Economics and Business International Conference Proceeding
Vol. 1 No. 2, pp. 1045-1056, August, 2024

Volatility and Stock Risk Analysis Using ARCH-GARCH Method

Meutya Anes Kurniawati[1], Agung Nusantara[2], Haerudin Haerudin[3], Annisa Fajri[4]
Departement of Management, University of Muhammadiyah Semarang
Correspondence author : meutyaanes30@gmail.com

ARTICLE INFORMATION

Publication information

Research article

HOW TO CITE

Kurniawati, M.A., Nusantara, A., Haerudin, H., & Fajri, A., (2024). Volatily And Stock Risk Analysis Using ARCH-GARCH Method. Economics and Business International Conference Proceesing, 1(2), 1045-1056.

Received: July 20, 2024
Accepted: July 25, 2024
Published: August 1, 2024

ABSTRACT

This study analyzes the volatility and risk of stock prices of three infrastructure construction companies in Indonesia: ADHI.JK, PTPP.JK, and WIKA.JK over 2023. Data from Yahoo Finance is used, covering 230 data points for each company. The method used is the ARCH-GARCH model to model stock price volatility and measure the associated risk. The results show that all three companies exhibit significant volatility patterns with GARCH (1,1) models. PTPP.JK has the highest volatility, indicating the highest risk, while ADHI.JK has the lowest volatility and risk. The volatility graph shows the sensitivity of the three stocks to the development event in the Capital City of the Archipelago (IKN). Value at Risk (VaR) calculation shows that WIKA.JK has the highest risk, while ADHI.JK has the lowest risk. This research provides insight into the dynamics of the stock market in the infrastructure construction sector, as well as its implications for risk management and investment decision making.

Keywords: Volatility, Stock Price Risk, ARCH-GARCH, Construction Company, Infrastructure, Value at Risk (VaR), Capital City of the Archipelago (IKN)

INTRODUCTION

The relocation of the national capital from Jakarta to the archipelago in East Kalimantan is a strategic step taken by the Indonesian government. This decision was taken to overcome various problems in Jakarta, such as population density, uneven development, clean water crisis, and environmental problems. The relocation of the capital city is also expected to encourage more equitable economic growth throughout Indonesia and help realize Indonesia's Vision 2045.

The construction industry, particularly companies involved in infrastructure development, such as PT Adhi Karya (Persero) Tbk (ADHI), PT PP (Persero) Tbk (PTPP), and PT Wijaya Karya (Persero) Tbk (WIKA), have an important role in this project. These companies are faced with the challenge of adapting to government policies and capitalizing on existing opportunities.

Figure 1 Share price conditions in 2023

Source: www.yahoo.finance.com

The chart above shows the closing price of three construction companies, namely WIKA.JK (blue striped), ADHI.JK (orange striped), and PTPP.JK (gray striped) during the 2023 period. In general, these three stocks show a consistent downward trend throughout the observed period. WIKA.JK and ADHI.JK experienced a steady decline, although WIKA.JK showed greater fluctuations in the middle of the period. PTPP.JK, on the other hand, exhibited higher volatility with several significant peaks in the middle of the period before falling sharply at the end of the period. The sharp decline seen at the end of the period in these three stocks may reflect unfavorable market conditions or external factors affecting the construction industry. Despite some minor fluctuations and peaks, the overall trend still shows a decline in share prices, indicating that investors may have lost confidence in the growth prospects of these three companies during this period.

Based on the above phenomenon, the authors will conduct research related to. This research is conducted with the aim of knowing the risks to stock prices that occur in related companies due to government policies. Through the exposure of the background and the statements described, the authors will conduct research with the title "Analysis of Volatility and Stock Risk Using the ARCH / GarCH Method (Study on Companies)".

LITERATURE REVIEW

Random Walk Theory

This theory states that stock price movements are random and unpredictable based on historical data. It emphasizes that future stock prices are not influenced by past stock prices, so investors have little opportunity to maximize profits or reduce risk. This concept also highlights stock price volatility that does not show significant trends in the long term (Gunarto & Wulansari, 2021).

Efficient Market Hypothesis

This theory states that the capital market is efficient in reflecting a company's fundamental information into its stock price. The market is said to be efficient if stock prices accurately reflect all relevant information, both past and current. Thus, no investor can consistently earn profits above the market average because all relevant information is already reflected in stock prices (Daffa et al., 2023).

Stock Price Volatility

According to (Tinggi S, 2022) stock price volatility is a measure of significant price fluctuations in the market. A high level of volatility indicates large price changes over a period of time, reflecting high risk for investors. Volatility affects the expected return of a stock, and is often used by investors to determine the appropriate timing of an investment. While volatility can be considered an indicator of risk, its use in investment strategies should be cautious to avoid irrational decisions. Common methods for measuring volatility include historical volatility using the standard deviation of stock price movements. Investors often see volatility as an opportunity for large gains, but also realize that high volatility can increase investment uncertainty and risk.

In Tandelilin's research (2012) states that stock risk is the possibility that occurs in the difference between actual and expected returns. The greater the possible difference, the greater the risk that will be experienced in investing (Bode et al., 2022). Usually in analyzing risk, the method used is Value at Risk (VaR), which is a risk assessment method that uses general statistical techniques and is often applied in various industries. In general, VaR calculates the worst loss expected in a given period assuming the market is under normal conditions, at a specified confidence level.

RESEARCH METHODS

The study also involved time series analysis to understand the behavior of daily stock price data over time. This analysis includes identifying trends, seasonal patterns, and cycles that may exist in the data. By using the ARCH-GARCH model, this study was able to capture the volatility changes that occur over time, where previous volatility affects current volatility. In addition, time series analysis allows the measurement of the impact of Value at Risk (VaR) on stock price risk, providing a more comprehensive insight into the market dynamics and risk factors affecting construction companies in the infrastructure sector.

RESULT

Table 1
Descriptive Statistics

Variabel	Perusahaan		
	ADHI.JK	**PTPP.JK**	**WIKA.JK**
Mean	432.817	618.782	493.4000
Std. Dev.	40.980	67.979	117.847
Skewness	-0.432	0.746	0.626
Kurtosis	2.754	2.889	2.843
Jarque-Bera	7.740	21.469	15.258
Probability	0.020	0.000	0.000

Source : data diolah dengan *E-Views* (2024)

In a normal distribution, skewness close to 0 indicates a symmetrical curve with no slope to the left or right. Kurtosis close to 3 indicates that the data distribution has moderate peaks and is not too pointed. However, in Table 4.1, the skewness and kurtosis values of the three stocks are much higher than the normal distribution. This indicates that the stock price distributions have significant skewness and sharp peaks, indicating the characteristics of a distribution that is not symmetrical and is more spiky than a normal distribution.

Table 2 Result of Test (ADF)

Variabel	ADF *Test Statistic*		
	ADHI.JK	**PTPP.JK**	**WIKA.JK**
Derajat (0)	-1,899	-2,305	-1,645
Prob	(0,332)	(0,171)	(0,457)
Derajat (1)	-15,387	-15,915	-13,454
Prob	(0,000)	(0,000)	(0,000)

Source : data diolah dengan *E-Views* (2024)

The Unit Root Test is conducted to test whether the data is stationary or not. This is because time series data generally contains unit roots due to its volatile nature so that it can cause non-stationarity in the data. The test results show that at degree (0), the ADHI.JK, PTPP.JK, and WIKA.JK stock price variables are not stationary. However, after differencing at degree (1), the three variables become stationary with statistically significant ADF values. This shows that the data of the three companies have stationary properties after differencing.

Table 3 Volatility Model Results

Variabel	*Coefficient (Probability)*					
	ADHI.JK		**PTPP.JK**		**WIKA.JK**	
	Koef	**Prob**	**Koef**	**Prob**	**Koef**	**Prob**
Constanta	7,915	0.175	62.182	0,079	61,615	0,025
RESID(-1) SQR	0.089	0.008	0.171	0.010	0.204	0.001
GARCH	0.855	0.000	0.659	0.000	0.575	0.000
Volatilitas	**8,859**		**63,012**		**62,394**	

Volatility is one of the ways investors observe the pattern of stock price movements of a company. From the volatility pattern, investors can analyze the risk of stock returns. One way to find out the volatility pattern is to use the ARCH-GARCH model. Based on the test results in, each company captures volatility. ADHI.JK shows a relatively low level of volatility compared to the other two companies. On the other hand, PTPP.JK and WIKA.JK experience very high volatility, showing significant stock price fluctuations. As such, PTPP.JK and WIKA.JK face higher levels of market uncertainty, while ADHI.JK shows greater stability in its share price.

Heteroscedasticity Test

Table 4 Heteroscedasticity Test Results

Variabel	Uji LM-ARCH		
	F-Stat	Prob.F	Keterangan
ADHI.JK	2,325	0,128	Homoskedastisitas
PTPP.JK	0,420	0.515	Homoskedastisitas
WIKA.JK	0,130	0,718	Homoskedastisitas

Source : data diolah dengan *E-Views* (2024)

The LM-ARCH *(Lagrange Multiplier Autoregressive Conditional Heteroskedasticity)* test is used to test for the presence of conditional heteroskedasticity in the regression model. Conditional heteroscedasticity occurs when the error variability in the model depends on the independent variable or other variables in the model. Based on the test results, it can be concluded that the three companies are not significant at the 5% level where the data is homoskedasticity, meaning that it is free from heteroscedasticity assumptions, then the data cannot be continued to the next stage or in other words, the data cannot be estimated with ARCH/GARCH volatility.

Correlogram Normality Test

Table 5 Correlogram Normality Test Results

	ADHI.JK	PTPP.JK	WIKA.JK
Normalitas (36)**	Tidak signifikan pada taraf 5%		

Source : data diolah dengan *E-Views* (2024)

At this stage, the normality test is used to find out the data modeled with ARCH-GARCH still has the effect of heteroscedasticity and is not normally distributed. The results of the normality test using the Correlogram Residual Square of the three companies are not significant at the 5% level, meaning that the three companies have normal data distribution.

DISCUSSION

PT Adhi Karya (Persero) Tbk, PT PP (Persero) Tbk, and PT Wijaya Karya (Persero) Tbk are the three largest construction companies in Indonesia which are State-Owned Enterprises (SOEs). These three companies have an important role in national infrastructure development through strategic projects driven by government policy. The involvement of the three companies in large projects such as the construction of the Capital City of the Archipelago (IKN) has consequences for the volatility of their shares.

The analysis shows that the three companies, ADHI.JK, PTPP.JK, and WIKA.JK, are able to capture volatility during the observed period. ARCH-GARCH tests on the three variables show significant values in ARCH(1) and GARCH(1). The existence of the

ARCH(1) phenomenon in each company indicates that ADHI.JK, PTPP.JK, and WIKA.JK are influenced by the squared residuals from one previous period. This residual is the difference between the actual stock price and the stock price predicted by the model. The squared residual is used to show that today's stock price is affected by yesterday's stock price that has been squared.

Furthermore, the existence of GARCH(1) in ADHI.JK, PTPP.JK, and WIKA.JK means that the volatility pattern in the observed data is influenced by the squared residual and conditional variance of one previous period. The conditional variance of one previous period shows that the volatility of the three variables is influenced by the volatility of the previous period. If the volatility in the previous period is high, then the volatility in the current period also tends to be high. This creates a continuous volatility pattern and makes it possible to capture consecutive periods of high volatility.

VOLATILITAS

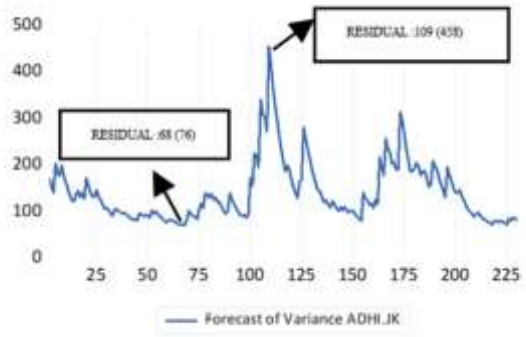

Figure 2 ADHI.JK *Forrecast*

The volatility pattern in ADHI.JK stock price shows the existence of variance clusters, which reflect periods with low and stable volatility and periods with high volatility. At the 68th residual point, volatility is low with a forecast of variance of 76, indicating calm market conditions without large fluctuations. However, between the 100th and 125th data, there is a high spike in volatility, with a peak at the 109th data (June 19, 2023) where the forecast of variance reaches 458. This variance cluster indicates the presence of high price fluctuations, possibly triggered by important news such as the Capital City of the Archipelago (IKN) project. After reaching the peak, the variance decreases towards the low cluster, and after point 125, the volatility decreases gradually as the market absorbs the information and adjusts the stock price.

Extreme residual movements occur between June and July, where there is information about the company ADHI getting a large project related to infrastructure development in the Capital City of the Archipelago (IKN). This information caused significant share price fluctuations, as investors reacted to the information. ADHI's involvement in strategic projects in IKN, such as the construction of toll roads and government buildings, was the reason behind the stock price fluctuation.

The behavior of ADHI shares during the observation period is consistent with the Efficient Market Hypothesis and Random Walk Theory. Information on major projects in IKN caused significant stock price fluctuations, reflecting the market's quick reaction to new information.Uncertainty and unpredictable price movements reflect the principle of Random Walk Theory, where stock prices move randomly based on new information.In

conclusion, ADHI stock during the observation period has a high risk due to the uncertainty faced by investors in predicting future stock price movements.

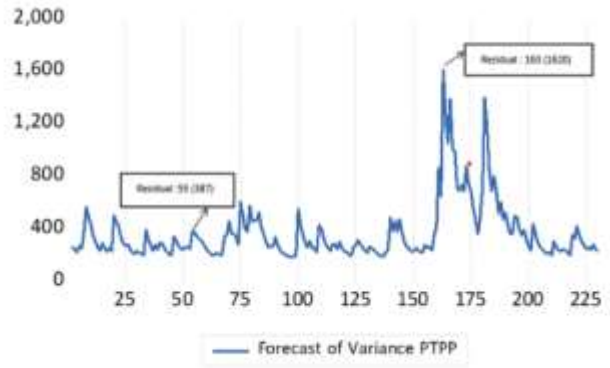

Figure 3 PTPP.JK Forrecast

The volatility pattern in the stock price of PTPP.JK shows clusters of relatively high residual values at certain points, reflecting high volatility during the period. At the beginning of the period, PTPP.JK stock price shows low and stable volatility, from January 1 to September 1, indicating a relatively calm market without significant information.

Volatility spikes occur between the 150th and 175th data, with the highest point at the 163rd data (September 8, 2023) with a forecast of variance value of 1620, and the last spike at the 181st data (October 6, 2023) with a forecast of variance value of 1408.This spike was caused by a significant event, which was in early September 2023, PTPP obtained a number of large contracts for infrastructure development in This spike was caused by a significant event, namely in early September 2023, PTPP obtained a number of large contracts for infrastructure development in the Capital City of the Archipelago (IKN), including toll road construction projects in segment 3B (Kariangu-SP, Tempadung).Optimism for PTPP's business prospects has increased due to the company's involvement in strategic projects in IKN.

The surge in PTPP.JK's stock price during the observation period indicates that the market reacts to new information regarding large contracts in IKN, which is in line with the Efficient Market Hypothesis theory. PTPP.JK's stock price reflects publicly available information and reacts quickly to positive news about the company's business prospects. In addition, the volatility and unpredictability of stock price fluctuations reflect the principle of Random Walk Theory, where new information causes unpredictable price changes, indicating that stock price movements follow random trajectories and are difficult to predict.

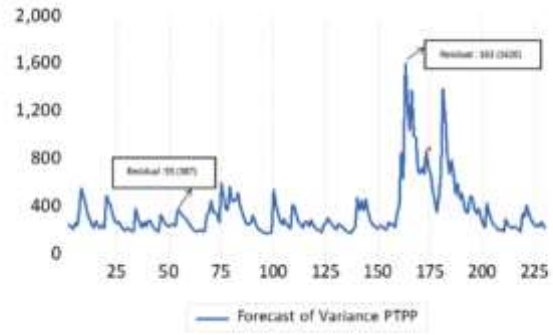

Figure 4 WIKA.JK *Forrecast*

The volatility pattern in the WIKA.JK stock price shows clusters of relatively high residual values in certain periods, reflecting high volatility during that period. At the beginning of the period, there were several significant spikes in variance, such as in the 8th data with a forecast of variance value of 783, which occurred on January 10, 2023. This spike occurred when WIKA.JK was involved in several large projects in the Capital City of the Archipelago (IKN), which contributed to the increase in the company's share price.

In the middle of the period, there is a more extreme spike in variance on the 100th data with a forecast of variance value of 1245, higher than the beginning of the period. This spike is most likely caused by news related to the development of the Capital City of the Archipelago (IKN), where WIKA.JK is working on projects such as the construction of Toll Roads in IKN Karingau-SP Tempadung Summit Segment, East Side National Axis Road, and Multi-Utility Tunnel which will accommodate water pipelines, optical fiber, and power cables in the Capital City of the Archipelago (IKN).

This spike in variance indicates that the market quickly captures the new information available, causing a significant change in volatility. This is consistent with the Efficient Market Hypothesis, where stock prices change immediately due to new information from the public. The random movement from one period to the next also supports the idea that stock price movements are difficult to predict consistently in accordance with the Random Walk Theory. Therefore, in the observed period, WIKA.JK shares show high risk due to significant volatility and market uncertainty.

Based on the analysis of volatility patterns above, it can be concluded that the variables ADHI.JK, PTPP.JK, and WIKA.JK have high risk because all three show high volatility patterns. Volatility reflects how often stock prices rise and fall within a certain period of time. The higher the volatility, the higher the uncertainty of stock returns and potential stock price fluctuations. Therefore, these three variables have a high stock risk. However, each company has different volatility and risk criteria based on the events underlying this research:

1. PTPP.JK has the highest stock risk, with significant spikes in variance at various points, especially in the 183rd and 181st data, which is related to the news of a large contract in the Capital City of the Archipelago (IKN).
2. ADHI.JK has the lowest stock risk, although it still shows high volatility, especially around major projects of the Capital City of the Archipelago (IKN).
3. WIKA.JK also shows high volatility, especially around toll road and infrastructure development projects in the Capital City of the Archipelago (IKN), but its risk is between PTPP.JK and ADHI.JK.

Overall, these three companies show high stock risk due to significant volatility and market uncertainty, with PTPP.JK being the riskiest and ADHI.JK being the least risky among the three.

Value at Risk

Since the data used in the observation is 230 for each company, the risk value calculated using VaR is presented in the form of a graph as follows:

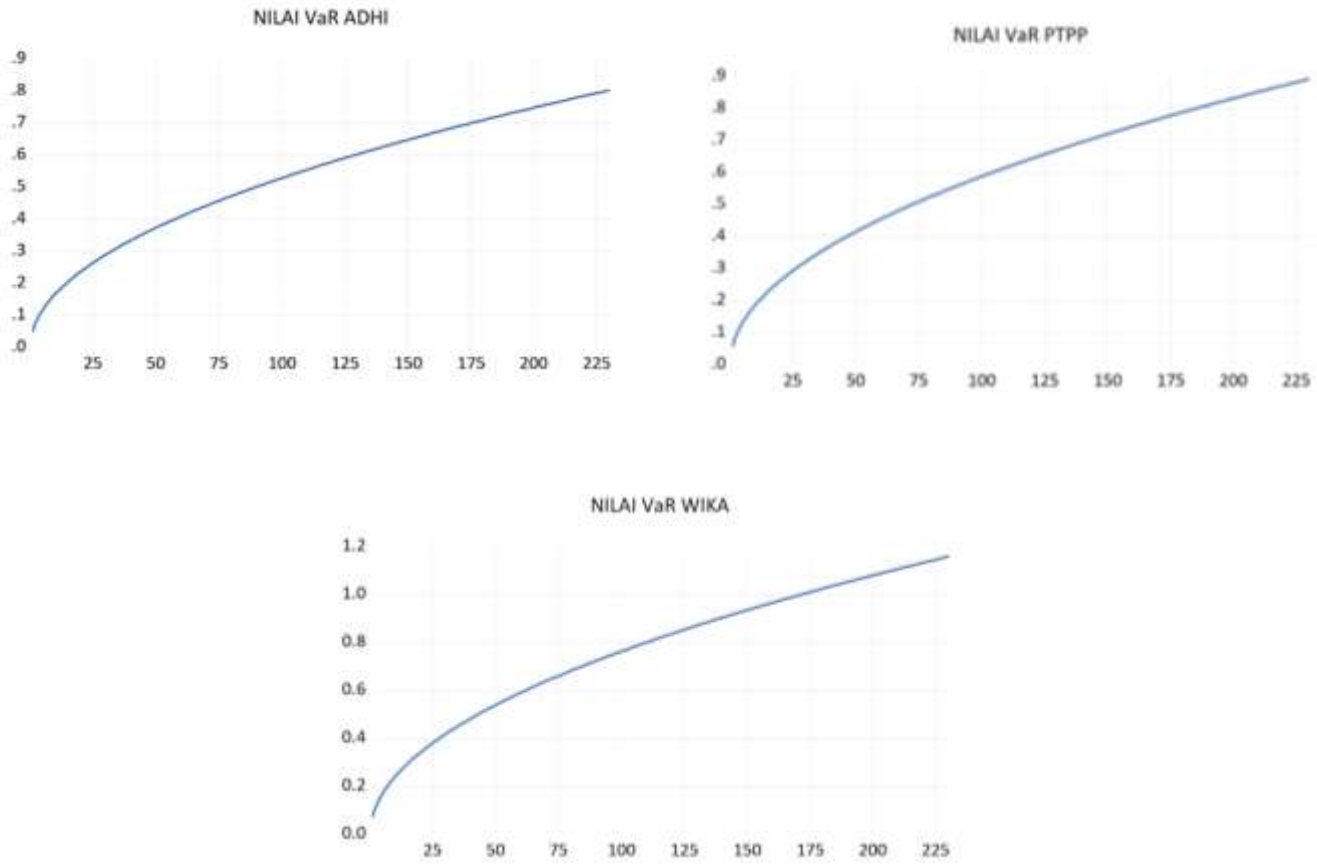

Figure 5 VaR Result Graph

Based on Figure 4.5, the three closing stock price variables ADHI.JK, PTPP.JK, and WIKA.JK show an increase in the Value at Risk (VaR) value during the observation period. With a 95% confidence level, the VaR analysis shows that the maximum expected loss of ADHI.JK stock is about 80.2% of the stock value. This means that in 95% of the observation time, the maximum possible loss will not exceed 80.2% of the total investment for 230 days, although there is a 5% chance that the loss could be greater than 80.2%.

For PTPP.JK stock, the maximum expected loss with a 95% confidence level is about 89.1% of the stock value. This means that in 95% of the time, the maximum loss will not exceed 89.1% of the total investment for 230 days, with a 5% chance that the loss could be greater than 89.1%. Meanwhile, the stock WIKA.JK shows a maximum expected loss of 115.9% of the stock value with a 95% confidence level. In other words, in 95% of the observation time, the maximum loss will not exceed 115.9% of the total investment over 230 days, but there is a 5% chance that the loss could be greater than 115.9%.
Based on this VaR calculation analysis, it can be concluded that during the observation period, the WIKA.JK variable has the highest VaR value, which indicates the highest risk,

while the ADHI.JK variable has the lowest VaR value, indicating the lowest risk. This VaR value can be used to analyze investment risk by looking at the value of stock risk from the previous period.

CONCLUSION

Based on the results of research that has been conducted related to "Volatility Analysis and Stock Risk Using the ARCH / GarCH Method (Study on Infrastructure Sector Construction Companies for the 2023 Period)", it can be concluded:

1. The volatility patterns of the three significant companies contain ARCH (1) and GARCH (1,1) phenomena with a significance level of 5%. This means that the volatility patterns of the three companies are influenced by the residual squares of the previous period and the conditional variance of the previous period.
2. Based on the calculation of volatility using the ARCH-GARCH model, the PTPP.JK variable has the highest volatility, which means that PTP.JK has stock price uncertainty so it has a high risk. While the lowest volatility is owned by the ADHI.JK variable, meaning that ADHI.JK has a more stable share price movement compared to PTPP.JK and WIKA.JK so that the risk of ADHI.JK shares is lower.
3. Based on the volatility graph analysis, the variables ADHI.JK, PTPP.JK and WIKA.JK are sensitive to events and information circulating in the market because high volatility spikes occur at times of development events in the Capital City of the Archipelago (IKN).
4. Based on the calculation of the risk value using the VaR formula, the WIKA.JK variable has a higher risk than PTPP.JK and ADHI.JK. While ADHI.JK has the lowest risk value. So that WIKA.JK is highly favored by risk seeker investors, PTPP.JK and ADHI.JK are highly favored by risk averse investors and risk neutral investors.

Based on this research, the suggestion that can be given to further research is that the observed time period is too long, namely looking at the impact of an event on stock price volatility, so that volatility does not look too volatile. Therefore, for event studies research it is recommended to use a shorter observation period in order to better see the momentum or volatility, the impact of an event. 2. The use of the ARCH-GARCH model, although effective, does not rule out the possibility that other models such as IGARCH or TGARCH can provide more comprehensive and accurate results.

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