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Analysis of Volatility and Stock Risk in Energy Sector Companies Using The ARCH/GARCH Method

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ABSTRACT

Events of geopolitical conflict and the stipulation of Presidential Decree No. 112 of 2022 change the prices of energy commodities, such as oil prices which are increasing and coal prices are falling. This situation influences share price movements and investor transactions. This research is a *time series analysis research* by looking at *event studies* . The aim of this research is to determine the volatility and risk patterns of shares of energy sector companies, namely ADRO, PGAS and POWR. The method used in this research is the ARCH-GARCH model and *value at risk calculations* . Based on the results of this research, it can be concluded that the three companies contain the ARCH(1) and GARCH(1,1) phenomena. The volatility patterns of the ADRO and PGAS variables are sensitive to events that occur so they are highly volatile. Based on the analysis of volatility patterns and *value at risk calculations* , it can be concluded that POWR has the lowest volatility and risk patterns compared to ADRO and PGAS.

Keywords: ARCH-GARCH, *time series* , volatility, stock risk, *value at risk* .

INTRODUCTION

In recent years, the world has experienced geopolitical conflicts involving important countries in the global economy such as Russia, Ukraine, America and several Middle Eastern countries. This conflict caused damage to the global economy by hampering the distribution of energy commodities such as crude oil. The impact is felt by countries that have bilateral relations with conflict countries, including developing countries in Southeast Asia.

In Southeast Asia, dependence on petroleum from Russia is increasing. The war that occurred caused an increase in oil prices, especially for the transportation sector. Data shows world Brent oil prices peaked in June 2022 after the outbreak of the Russia-Ukraine war. The price then decreased, but rose again due to the conflict between Hamas and Israel.

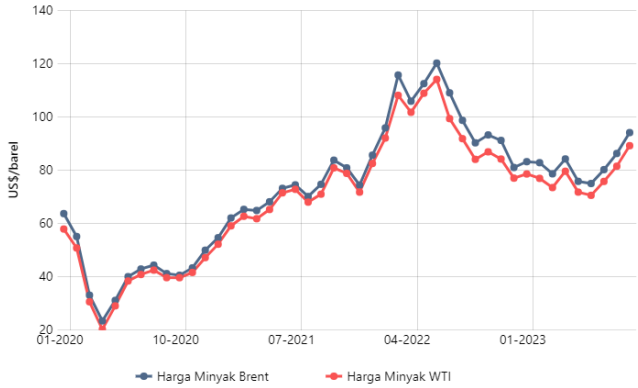

Figure 1. Monthly Average Movement of World Oil Prices

Source: data taken from katadata.co.id (2023)

Apart from increasing oil prices, geopolitical conflicts also have an impact on decreasing coal prices. The Indonesian government issued Presidential Decree no. 112 of 2022 to accelerate the development of renewable energy, which also influences coal prices. Restrictions on the production and sale of coal as an emission producing commodity are carried out to support the commitment to green energy.

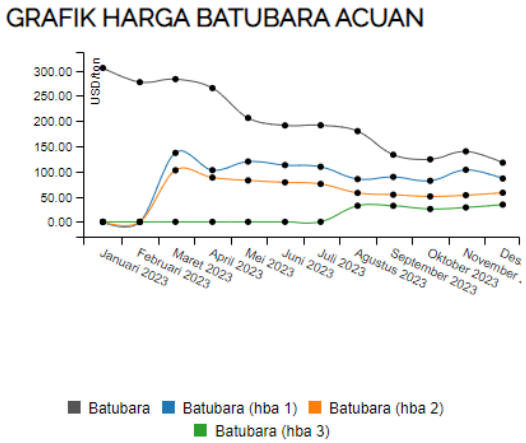

Figure 2. Coal Prices for the 2023 Period

Source: data taken from www.minerba.esdm.ac.id (2023)

These events caused a decline in coal prices and fluctuations in stock prices in the energy sector, such as coal, gas and electricity. High volatility in energy company share prices increases investment risk, fueling investor concerns about the sustainability of energy sector companies as long-term investments. Investors are starting to consider the risk of potential losses when investing in energy companies.

Figure 3. ADRO, PGAS and POWR Share Price Chart for the 2022-2024 Period
Source: data processed using E-Views (2024)

Based on the background above, this research was conducted to determine stock volatility and risk patterns in energy-related companies, namely PT Adaro Energy Indonesia Tbk (ADRO), PT Perusahaan Gas Negara Tbk (PGAS), and PT Cikarang Listrindo Tbk (POWR). This analysis is carried out as a form of investment consideration for investors so that they make appropriate decisions.

LITERATURE REVIEW

Random Walk Theory and *Efficient Market Hypothesis*

Random Walk theory was first discovered by Maurice Kendall in 1953. Then in 1973 an economist named Burton Malkiel popularized the *random walk theory* in his book entitled *"A Random Walk Down Wall Street"* . This theory suggests that price movements in the market are basically random and unpredictable (Pratama & Asnawi, 2020) . The *random walk* theory assumes that stock price movements in the past cannot predict future stock price movements, because stock price movements are random and the possibility of an increase in stock prices is as great as the possibility of a decrease in stock prices.

Therefore, the *random* walk theory is very closely related to the efficient market theory or *Efficient Market Hypothesis* (EMH). Eugene Fama is an economist who developed *the Efficient Market Hypothesis* (EMH) in 1970. This theory states that financial asset prices, including stock prices, efficiently reflect all information available in the market, both published and unpublished. In an efficient market, stock prices reflect all available information.

Stock Price Volatility

Stock price volatility is a situation where stock prices deviate (up or down) in the index from the average (Santioso & Angesti, 2019) . Stock price volatility can occur due to

internal and external factors. From an investor's perspective, share price volatility can also be interpreted as information that describes how well the company is performing by observing the up-and-down movement of share prices. The more trading that occurs on a stock, the higher the possibility that the price will change a lot (Samsiar & Haryono, 2023) . Investors tend to like shares with a high level of volatility because the opportunity to gain capital gains will be greater, although on the other hand, the risk will be greater (Larasati et al., 2021) .

Value at Risk

Value at Risk (VaR) has been used as a model to measure risk exposure since the introduction of RiskMetricsTM by JP Morgan in 1994. Value at Risk (VaR) is a common method for measuring risk and is considered a standard method (Zulfikar, 2016) . Financial institutions have created and use Value at Risk (VaR) as a standard tool for reporting their risks. Value at Risk (VaR), according to the theoretical concept of Jorion (1996), is a risk measurement that calculates the maximum investment loss and a certain target time period at a certain level of confidence under normal market conditions. VaR calculates the maximum loss that may occur the next day, the next week, and so on during the desired period.

$$VaR = Pz_{0,95}\sigma\sqrt{t} \quad \text{.....(1)}$$

RESEARCH METHODS

This research uses the *Autoregressive Conditional Heteroscedasticity* (ARCH) method, which was first introduced by Robert Engle in 1982. The ARCH model is a *time series* model to handle research problems for data that has heteroscedasticity effects. The ARCH(1) model occurs because the conditional variance is σ_t^2influenced only by the fluctuation of the squared residual one period ago, so the ARCH model in general is as follows:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i \varepsilon_{t-i}^2 \quad \text{.....(2)}$$

The ARCH model cannot be used to analyze a model that has high order parameters. Therefore, someone named Bollerslev (1998) re-developed the ARCH model into a model with a more general form, namely *Generalized Autoregressive Conditional Heteroscedasticity* or GARCH. Bollerslev said that the conditional variance is not only influenced by the square of the residual one period ago, but is also influenced by the conditional variance one period ago .

$$\sigma_t^2 = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \ldots + \alpha_p \varepsilon_{t-p}^2 + \beta_1 \sigma_{t-1}^2 + \cdots + \beta_q \sigma_{t-q}^2 \quad \text{.....(3)}$$

RESULTS

The object of this research is the daily closing stock prices of three energy sector companies listed on the Indonesia Stock Exchange (BEI), namely ADRO, PGAS and POWR. The data analyzed is historical daily closing stock price data from January 3 2022 – April 29 2024 totaling 558 *data ranges* for each company. The data for the three companies was processed and produced descriptive statistics written in Table 4.1 as follows:

Table 1 . Descriptive statistics

Variable	Company		
	ADRO	**PGAS**	**POWR**
Mean	2,904,892	1,468,746	668,145
Standard Deviation	518,047	227,826	35,149
Skewness	0.706	0.307	0.339
Kurtosis	2,574	2,219	2,791
Jarque-Bera	50,695	22,939	11,706
Probability	0,000	0,000	0.002

Source: secondary data processed using E-Views (2024)

Based on the statistical description of the description of the research object above, it can be concluded that the stock price data for the companies ADRO, PGAS, and POWR have a relatively low standard deviation from the average and the data tends to be stable when viewed in terms of the coefficient of variation because of the large amount of observation data and the observation period. long. However, when a company has abnormal data distribution, it indicates volatility. So the ARCH GARCH model is needed to analyze problems in the time series data.

Table 2. Stationary Test: *Augmented Dickey Fuller*

ADF	Company Share Price Variables					
	ADRO		**PGAS**		**POWR**	
	t	**Prob**	**t**	**Prob**	**t**	**Prob**
Degree 0 (level)	-1,849	0.356	-1,521	0.521	-2,885	0.047
Degree 1 (1 st difference)	-23,931	0,000	-24,731	0,000	-26,476	0,000

Source: secondary data processed using E-Views (2024)

Based on Table 2 above, ADRO and PGAS share prices are not stationary at degree 0, indicating the existence of a unit root and non-constant data patterns. On the other hand, POWR's share price is stationary at degree 0. In the 1st degree test (1st difference), the share prices of the three companies are significant at the 5% level and stationary, indicating a stable data pattern without a unit root. Therefore, the analysis for POWR will be carried out at degree 1 because it describes the company's return.

Table 3. Volatility Model

Variable	Company Stock Price Variable Volatility Model					
	ADRO		**PGAS**		**POWR**	
	Coef	**Prob**	**Coef**	**Prob**	**Coef**	**Prob**
Constanta (α_0)	167,673	0.002	30,569	0.003	3,016	0,000
RESID(-1) SQR ($\alpha_1 \varepsilon_{t-1}^2$)	0.084	0,000	0.081	0,000	0.080	0,000
GARCH (-1) ($\beta_1 \sigma_{t-1}^2$)	0.889	0,000	0.888	0,000	0.867	0,000
Volatility (σ^2)	**168,646**		**31,538**		**3,963**	

Source: secondary data processed using E-Views (2024)

Based on Table 3, the share price variables for the three companies ADRO, PGAS, and POWR have RESID(-1) SQR and GARCH(-1) values which are significant at the 5% level. This means these three companies has almost the same model , where the patterns of all three are influenced by the ARCH and GARCH phenomena. Where containing the ARCH phenomenon means that the volatility pattern of the three companies is influenced by the square of the residuals from the previous period, while containing the GARCH phenomenon means that the volatility pattern of the three companies is influenced by the squared residuals from the previous period and the variance of the residuals from the previous period. From the volatility calculation results, it can be seen that the three variables have high volatility because they $\sigma^2$are > 1. However, POWR is the variable with the lowest volatility among the three companies observed.

Table 4. Heteroscedasticity Test

Variable	LM-ARCH test		
	F-Stat	**Prob. F**	**Information**
ADRO	0.213	0.644	**Homoscedasticity**
PGAS	0.131	0.717	**Homoscedasticity**
POWR	0.358	0.549	**Homoscedasticity**

Source: secondary data processed using E-Views (2024)

Based on Table 4, the share price variables for the three companies are not significant at the 5% level, meaning that the heteroscedasticity test does not reject H0 that the data has the same residual variance (homosecedasticity). In other words , these three companies do not have symptoms of heteroscedasticity.

DISCUSSION

In the analysis, the ARCH-GARCH model was used to identify the share price volatility patterns of the three companies. Based on the calculation results above, it shows that ADRO, PGAS, and POWR have the ARCH(1) and GARCH(1,1) phenomena, which means that their volatility patterns are influenced by the squared residual of the previous period and the conditional variance of the previous period. ADRO is known to have the highest volatility while POWR has the lowest volatility.

The purpose of this research is to determine the impact of events that occur on the volatility and risk patterns of the three companies, so the discussion is detailed as follows:

a) ADRO : The volatility pattern shows the presence of high variance clusters in certain periods, reflecting high volatility. The highest volatility points occurred on March 8 2022 and January 6 2023. This pattern shows that ADRO is sensitive to market information related to geopolitical conflicts and energy policy, which causes high volatility and large risks.
b) PGAS : The volatility pattern also shows a high variance cluster, with the largest spike on September 7, 2022. The period of high volatility occurred between March 2022 to September 2022, influenced by geopolitical conflicts and energy policy, reflecting high risk.
c) POWR : POWR volatility is the lowest of the three, with high variance clusters in May 2022 and August 2023. This volatility is influenced by the Russian-Ukrainian geopolitical conflict and other events that affect the distribution of energy commodities.

Based on VaR calculations, ADRO, PGAS and POWR have VaR values that increase over the observation period. With a 95% confidence level, the maximum expected loss from investing in ADRO shares in a 558 day period is around 115.7% of the share value. This means that in 95% of the scenarios, the maximum possible loss will not exceed 115.7 % of the total investment value over a 558 day period. On the other hand, there is a 5% chance that the loss experienced could be greater than 115.7 % .

Meanwhile, PGAS with a confidence level of 95%, the maximum expected loss from investing in PGAS shares in a 558 day period is around 87.9% of the share value. This means that in 95% of the scenarios, the maximum possible loss will not exceed 87.9 % of the total investment value over a 558 day period. On the other hand, there is a 5% chance that the loss experienced could be greater than 87.9 % .

Meanwhile, POWR with a confidence level of 95%, the maximum expected loss from investing in POWR shares in a 558 day period is around 46.2% of the share value. This means that in 95% of the scenarios, the maximum possible loss will not exceed 46.2 % of the total investment value over a 558 day period. On the other hand, there is a 5% chance that the losses experienced could be greater than 46.2 % .

CONCLUSION

This research evaluates the impact of geopolitical conflicts and Presidential Decree no. 112 of 2022 concerning renewable energy on stock price volatility in the energy sector. The research object is the daily share prices of PT Adaro Energy Indonesia Tbk (ADRO), PT Perusahaan Gas Negara Tbk (PGAS), and PT Cikarang Listrindo Tbk (POWR), using the ARCH-GARCH model. Based on the analysis that has been carried out previously, several main conclusions can be drawn as follows:

1. The volatility patterns of the three significant companies contain the ARCH(1) and GARCH(1,1) phenomena with a significance level of 5%. This means that the volatility pattern of the three companies is influenced by the squared residual of the previous period and the conditional variance of the previous period.
2. Based on volatility calculations using the ARCH-GARCH model, the ADRO variable has the highest volatility, which means that ADRO has share price uncertainty and therefore has high risk. Meanwhile, the lowest volatility is owned by the POWR variable, meaning that POWR has more stable share price movements compared to ADRO and PGAS so that the risk of POWR shares is lower.
3. Based on volatility graph analysis, the ADRO and PGAS variables are sensitive to events and information circulating in the market because spikes in high volatility occur during times of hot geopolitical conflict and the enactment of Presidential Decree No. 112 of 2022. Meanwhile, POWR does not experience spikes during hot times. information circulating in the community, but actually spikes outside the time the event occurs, so it can be concluded that the POWR share price variable is not sensitive to information circulating in the market.
4. Based on the risk value calculation using the VaR formula, the ADRO variable has a higher risk compared to PGAS and POWR. Meanwhile POWR has the lowest risk value. So ADRO is very popular with *risk seeking investors* , PGAS and POWR are very popular with *risk averse investors* and *risk neutral investors* .

LIMITATIONS

1. The time period observed is too long for *event studies research* , namely looking at the impact of an event on stock price volatility, so that volatility does not appear too volatile. Therefore, for *event studies research* it is recommended to use a shorter

observation period so that you can better see momentum or volatility, the impact of an event.

2. Although the use of the ARCH-GARCH model is effective, it does not cover the possibility that other models such as EGARCH or TGARCH can provide more comprehensive and accurate results .

REFERENCES

Arifin, A. (2004). *Membaca Saham*. Andi.

Bakrie, C. R., Delanova, M. O., & Mochamad Yani, Y. (2022). Pengaruh Perang Rusia Dan Ukraina Terhadap Perekonomian Negara Kawasan Asia Tenggara. *Jurnal Caraka Prabu*, *6*(1), 65–86. https://doi.org/10.36859/jcp.v6i1.1019

Damayanti, E. N., & Kuswanto, H. (2019). *Analisis Risiko Pada Return Saham Perusahaan Asuransi Menggunakan Metode VaR dengan Pendekatan*. *16*(1), 40–50. https://doi.org/10.20956/jmsk.v

Fahmi, I., & Hadi, Y. L. (2009). *Teori Portofolio dan Analisis Investasi: Teori dan Soal Jawab*. Alfabeta.

Gam, T., Nainggolan, N., & Komalig, H. A. H. (2022). Analisis Volatilitas dan Peramalan Inflasi di Maluku Utara Menggunakan Model Generalized Autoregressive Conditional Heteroscedasticity (GARCH). *Jurnal LPPM Bidang Sains Dan Teknologi*, *7*(2), 8–18.

Gu, G. (2023). The Dynamic Interplay of Market Forces and Human Behavior: A Critical Review of Efficient Market Hypothesis and Behavioral Finance. *Advances in Economics, Management and Political Sciences*, *31*(1), 55–60. https://doi.org/10.54254/2754-1169/31/20231498

Gu, Y. (2023). Efficient Market Hypothesis during COVID-19 Pandemic. *Advances in Economics, Management and Political Sciences*, *26*(1), 301–307. https://doi.org/10.54254/2754-1169/26/20230588

Jorion, P. (2007). *Value At Risk The New Benchmark for Managing Financial (3rd ed.)*. McGraw-Hill.

Larasati, M. S., Astuti, T., & Ambarwati, S. (2021). *Determinan volatilitas harga saham*. *1*(2), 73–82.

Octavianus, H. (2021). *Telaah Literatur Efficient Market Hypothesis*. *November*, 417. https://doi.org/10.13140/RG.2.2.17253.93925

Olawale, A. O., Oladude, G. A., Akintunde, M. O., Ojo, T. O., & Amusan, A. S. (2022). *Univariate Analysis of Volatility of Stock Market Returns Using Garch Models . 10*(11).

Pratama, S., & Asnawi, S. K. (2020). *Analisis Pengujian Hipotesis Pasar Efisien Pada Indeks JII , Manufacture , Infrastructure , Mining , Dan Miscellaneous Di Bursa Efek Indonesia (BEI) Periode 2015-2020*. *i*.

Purnama, C. (2023). *Estimasi Risiko Pasar Pada Data Return Kurs Harian Dengan Value At Risk Menggunakan Model – Model Volatilitas GARCH*. *25*(2), 429–444.

Ramayanti, R., Devianto, D., & Alhusna, D. (2023). *Pemodelan ARIMA-GARCH Untuk Volatilias Dan Value At Risk Pada Saham Pt . Gudang Garam Tbk*. *4*(2), 1029–1040.

Rusere, W., & Kaseke, F. (2021). Modeling South African Stock Market Volatility Using Univariate Symmetric and Asymmetric Garch Models. *Indian Journal of Finance and Banking*, *6*(1), 1–16. https://doi.org/10.46281/ijfb.v6i1.1177

Samsiar, & Haryono, S. (2023). Faktor-Faktor Penentu Volatilitas Harga Saham Syariah Dengan Ukuran Perusahaan Sebagai Variabel Moderasi. *Bahtera Inovasi*, *6*(2), 175–186. https://doi.org/10.31629/bi.v6i2.5245

Samsul, M. (2006). *Pasar Modal dan Manajemen Portofolio*. Erlangga.

Santioso, L., & Angesti, Y. G. (2019). *Faktor-Faktor Yang Mempengaruhi Volatilitas Harga Saham Perusahaan Manufaktur*. *XXIV*(01), 46–64.

Sari, L. K., Achsani, N. A., & Sartono, B. (2017). *Pemodelan Volatilitas Return Saham : Studi Kasus Pasar Saham Asia*. *18*(1). https://doi.org/10.21002/jepi.2018.03

Sari, W., & Setiyawan, S. (2023). Volatilitas Saham Sektor Teknologi yang Terdaftar di Indeks Saham Syariah Indonesia pada Masa Pandemi COVID-19. *Jurnal Accounting Information System (AIMS)*, *6*(1), 53–62. https://doi.org/10.32627/aims.v6i1.705

Sumiyati, Arisandi, B. D. A., & Wilujeng, P. R. (2022). *Metode ARCH / GARCH Untuk Memprediksi Hubungan Economic Uncertainty (Covid 19) Dan Volatilitas Saham*. *24*(1), 117–130.

Trimono, Riyantoko, P. A., & Agista, F. (2022). *Model ARMA-GARCH dan Ensemble ARMA- GARCH untuk Prediksi Value-at-Risk pada Portofolio Saham*. *2022*(Senada), 83–91.

Umar, H. (2013). *Metode Penelitian untuk Skripsi dan Tesis* (Rajawali (ed.)).

Wei, W. W. . (2006). *Time Series Analysis: Univariate and Multivariate Methods Second Edition* (2nd ed.). Pearson Prentice Hall.s.

Wellington Garikai Bonga. (2019). *Stock Market Volatility Analysis using GARCH Family Models: Evidence from Zimbabwe Stock Exchange*. *30 May 2019*, 13.

Widarjono, A. (2013). *Ekonometrika. Pengantar dan Aplikasinya. Disertai Panduan Eviews. Edisi keempat*. UPP STIM YKPN.

Zulfikar. (2016). *Pengantar Pasar Modal dengan Pendekatan Statistika* (1st ed.). Gramedia.