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# Dynamic Modelling of Sharia-Based Corporate, Islamic Index and Exchange Rate: VAR Model Application

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#### Abstract

Indonesia is one of largest users of sharia-based compliant recently which bring into many concerns how the sharia stocks listing in the most valuable sharia stocks index in Indonesia perform and correlate with other variables, particularly exchange rates. The study aims to analysis the causal relationship and to forecast the performances of sharia-based stocks and its Islamic index in Indonesia along with the volatility of exchange rate. Vector Autoregressive (VAR) model is applied as the method to analyse the multivariate time series as it is believed as the suitable model in predicting such time-series data in the scope of multivariate variables. The finding suggests VAR(1) model is the fitted model as such to both analyse its dynamic relationship and forecast the data set for the next 24 weeks. While the prediction shows the JII has an increasing data, both ANTM and EXR are predicted to have a stable volatility. In addition, granger causality defines variables to have effect in its respective variables, and IRF describes the shocks in one variable cause another variable is relatively difficult in reaching its zero condition in short-term period. VAR(1) is then implacated to predict each variable for the upcoming 2 years.

Keywords: Vector Autoregressive Model, Islamic Index, Sharia-Based Compliant, Forecasting

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# 1. INTRODUCTION

Currently sharia market has increased rapidly globally as the report of (Office of Financial Research, 2016) with the asset of global sharia industry has been growing from USD150 billion in 1990s to USD2 trillion in 2015. Financial Services Authority of Indonesia (Otoritas Jasa Keuangan, 2016) stated that the growth of sharia-based market has been significantly improved although the scale is still relatively small compared to conventional-based market.

In Indonesia, National Sharia Board (DSN) is the one who screen the corporates, including stateowned and private owned company, to be considered as sharia-based company (Otoritas Jasa Keuangan, 2016). The screening criteria includes business and financial screening. The letter is that the total interestbased debt for company are not allowed to exceed 45% from the total asset, and its non-halal income is not more than 10% from its revenue.

According to this regulation, PT Aneka Tambang Tbk (code: ANTM) is one of the company that has sharia-based stock that trade in stock Islamic index in Indonesia since 2009 although it had unlisted on 2013 but relisted on 2016 until now. ANTM is a state-owned company that operates in mining as well as other related businesses in Indonesia (PT Aneka Tambang Tbk, 2020). With the current pandemic of Covid-19 crisis, ANTM share price becomes one of stocks based sharia experiencing a drop.

The drop also occurs on Jakarta Islamic Index (JII) as the indexing sharia stocks in Indonesia as well as the depreciation of Indonesian Rupiah (IDR) since the early 2020. Therefore, the decrease phenomena of those encourage us to demonstrate their dynamics behaviour and to forecast them from the past data including data during the pandemic crisis.

To estimate the dynamics model over time, we apply a Vector Autoregressive (VAR) model that is frequently used to examine the variable's behaviours (Al-Hajj et al., 2017; Warsono et al., 2019). Back to 1980 when Sims (1980) introduced for the first time model of VAR to analyse data macroeconomic. As Tsay (2014) argued that the presence of dependency among variables from financial markets and macroeconomic is very obvious and to have more understanding on how they behave dynamically they need to be estimated jointly. Thereby, an empirical study of Sharma et al. (2018) explains that VAR model has a crucial role in playing the advanced techniques of analysis. Warsono et al. (2018) adds the literature for application of VAR in measuring the credit risk data stating that the model is Autoregressive (AR) model extension in which VAR model is more applicable to be used in multivariate model.

#### 2. METHOD AND DATA ANALYSIS

In this study, the data used is the time series data of exchange rate (EXR) IDR/USD, stock prices of PT Aneka Tambang Tbk (ANTM\_SP), and Jakarta Islamic Index (JII\_Index) for the observed horizon of March 2013 to March 2020. The dataset are taken secondarily from yahoo finance website (Yahoo Finance, 2020). The application of VAR model is used to understand the dynamics behaviour among variables in which the stages are as follows (Warsono et al., 2019).

# 2.1. Stationarity Check

Azhar et al. (2020) stated that before running the model for predicted time-series data, it is initially to ensure the dataset stationarity both visually and statistically. To measure visually, it is simply by studying the plotting graphs of variables (Virginia et al., 2018). Statistically, the stationary data can be checked by following the augmented Dickey Fuller test (ADF Test) (Brockwell & Davis, 2002), equated as:

$$DF_{\tau} = \frac{\partial_i}{\widehat{Se}_{\partial_1}} \tag{1}$$

with the hypothesis:

 $H_0$ :  $\partial = 0$  (non stationary)

 $H_1$ :  $\partial > 0$  (stationary)

We reject the null hypothesis if  $DF_{\tau}$  is < -2.57 or p-value is less than 5% (Brockwell & Davis, 2002). Azhar et al. (2020) explained that when dataset are nonstationary, then differencing is required to

transform into stationary, meaning to have the stable mean and variance.

# 2.2. Estimation of VAR Model

The process of VAR model in order p (VAR (p)) can be written mathematically as follows.

$$\theta_{i} = \beta + \sum_{k=0}^{p} \gamma_{k} \theta_{i-k} + \varepsilon_{i}$$
 (2)

Where k is 1,2,3,...p;  $\gamma_k$  is matrix k x k; and hence can be expressed for

$$\begin{pmatrix} \theta_{1j} \\ \theta_{2j} \\ \theta_{3j} \end{pmatrix} = \begin{pmatrix} \beta_{1} \\ \beta_{2} \\ \beta_{3} \end{pmatrix} + \begin{bmatrix} \gamma_{11}^{k} & \gamma_{12}^{k} & \gamma_{13}^{k} \\ \gamma_{21}^{k} & \gamma_{22}^{k} & \gamma_{23}^{k} \\ \gamma_{31}^{k} & \gamma_{32}^{k} & \gamma_{33}^{k} \end{bmatrix} \begin{pmatrix} \theta_{1j-k} \\ \theta_{2j-k} \\ \theta_{3j-k} \end{pmatrix} + \varepsilon_{j}$$
(3)

## 2.3. Granger Causality Test

The following is the bivariate VAR model of two variables  $(A_x \text{ and } B_x)$ .

$$A_{x} = C_{0} + \sum_{k=1}^{p} C_{k} A_{j-k} + \sum_{k=1}^{p} D_{k} B_{j-k} + \varepsilon_{1j}$$
(4)  

$$B_{x} = N_{0} + \sum_{k=1}^{p} N_{k} A_{j-k} + \sum_{k=1}^{p} M_{k} B_{j-k} + \varepsilon_{2j}$$
(5)

Warsono (2018) described linear model of granger causality if  $A_x$  granger causes  $B_x$ , then the  $A_x$  past data can predict the  $B_x$  better than  $B_x$  past alone. The hypothesis of this test can be expressed as.

 $H_0$ : if  $\alpha_j = 0$ , j = 1,2,...,p, then it is granger non-causality where  $A_x$  does not predict  $B_x$ .

 $H_1$ : if  $\alpha_j \neq 0$ , j = 1,2,...,p, then it is granger causality where  $A_x$  does predict  $B_x$ .

### 2.4. Impulse Response Function (IRF)

Lutkepohl (2013) measures shocks or the effects of nonzero residuals can be studied to see relationship between variables. It is because VAR model can interpret the shocks within variables by using the nonzero residuals only if there are some structural restrictions that have been considered accordingly. Tsay (2014) stated that IRF is a function to understand more deeply regarding the effect of alterations among observed variables in analysing multivariate time series. While Warsono et al. (2019) argued that when interpreting  $\delta_i = \frac{\vartheta X_{r+i}}{\vartheta \varepsilon r_i}$ , and having row x and column y as  $\delta_i$  element, it identifies as a one-unit increase of y<sup>th</sup> innovation at time r  $(\varepsilon_{ir})$ affects the xth value at time r+i, holding others constants. Therefore,  $\delta_i = \frac{\vartheta X_{x,r+i}}{\vartheta \varepsilon y_i}$  is the plotting of raw x and column y with r is a function of IRF.

#### 3. RESULTS AND DISCUSSION

## 3.1. Stationary Condition

Prior to conduct the VAR model, the observed data series need to be tested their respective stationarity. To run this test, we examine both visual and statistical test to obtain more valid result. Figure 1 shows the graph of plotting data series of each variable. The graphs visually explain that no data series are stationary as their respective mean and variance are not around zero. On the basis statistical test, we apply the ADF unit-root test in which as shown on Table 1 all three data series have probability value of more than 5% indicating they have a unit-root that is measured as non-stationary data set.

Given the dataset are not stationary in mean, the further step is to transform them into stationary dataset by using differencing method. Table 2 shows the statistical test of ADF with differencing 1 (d=1). After applying d=1, the dataset are stationary in mean since each p-value is less than 0.0001. Therefore, the VAR model then can statistically be run.

#### 3.2. VAR Model Estimation

Determining the optimum lag in VAR model is an initial required test as it can explain the dynamics model more accurately for VAR model. Table 3 measures the optimum lag of 1, as there is a significant AR1 in schematic representation for all variables.

It is then said that the optimum lag of p for VAR model is 1 or VAR(1). Hence, VAR(1) can be equated as follows.

$$\theta_j = \beta + \gamma_k \theta_{j-1} + \varepsilon_j \quad (1)$$

Where

$$\theta_{j} = \begin{bmatrix} EXR_{j} \\ ANTM\_SP_{j} \\ JII\_Index_{j} \end{bmatrix}; \quad \theta_{j-1} = \begin{bmatrix} EXR_{j-1} \\ ANTM\_SP_{j-1} \\ JII\_Index_{j-1} \end{bmatrix} ; \quad \beta = \frac{1}{2} \left[ \frac{EXR_{j-1}}{ANTM\_SP_{j-1}} \right]$$

Constant;  $\gamma_k = 1 \times 1$  matrix parameters of AR1; and  $\varepsilon_j =$  error.

The results of statistical test of VAR(1) is presented on Table 4. On this table, it is shown that the presence of insignificant parameters. As Tsay (2005) explained to address this issue, it is simply by removing those that are not significant to improve the model. AR1\_1\_1, AR1\_1\_2, AR1\_2\_2, AR1\_2\_3, AR1\_1\_3\_1, and AR1\_3\_3 are able to be removed from the model as their p-value is above the critical value of 5%.

Therefore, VAR(1) model can be expressed as follows.

$$\begin{array}{l} \theta_{j} \\ = \begin{bmatrix} 505.54579 \\ 27.18808 \\ 17.76070 \end{bmatrix} \\ + \begin{bmatrix} 0.97895 & 0.00000 & 0.00000 \\ 0.00000 & 0.96551 & 0.00000 \\ 0.00000 & 0.00000 & 0.96164 \end{bmatrix} \theta_{j-1} + \varepsilon_{j} \end{array}$$

The expression can be also equated in three univariate models into:

EXR<sub>j</sub> = 505.54579 + 0.97895EXR<sub>j-1</sub> + 
$$\varepsilon_j$$
 (2)  
ANTM\_SP<sub>j</sub> = 27.18808 + 0.96551ANTM\_SP<sub>j-1</sub> +  $\varepsilon_j$  (3)  
JII\_Index<sub>j</sub> = 17.76070 + 0.96164JII\_Index<sub>j-1</sub> +  $\varepsilon_j$  (4)

Table 5 explains statistically the parameters for model (2), (3), and (4). In association with statistic test for model (2), F-value of 2489.86 with p-value less than 0.05 shows the model is significant with the determined R-squared of 96.63%. For model 3, it shows similar result as F-value of 2323.29 has the significant p-value of less than 0.05 with R-squared determination of 95.02%. Model (4) has also a significant result since F-value with p-value <0.00001 and R-squared of 89.43%. In addition, model (2) regressively explains that exchange rate has a positive effect over itself at lag 1 (j-1); model (3) explains that the sharia price of ANTM positively affects itself at the lag of 1; model (4) explains that the JII\_index has a significant effect on the Islamic index of JII at lag 1.

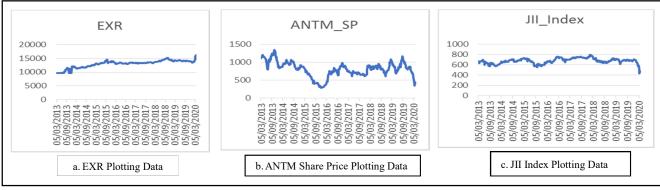


Figure 1. Plotting Data Graph of a) EXR, b) ANTM SP, and c) JII index

# Table 1. ADF Unit-root Test

Table 1. ADF Unit-root Test						
Variable	Type	Rho	Pr < Rho	Tau	Pr < Tau	
EXR	Zero Mean	0.4510	0.7941	1.31	0.9524	
	Single Mean	-6.1883	0.3307	-1.78	0.3884	
	Trend	-21.9981	0.0435	-3.28	0.0707	
ANTM_SP	Zero Mean	-1.4594	0.4006	-1.29	0.1815	
	Single Mean	-10.6334	0.1138	-2.29	0.1772	
	Trend	-11.1182	0.3601	-2.33	0.4157	
JII_Index	Zero Mean	-0.2763	0.6197	-0.68	0.4242	
	Single Mean	-8.0394	0.2132	-1.38	0.5935	
	Trend	-5.5642	0.7769	-0.91	0.9524	

**Table 2.** ADF Unit-root Test after d=1

Variable	Type	Rho	Pr < Rho	Tau	Pr < Tau
EXR	Zero Mean	-336.66	0.0001	-12.86	<.0001
	Single Mean	-342.81	0.0001	-12.97	<.0001
	Trend	-342.84	0.0001	-12.95	<.0001
ANTM_SP	Zero Mean	-341.55	0.0001	-13.00	<.0001
	Single Mean	-343.33	0.0001	-13.01	<.0001
	Trend	-343.32	0.0001	-12.99	<.0001
JII_Index	Zero Mean	-446.62	0.0001	-14.89	<.0001
	Single Mean	-448.10	0.0001	-14.88	<.0001
	Trend	-455.77	0.0001	-14.99	<.0001

 Table 3. Estimation Parameter of Schematic Representation

Variable/Lag	$\boldsymbol{C}$	AR1
EXR	+	+
ANTM_SP		+
JII_Index		.+.
+is > 2*std error, -is < -2*std error	r, .	is between, * is N/A

**Table 4.** Estimation Parameters of Model VAR(1)

Table 4. Estimation I attained by Wilder Ville(1)						
Equation	Parameter	Estimate	Standard	t Value	Pr >  t	Variable
			Error			
EXR	CONST1	505.54579	219.99862	2.30	0.0221	1
	AR1_1_1	0.97895	0.01180	82.98	0.0001	EXR(j-1)
	AR1_1_2	-0.05646	0.07515	-0.75	0.4530	$ANTM_SP(j-1)$
	AR1_1_3	-0.24904	0.25879	-0.96	0.3365	JII_Index(j-1)
ANTM_SP	CONST2	27.18808	42.09905	0.65	0.5188	1
	AR1_2_1	-0.00243	0.00226	-1.08	0.2819	EXR(j-1)
	AR1_2_2	0.96551	0.01438	67.14	0.0001	ANTM_SP(j-1)
	AR1_2_3	0.04497	0.04952	0.91	0.3644	JII_Index(j-1)
JII_Index	CONST3	17.76070	15.47801	1.15	0.2519	1
	AR1_3_1	0.00053	0.00083	0.64	0.5206	EXR(j-1)
	AR1_3_2	0.00078	0.00529	0.15	0.8823	ANTM_SP(j-1)
	AR1_3_3	0.96164	0.01821	52.82	0.0001	JII_Index(j-1)

Table 5. Diagnostics of Univariate Model Anova

Variable	R-Square	Standard	F Value	Pr > F
		Deviation		
EXR	0.9663	245.37398	3489.86	<.0001
ANTM_SP	0.9502	46.95490	2323.29	<.0001
JII Index	0.8943	17.26330	1029.52	<.0001

Table 6. Wald Test of Granger Causality

Test	Group	<b>DF</b>	Chi-Square	Pr > ChiSq
1	Group 1 Variable: EXR	2	2.09	0.1008
	Group 2 Variables: ANTM_SP; JII_Index			
2	Group 1 Variable: ANTM_SP	2	1.58	0.4545
	Group 2 Variables: EXR; JII_Index			
3	Group 1 Variable: JII_Index	2	0.48	0.7851
	Group 2 Variables: EXR; ANTM_SP			

## 3.3. The Test of Granger Causality

Granger causality tests the hypothesis of correlation in which the current value of one variable is only affected by itself and not by other variables' past value. On the words, the test of granger causality for all variables can be hypothesized as follows.

- H<sub>01</sub>: exchange rate is only affected by itself and not by share price of ANTM as well as JII Index.
- H<sub>02</sub>: share price of ANTM is only affected by itself and not by exchange rate as well as JII Index.
- H<sub>03</sub>: JII\_Index is only affected by itself and not by exchange rate as well as share price of ANTM.

Table 6 demonstrates the causal relationship among variables showing that each hypothesis do reject the null hypothesis, since the p-value of chisquare is more than the acceptance value of 5%. These results are in line with what has been displayed on Table 4 which explains that each variable has only an effect over itself and not by other variables.

# 3.4. The Analysis of Impulse Response Function (IRF)

Warsono et al. (2019) stated in his empirical study that IRF is to inform us statistically and economically how shocks in one variable intervene other variables as a result from a constructed VAR model. Figure 2 measures an IRF graph regarding the response of one variable over itself and other variables with the confident interval of two standard errors for the period of 10.

The first group is the responses given a shock occurred in EXR as shown on Figure 2. Figure 2a tells us that a positive response on EXR over itself at the first shock and it tends to reach the equilibrium, which is a stable condition of zero, over the periods. Interestingly, it is predicted that it will go towards its equilibrium if the given period is lengthened but with higher confidence interval. Similarly, the changes in EXR shown on Figure 2b will affect to the share price of sharia-based company of ANTM with an

initial positive response. Going forward, it will reach its zero condition over the periods if the exchange rate keeps changing. It is believed that with the commodity of gold company, ANTM will response positively and/or negatively on the movement of exchange rates. Furthermore on Figure 2c, Islamic Index of JII will response positively in the first hand after shocking in exchange rate, while it remains constant over the given period of 10. On other words, JII seems to be very sensitive to the change of EXR since the shock makes JII is far away from its equilibrium.

The two standard errors movement of ANTM share price shocks as depicted on Figure 3a will lead to EXR response negatively. It is noticed that EXR goes further from the equilibrium over the periods given shock in ANTM share price. Next to Figure 3b, shocking on ANTM share price will lead itself to positive response and tend to reach the equilibrium but with a longer time. In contrast, the shocks on ANTM share price shown on Figure 3c makes JII response negatively on the first time, and it keeps in the negative regions over the horizon, which indicates it needs much times to reach the stable condition of zero.

Furthermore, Figure 4a explains that EXR gives a negative response in the first period given shocks on Islamic Index of JII. However, instead reaching its equilibrium, it goes further for the next ten period with high confidence interval. Contrary, the shock will lead to ANTM share price a positive response initially as depicted on Figure 4b, but it also goes far from the stable condition. Meanwhile on Figure 4c, JII index over itself gives positive response and tries to reach the stable condition although it needs a more lengthened periods.

## 3.5. Forecasting

Figure 5a, 5b and 5c are the graphs of actual and forecasting data plot for each variable with 24-week prediction period. Overall, the predicted lines are fitted well with their respective actual lines, making

them a better prediction model. Figure 5a predicts what will happen in the future of exchange rate given the model of VAR(1). As the exchange rates went significantly in recent weeks due to a shock from external factor which is Pandemic Covid-19, it is predicted that exchange rate of IDR to USD will remain stable approximately IDR16,000 per US\$1 over the next few weeks. Meanwhile, the shock that has been happening since the early year of 2020 makes the significant drops of ANTM share price as depicted on Figure 5b, but the few weeks ahead it will predicted that the decrease will slowly be under control as shown on prediction lines that experiences a constant movement. Islamic Index of JII on the though the Pandemic decreased hand, even significantly from the beginning of 2020 it is forecasted to go up very significantly on the next 24 weeks as shown on Figure 5c with the predicted increase of around 20%.

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#### 5. CONSLUSION

The relationship between the sharia-based company of ANTM and its indexing of JII with another endogenous variable of exchange rate is discussed on this study. From this study, the best fitted model used to describe their relationship is VAR(1) model. This model of VAR(1) is then applicable to forecast the behaviour of respective variable over the next 24 weeks. Prior to conduct the forecast, the model is tested for its univariate models, granger causality and its impulse response function. On the basis of its univariate model, the model is very significant with the probability value less than zero. On the hand, the granger causality explains that each variable only affects itself and not by other variables. In association impulse response, it can be seen that overall the variables do not reach their stable point of zero after a shock in one variable to other variables. Finally, the forecasting models are fitted very well in which the prediction lines are closely matched to their actual data plot, indicating the VAR(1) model is best-fitted model to forecast. The results show that both EXR and ANTM share price are predicted to have stable movement over the prediction horizon, while JII will be predicted to increase significantly for the next six months.

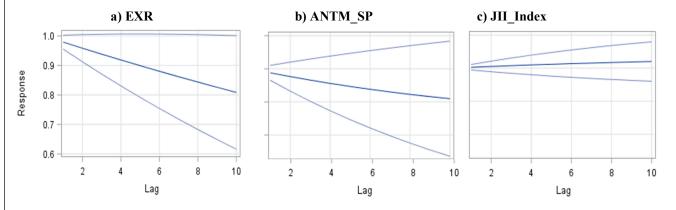
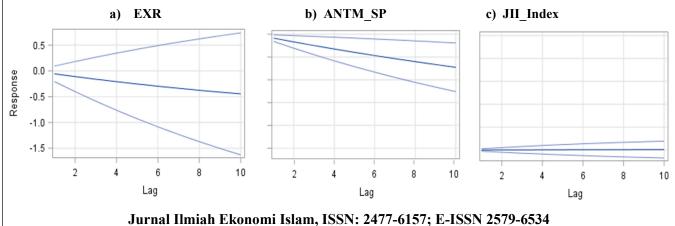


Figure 2. Response to Impulse in EXR with Two Standard Errors

Figure 3. Response to Impulse in ANTM\_SP with Two Standard Errors



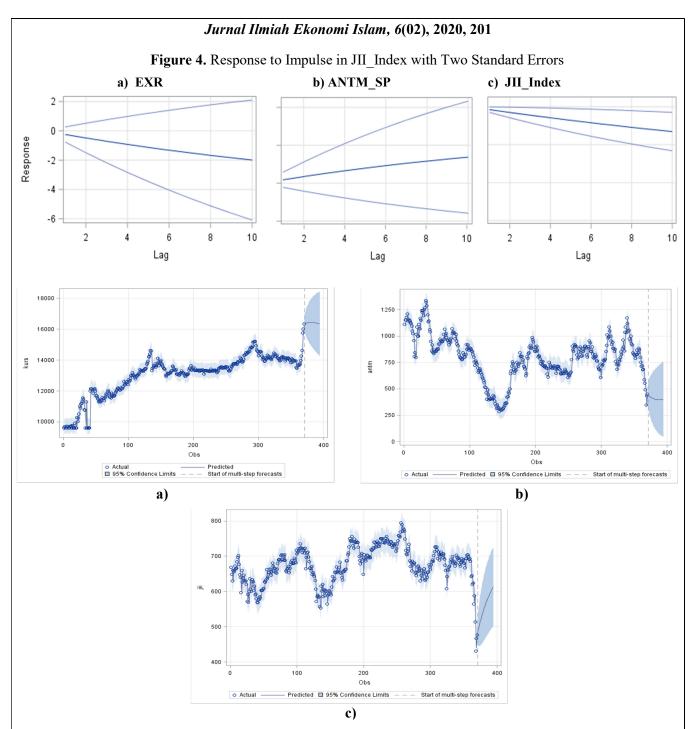


Figure 5. Plotting Graph of Forecasting Dataset of a) EXR; b) ANTM SP; and c) JII Index

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