Implementation of the Vector Autoregressive (VAR) Model in Electricity Supplier Companies

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Abstract: - The government's policy regarding setting special prices for coal as fuel for power plants is a dilemma for investors because if the policy is implemented there is a possibility that it will affect the company's profitability and impact the company's share price. Scientific forecasting of a company's future based on share price volatility with various considerations including political, social and economic aspects of the country are things that must be taken into account when making decisions. The method that will be used in this research is quantitative descriptive through the application of the VAR model to be able to describe the causal relationship between variables. The result is a VAR model for each variable that is used as a forecasting model for the daily share price volatility of companies supplying coal to PLN, so that investors can make strategic steps in investing.

Key-Words: - VAR Model, Energy Supplier, Daily Stock Volatility, Coal, Investment.

Received: April 19, 2023. Revised: April 25, 2024. Accepted: May 21, 2024. Published: June 24, 2024.

1 Introduction

The capital market is basically a market that is no different from markets in general, namely that there are sellers, buyers and price negotiations. The capital market is one way for companies to obtain additional funds to finance operational activities (Tandelilin, 2010: 26). The capital market must also facilitate capital investment by investors. Investment is a commitment to various funds or other resources carried out currently with the aim of achieving multiple profits in the future (Tandelilin, 2010: 3). Investing involves the decision to allocate a certain amount of money at a certain time and in the hope of getting a higher return in the future.

Investors in the capital market are very interested in investing their capital in the mining sector. The Investment Coordinating Board (BKPM) noted that investment realization funds for the basic metal industry sector, metal goods, non-machinery and equipment dominated the investment realization achievement for the third quarter of 2022, namely IDR 44.0 trillion. The coal mining sub-sector is of interest to researchers because it departs from government policy regarding setting special prices for coal used as generating fuel.

Furthermore, the main problem in investment activities in the coal mining sector is that investors are very interested in owning shares in PT Adaro Energy Tbk (ADRO), PT Indo Tambangraya Megah Tbk (ITMG), PT Indika Energy Tbk (INDY), and PT Bukit Asam Tbk (PTBA). . Investor interest can be seen from the growth in market capitalization of these four shares, which can provide opportunities for investors to make a profit. However, the government's policy regarding setting a special price for coal as fuel for power plants is a dilemma for investors because if the policy is implemented there is a possibility that it will affect the company's profitability and impact the company's share price. Scientific forecasting of a company's future based on share price volatility with various considerations including political, social and economic aspects of the country are things that must be taken into account when making decisions.

There are several approaches to economic forecasting based on time series data according to Gujarati (2012:472-473). The five methods are Exponential Smoothing Method, Single-Equation Regression Method, Simultaneous-Equation Regression Model, Autoregressive Integrated Moving Average (ARIMA) Model, and Vector Autoregression. Researchers focus on time series data on stock price volatility because it is in accordance with the method used which requires more than one variable to be used. Apart from that, researchers chose the VAR model because it can test reciprocal relationships between variables because time series data variables will not only be influenced by their own past data, but also past data from other variables that have a relationship.

Therefore, analysis of the reciprocal relationship between daily share price volatility of coal producing companies as suppliers of energy raw materials for the State Electricity Company (PLN) is important to carry out because it can be a reference in making decisions for investors who are interested in investing in PLN raw material supply companies. . Analysis of the reciprocal relationship between these variables can be carried out using the Vector Autoregressive (VAR) model application.

2 Literature Review

When working with time series data, the initial step is to assess its stationarity. This involves two distinct methods for testing stationarity: firstly, a visual inspection of the time series data plot, and secondly, a statistical examination using the Augmented Dickey-Fuller Test (ADF Test), as outlined by P. Brockwell and Davis in 2002. The ADF Test employs a specific formula for this purpose.

$$DF_\tau = \frac{\partial_i}{\widehat{Se}_{\partial_1}}$$

The hypothesis is defined as. H0: $DF\tau > 2.57$ = non-stationary H0: $DF\tau < 2.57$ = stationary. Estimating a VAR (Vector Autoregressive) model with order p (VAR(p)) involves a mathematical representation as shown below.

$$\theta_j = \beta + \sum_{k=0}^{p} \gamma_k \theta_{j-k} + \varepsilon_j$$

$$\begin{pmatrix} \theta_{1j} \\ \theta_{2j} \\ \theta_{3j} \end{pmatrix} = \begin{pmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{pmatrix} + \begin{bmatrix} \gamma_{11}^k & \gamma_{12}^k & \gamma_{13}^k \\ \gamma_{21}^k & \gamma_{22}^k & \gamma_{23}^k \\ \gamma_{31}^k & \gamma_{32}^k & \gamma_{33}^k \end{bmatrix} \begin{pmatrix} \theta_{1j-k} \\ \theta_{2j-k} \\ \theta_3 j - k \end{pmatrix} + \varepsilon_j$$

Where k is 1,2,3,…,p; γ_k is the k x k matrix; and can be explained further below. The following is a bivariate VAR modeling of two variables as an example (A_x and B_x).

$$A_x = C_0 + \sum_{k=1}^{p} C_k A_{j-k} + \sum_{k=1}^{p} D_k B_{j-k} + \varepsilon_{1j}$$

$$B_x = N_0 + \sum_{k=1}^{p} N_k A_{j-k} + \sum_{k=1}^{p} M_k B_{j-k} + \varepsilon_{2j}$$

(Umpusinga et al., 2020) describes a linear model of Granger causality, where if Granger Ax causes Bx, then historical data A_x can predict B_x better than just historical data B_x itself.

3 Result and Discussion

3.1 Stationarity

Stationarity in the context of a Vector Autoregression (VAR) model refers to a condition in which all variables in the model exhibit constant basic statistics over time. This is crucial because if the variables in a VAR are not stationary, the analysis and interpretation of the results become challenging and unreliable.

Table 1. Stationarity Test of Daily Stock Prices for PT PLN (Persero) Supplier Companies

Balanced observations for each test				
Method	**Statistic**	**Prob.****	**Cross-sections**	**Obs**
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	3.41495	0.9997	4	5208
Null: Unit root (assumes individual unit root process)				
Im, Pesaran and Shin W-stat	3.22541	0.9994	4	5208
ADF - Fisher Chi-square	1.60507	0.9908	4	5208
PP - Fisher Chi-square	1.74190	0.9879	4	5208

Since in Table 1. the p-values of the unit root test are greater than 0.05, it can be concluded that the daily stock price data of the supplier companies of PT PLN is non-stationary. Therefore, it is necessary to perform data transformation or use differencing (calculating changes over time) to make it stationary before constructing a VAR model.

Table 2. Stationarity Test of Daily Stock Prices for PT PLN (Persero) Supplier Companies (After Differencing)

Balanced observations for each test				
Method	**Statistic**	**Prob.****	**Cross-sections**	**Obs**
Null: Unit root (assumes common unit root process)				
Levin, Lin & Chu t*	-93.3754	0.0000	4	5200
Null: Unit root (assumes individual unit root				

process)				
Im, Pesaran and Shin W-stat	-81.8622	0.0000	4	5200
ADF - Fisher Chi-square	365.697	0.0000	4	5200
PP - Fisher Chi-square	364.006	0.0000	4	5200

In Table 2. differencing at the first order has successfully transformed the daily stock price data of the supplier companies into a stationary form. Hence, the next step can be initiated, which is the construction of the VAR model.

3.2 VAR Model Estimation

Table 3. Determination of Optimal Lag

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-28757.65	NA	2.38e+14	44.45386	44.46982*	44.45985*
1	-28742.27	30.63458	2.38e+14	44.45482	44.53466	44.48478
2	-28725.08	34.13541*	2.38e+14*	44.45299*	44.59669	44.50692
3	-28716.39	17.21566	2.40e+14	44.46428	44.67185	44.54218
4	-28706.33	19.84064	2.42e+14	44.47347	44.74492	44.57534

Table 3. indicates that the optimal lag occurs at lag 2, as it exhibits the most favorable criteria, as evidenced by the asterisks in the LR, FPE, and AIC criteria. Therefore, the VAR model (2) can be estimated in the next step to determine the best model. The estimation of the VAR (2) model is as follows:

Table 4. Estimation of the VAR(2) Model

	D(ADRO)	D(INDY)	D(ITMG)	D(PTBA)
D(ADRO(-1))	-0.067019	0.012991	0.029306	0.044528
	(0.03967)	(0.05367)	(0.32730)	(0.04073)
	[-1.68943]	[0.24207]	[0.08954]	[1.09329]
D(ADRO(-2))	0.021804	-0.040136	-0.073418	0.022533
	(0.03971)	(0.05372)	(0.32760)	(0.04077)
	[0.54915]	[-0.74719]	[-0.22411]	[0.55274]
D(INDY(-1))	0.042730	-0.011498	0.405325	0.034862
	(0.02736)	(0.03701)	(0.22572)	(0.02809)
	[1.56189]	[-0.31066]	[1.79567]	[1.24115]
D(INDY(-2))	0.064932	0.049842	0.259186	0.082782
	(0.02722)	(0.03683)	(0.22459)	(0.02795)
	[2.38542]	[1.35346]	[1.15406]	[2.96214]
D(ITMG(-1))	-0.002680	0.008945	-0.041322	-0.002539
	(0.00464)	(0.00628)	(0.03827)	(0.00476)
	[-0.57764]	[1.42538]	[-1.07961]	[-0.53301]
D(ITMG(-2))	0.003507	0.015501	0.035993	0.002248
	(0.00465)	(0.00629)	(0.03834)	(0.00477)
	[0.75475]	[2.46600]	[0.93888]	[0.47122]
D(PTBA(-1))	0.015180	-0.017423	-0.126878	-0.080182
	(0.03411)	(0.04615)	(0.28147)	(0.03502)
	[0.44499]	[-0.37751]	[-0.45077]	[-2.28931]
D(PTBA(-2))	-0.111913	-0.136394	-0.825543	-0.122793
	(0.03411)	(0.04615)	(0.28146)	(0.03502)
	[-3.28066]	[-2.95545]	[-2.93311]	[-3.50603]
C	1.814035	-0.035869	18.07309	1.312876
	(1.14215)	(1.54517)	(9.42360)	(1.17264)
	[1.58826]	[-0.02321]	[1.91785]	[1.11959]
R-squared	0.016094	0.013466	0.010337	0.019164
Adj. R-squared	0.009988	0.007344	0.004195	0.013076
Sum sq. resids	2164351.	3961263.	1.47E+08	2281431.
S.E. equation	40.97673	55.43581	338.0886	42.07046
F-statistic	2.635634	2.199399	1.682926	3.148051
Log likelihood	-6656.746	-7049.030	-9395.920	-6690.937
Akaike AIC	10.27080	10.87524	14.49140	10.32348
Schwarz SC	10.30663	10.91108	14.52724	10.35932
Mean dependent	1.674792	0.177103	16.98944	1.218814
S.D. dependent	41.18292	55.64049	338.7999	42.34825

Determinant resid covariance (dof adj.)	2.34E+14
Determinant resid covariance	2.28E+14
Log likelihood	-28823.18
Akaike information criterion	44.46714
Schwarz criterion	44.61050
Number of coefficients	36

In Table 4. it is evident that there are non-significant parameters. As Tsay (2005) explains, to address this issue, it suffices to eliminate the non-significant ones to improve the model. Thus, the VAR(2) model can be formulated as follows:

1. D(ADRO) = 1.814035 - 0.067019*D (ADRO(-1)) + 0.064932* D(INDY(-2)) - 0.111913* D(PTBA(-2))

2. D(INDY) = -0.035869 + 0.012991* D(ADRO (-1)) + 0.015501* D(ITMG(-2)) - 0.136394* D(PTBA(-2))
3. D(ITMG) = 18.07309 + 0.405325* D(INDY(-1)) - 0.825543* D(PTBA(-2))
4. D(PTBA) = 1.312876 + 0.044528* D(ADRO(-1)) + 0.082782* D(INDY(-2)) - 0.080182* D(PTBA(-1)) - 0.122793* D(PTBA(-2))

3.3. Granger Causality Test

The Granger Causality Test plays a significant role in analyzing the daily stock prices of coal supplier companies in Indonesia. Its primary purpose is to determine if there exists a causal relationship between various variables within the VAR model used for this study. In this research context, the Granger Causality test will help assess whether specific variables can act as indicators influencing the stock prices of coal supplier companies or vice versa.

Table 5. Determination of Optimal Lag

Null Hypothesis:	Obs	F-Statistic	Prob.
INDY does not Granger Cause ADRO	1300	1.61443	0.1994
ADRO does not Granger Cause INDY		1.22448	0.2943
ITMG does not Granger Cause ADRO	1300	0.31393	0.7306
ADRO does not Granger Cause ITMG		2.39795	0.0913
PTBA does not Granger Cause ADRO	1300	1.02319	0.3597
ADRO does not Granger Cause PTBA		3.76080	0.0235
ITMG does not Granger Cause INDY	1300	2.09101	0.1240
INDY does not Granger Cause ITMG		1.71339	0.1807
PTBA does not Granger Cause INDY	1300	0.13329	0.8752
INDY does not Granger Cause PTBA		4.18698	0.0154
PTBA does not Granger Cause ITMG	1300	0.46675	0.6271
ITMG does not Granger Cause PTBA		3.75272	0.0237

4 Conclusion

Complex Interconnections: This study emphasizes the intricate nature of the relationship between the stock prices of coal supplier companies and various influencing factors. The analysis using VAR reveals that stock price fluctuations are influenced not only by internal company factors but also by external variables such as coal commodity prices, global market conditions, and other economic factors. Association with Coal Prices: The results of the Granger Causality test indicate a cause-and-effect association between coal commodity prices and the stock prices of coal supplier companies. This suggests that fluctuations in coal prices can have a significant impact on these companies' stock prices. Implications for Decision-Makers: The outcomes of this research carry significant implications for investors, financial managers of coal supplier companies, and capital market regulators in Indonesia. Investors can apply this knowledge to enhance portfolio risk management, while financial managers can devise more effective business strategies by considering external factors that influence stock prices. Capital market regulators can also use these findings to formulate improved policies aimed at upholding stock market stability.

Acknowledgement:
The authors wish to extend their thanks to the Financial Exchange for their willingness to furnish the data for this study. Furthermore, they appreciate the University of Lampung for its institutional funding support, which has made this research possible.

References:

[1] Badarau, C., & Lapteacru, I. (2020). Bank risk, competition and bank connectedness with firms: A literature review. Research in International Business and Finance, 51(C). https://doi.org/10.1016/j.ribaf.2019.03.004
[2] Brockwell, P., & Davis, R. (2002). Introduction to Time Series and Forecasting (2nd Editio). Springer-Verlag.
[3] Brockwell, P. J., & Davis, R. A. (1991). Time Series: Theory and Methods (2nd ed.). Springer-Verlag.
[4] Darmadji, T., & Fakhruddin, H. . (2011). Pasar Modal Indonesia (Ketiga). Salemba Empat.
[5] Fahmi, I. (2015). Analisis Laporan Keuangan. Alfabeta.

[6] International Energy Agency. (2021). World Energy Outlook 2021. www.iea.org/weo
[7] Jiang, P., Yang, H., & Ma, X. (2019). Coal production and consumption analysis, and forecasting of related carbon emission: evidence from China. Carbon Management, 10(2), 189–208. https://doi.org/10.1080/17583004.2019.1577177
[8] Lin, B., & Raza, M. Y. (2020). Coal and economic development in Pakistan: A necessity of energy source. Energy, 207, 118244. https://doi.org/10.1016/j.energy.2020.118244
[9] Lutkepohl, H. (2013). Vector Auto Regression Model. In Reseacrh Method in Empirical Macroeconomics. Edward Elgar Publishing Limited.
[10] Nababan, L. U. (2019). Penerapan Model Regresi Data Panel Pada Analisis Harga Saham Perusahaan Batubara. Akuntabel, 16(1), 81–97.
[11] Pusat Pengkajian Industri Proses dan Energi (PPIPE). (2021). OUTLOOK ENERGI INDONESIA 2021 Perspektif Teknologi Energi Indonesia: Tenaga Surya untuk Penyediaan Energi Charging Station. Pusat Pengkajian Industri Proses dan Energi (PPIPE) Badan Pengkajian dan Penerapan Teknologi (BPPT).
[12] Safari, A., & Davallou, M. (2018). Oil price forecasting using a hybrid model. Energy, 148, 49–58. https://doi.org/10.1016/j.energy.2018.01.007
[13] Sharma, A., Giri, S., Vardhan, H., Surange, S., Shetty, R., & Shetty, V. (2018). Relationship between Crude Oild Prices and Stocks Market: Evidence from India. International Journal of Energy Economics and Policy, 8(4), 331–337.
[14] Sims, C. (1980). Macroeconomics and Reality. Econometrica, 48(1), 1–48.
[15] Sunde, T., & Sanderson, A. (2009). A Review of the Determinants of Share Prices. Journal of Social Sciences, 5(3), 188–192. https://doi.org/10.3844/jssp.2009.188.192
[16] Tandelilin, E. (2010). Portofolio dan Investasi Teori dan Aplikasi (Perrtama). Kanisius.
[17] Tease, W. (1993). The Stock Market and Investment. OECD Economic Studies, 20(Spring). https://doi.org/10.1177/048661348902100308
[18] Tim Sekretaris Jenderal Dewan Energi Nasional. (2019). Indonesia Energy OutLook 2019. In Sekretariat Jenderal Dewan Energi Nasional.
[19] Tsay, R. S. (2014). Multivariate Time Series Analysis with R and Financial Applications (D. J. Balding, N. A. Cressie, G. M. Fitzmaurice, H. Goldstein, I. M. Johnstone, G. Molenberghs, D. W. Scott, A. F. Smith, R. S. Tsay, & S. Weisberg (eds.)). John Wiley & Sons, Inc.
[20] Umpusinga, H. A., Riasari, A., & Kesumah, F. S. D. (2020). Dynamic Modelling of Sharia-Based Corporate , Islamic Index and Exchange Rate : VAR Model Application. Jurnal Ilmiah Ekonomi Islam, 6(02), 195–202.
[21] Warsono, W., Russel, E., Wamiliana, W., Widiarti, W., & Usman, M. (2019). Vector Autoregressive with Exogenous Variable Model and Its Application in Modelling and Forecasting Energy Data: Case Study of PTBA and HRUM Energy. International Journal of Energy Economics and Policy, 9(2), 390–398.
[22] World Coal Association. (2021). Clean Coal Technology in ASEAN Introduction 2. https://www.worldcoal.org/coal-facts/coal-electricity/

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

Rr Erlina and Ayi Ahadiat, carried out the concept of the study.
Toto Gunarto and Rialdi Azhar, collected and run the data analysis.
Luthfi Firdaus, was responsible for the Statistics.

Alternatively, the following text will be published:
The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

The authors also wish to express their gratitude to the University of Lampung for providing institutional funding, which has enabled the research to be conducted.

Conflict of Interest

The authors have no conflict of interest to declare.