1 = 0.702\%$ when the positive volatility of the IP index exceeds its 70th percentile. Conversely, this change is $e^{\{s^+ - a^+\}} - 1 = e^{\{0.036 + 0.029\}} - 1 = 6.72\%$ when the positive volatility of the IP index falls below its 70th percentile. Furthermore, if the negative volatility of the IP index falls below its 50th percentile threshold, the change in the stock volatility resulting from a 1% decrement in negative volatility of the IP index can be computed $e^{\{-s^- - a^-\}} - 1 = e^{\{-0.106 - 0.105\}} - 1 = -19.023\%$. If the negative volatility of the IP index surpasses its 50th percentile, this change can be determined as $e^{\{-s^- + a^-\}} - 1 = e^{\{-0.106 + 0.105\}} - 1 = -0.1\%$.

In Column B, Hypothesis H1 is also confirmed regarding the asymmetric impact of interest rate volatility on stock volatility. The findings are consistent with those of Lobo (2000) and Hashmi and Chang (2023). The estimated coefficients a^+ and a^- are −0.497 and 0.159, respectively. Thus, stock volatility exhibits distinct patterns at thresholds when interest rate volatility surpasses these levels. The thresholds are 60% for positive and negative interest rate volatility. These thresholds are lower than those of the studies by Wang *et al.* (2020) and Himmelmann *et al.* (2012). Moreover, the thresholds of interest rate volatility differ from those for the IP index volatility estimated in column A.

4.1.2 In the period from 2019 to 2022. In column C, Hypothesis H1 is also confirmed in the unstable period influenced by the COVID-19 pandemic. The estimated coefficient a^+ of volatility of the IP index is 0.008 and is statistically significant. The threshold ξ^+ for positive volatility of the IP index rises to 90% in the unstable period. The findings confirm H2 regarding the difference in the thresholds of volatility of the IP index between normal and unstable market periods. These thresholds are the same as those in the study by Wang *et al.* (2020) in the American stock market.

Interestingly, in Column D, interest rate volatility also plays a crucial role during the unstable period. The thresholds of interest rate volatility differ between normal market periods and unstable periods. The estimated coefficients a^+ and a^- are statistically significant, standing at 0.194 and 0.204, respectively. Therefore, Hypothesis H1 is also confirmed. During the unstable period, the threshold ξ^+ for positive interest rate volatility rises to 90%, while the threshold ξ^- for negative interest rate volatility decreases to 50%. The findings confirm Hypothesis H2, indicating differences in the thresholds of interest rate volatility between normal market and unstable periods.

4.2 Discussion

In summary, it is noteworthy that when the volatility of the IP index surpasses asymmetric thresholds, the stock prices exhibit changes in their response patterns. Stock prices experience fewer increases when the IP index's volatility is favorable and reaches its 70th percentile. Additionally, the stock volatility undergoes a more pronounced decrease when the IP index's volatility is unfavorable and reaches its 50th percentile. The lower thresholds of the IP index's volatility in Vietnam mean that Vietnamese investors are more sensitive to growth policies than developed markets. The stock price volatility in Vietnam also experiences a more substantial decrease in negative volatility of the IP index (unfavorable volatility) when it is below its 50th percentile. The findings are consistent with the Vietnamese stock market, where investors are prone to herd mentality. Negative volatility and herd effects may lead to more pronounced decreases in stock prices.

The changes in response patterns of stock prices are evident in both cases of positive interest rate volatility (unfavorable volatility) and negative interest rate volatility (favorable volatility) when they surpass their 60th percentiles. These findings suggest that the volatility of stock prices demonstrates greater stability when positive interest rate volatility surpasses its 60th percentile and experiences more pronounced decreases when negative interest rate volatility exceeds its 60th percentile. These findings imply that participants in the Vietnamese stock market are more responsive to volatility in the monetary market than those in developed markets. They may also exhibit greater sensitivity to changes in interest rates than to changes in GDP.

In the unstable periods, the thresholds for macroeconomic volatility undergo significant changes. The thresholds for positive and negative volatility of the IP index increase to 90 and 80%, respectively. Remarkably, the threshold for positive interest rate volatility rises to 90%, while that for negative interest rate volatility decreases to 50%. The findings indicate that Vietnamese investors react differently to positive and negative news in the monetary and commodity markets during the COVID-19 pandemic.

5. Conclusion and policy implications

Our study extends the existing EGARCH model by adding a new component to the model: the thresholds of macroeconomic variables. This inclusion helps provide more insights into the impact of macroeconomic factors on stock volatility. Our model not only captures the non-linearity in the relationship but also helps find the critical values in the relationship where the relationship changes its pattern. Additionally, in the extended EGARCH model,

macroeconomic volatility is decomposed into two cases: negative volatility and positive one. This model captures a fact in the market that people react to negative news differently from positive news. Furthermore, the study is conducted under different market conditions, including normal and unstable periods. The results aim to evaluate the roles of macroeconomic variables in specific periods by estimating the market's reaction to changes in volatility according to each macroeconomic variable. With that construction, the recommendations drawn from the results are expected to be more accurate and meaningful. Two vital macroeconomic variables in our study are the GDP and interest rates. The volatility of these variables serves as proxies for the volatility observed in the commodity and monetary markets, respectively. The use of these two variables as representative of macroeconomic factors is widely considered in the field (Amendola *et al.*, 2019; Hashmi and Chang, 2023).

Our key findings are as follows:

(1) Macroeconomic volatility has an asymmetric impact on stock volatility at specific thresholds. When macroeconomic volatility reaches certain thresholds, the stock market undergoes a sharp response pattern in positive and negative volatility cases. The asymmetric threshold for the IP index's positive volatility is 70%, whereas its negative volatility is lower at 50%.

(2) Thresholds differ among different macroeconomic variables. The threshold for favorable volatility of the IP index is higher than that for favorable interest rates. In comparison, the threshold for unfavorable volatility of the IP index is lower than that for unfavorable interest rates. This finding suggests that Vietnamese investors pay great attention to favorable volatility in the monetary market during the study period. Even small favorable volatility in interest rates can influence investors' behavior.

(3) Another interesting finding is the threshold disparity between the normal and unstable periods. Thresholds during the normal period are lower than those in the unstable phase. In the normal period, the thresholds of the IP index's positive and negative volatility are 70 and 60%, respectively. In the unstable period, they reach higher levels, at 90 and 80%, respectively. These findings suggest that Vietnamese investors are more tolerant of macroeconomic volatility during the COVID-19 pandemic. They adjust their behaviors only when volatility is relatively high.

(4) The role of different macroeconomic factors also varies according to different market situations. While GDP plays a more significant role during normal periods, interest rates have an important influence in both normal and unstable periods. These findings imply that Vietnamese investors consider GDP a fundamental factor during normal periods. However, they pay more attention to the volatility of interest rates during unstable market periods. Because interest rates directly influence opportunity cost and discounting factors, Vietnamese investors might assess risks and adjust their investment strategies to respond to the volatility of interest rates in the monetary market.

Based on these findings, some implications can be drawn as follows:

Firstly, policymakers should take into account the impact of macroeconomic volatility on the stock market when designing policies, especially when macroeconomic volatility approaches threshold values, to mitigate the negative impact on the Vietnamese stock market.

Secondly, the findings underscore the importance of Vietnamese investors' role in managing risk during macroeconomic volatility. They should be vigilant, especially when volatility approaches asymmetric thresholds. Given the disparity in the thresholds of

macroeconomic variables, they should evaluate stock prices and adjust their portfolios accordingly. The findings also highlight the need to be mindful of negative interest rate volatility, as stock prices can be significantly affected even when the unfavored volatility of interest is not very high.

It is important to note that the role of macroeconomic factors and their corresponding thresholds can vary depending on market conditions. This calls for a flexible approach from both investors and policymakers, one that is tailored to the real market conditions for each phase.

In the future, with new improvements in computational capacity, Model (4) can include more lags of macroeconomic variables as well as more macroeconomic variables to make the analysis more comprehensive.

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