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# Partial modeling of macroeconomic variables in industrial fields

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**Abstract**. This study modifies Catalbas's (2016) and Pratikto's (2012) research. The analysis used in this study is cross-correlation and analysis of the Vector Autoregression (VAR) method, Vector Autoregression in difference form (VARD) or Vector Error Correction Model (VECM) to test the relationship between variables with the ordinary least square (OLS) method and the causality test to test the relationship (causal relationship) between variables with the Granger Causality (GC) Test. Based on the correlation analysis, it is obtained that exports, imports, and interest rates have a negative and statistically significant relationship at the real level of 5% of the rupiah exchange rate. The model between exports and the rupiah exchange rate is the VAR (2) model. The model between imports and the rupiah exchange rate is a VECM with lag 3, there is 1 cointegration and the deterministic trend used is none intercept no trend. The model between the interest rate and the rupiah exchange rate is a VARD vector model with a lag 1. The model between inflation and the rupiah exchange rate is a VECM with lag 2 and the deterministic trend used is none intercept no trend and there is 1 significant cointegration at the 5% level.

## 1. Introduction

The analysis that needs to be done by investors is economic and capital market analysis, industry analysis, and company analysis. In this study, more focused on economic analysis and capital markets. The economic and capital market analysis aims to make decisions on the allocation of investment funds in several countries or domestically in the form of shares, bonds, or cash. Economic analysis needs to be done by investors reflecting the tendency for a strong relationship between what happens in the macroeconomic environment and the performance of a capital market. If estimating the cash flow, interest, and risk premium of security, it must consider macroeconomic analysis [1]. The environment that influences the company's daily operations is the macroeconomic environment. Investors' ability to

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understand and predict future macroeconomic conditions is very useful when making profitable investment decisions, so investors should be aware of various macroeconomic indicators that can help them understand and predict macroeconomic conditions [1]. One of the macroeconomic indicators in the preparation of the state budget (APBN) is the exchange rate of the rupiah against US $. Rupiah exchange rates are interrelated with other macro indicators. Factors in exports, imports, and inflation affect the exchange rate [2].

One of the studies related to macroeconomic variables can be read in [3]. The study uses multiple linear regression analysis. Based on [3], the consumer price index does not need to be considered in analyzing and estimating both imports and exports. Research on [4] analyzes exports, imports, and inflation of the rupiah exchange rate in Indonesia. The method used in that study is multiple linear regression. It found that export and import variables (net exports) had a negative and significant effect on the rupiah exchange rate variable against the US dollar while the inflation variable was not significant on the rupiah exchange rate variable against the US dollar. Selected macroeconomic variables and food security in Malaysia using VAR have been reaserched on [5].

Macroeconomic namely exchange rate change and inflation have been research on [6]. It research found an inertia effect of price increases in India. Research on macroeconomics is also discussed in [7]. It research found a significant relationship between exports and imports of crude steel and Iran's macroeconomic variables. Research on [8] found simultaneously, the economic growth of Indonesia's Riau Islands Province is affected by exports, imports, and investment.

The concentration of research on macroeconomic variables in Indonesia can be seen in [9]. This study uses the VAR method as its approach, which has impulse response and variance decomposition to obtain variable dynamics. The results of the Augmented Dickey-Fuller and Phillips-Perron root unit tests confirm that all stationary variables are in the level, therefore, the VAR level is the VAR method used. Empirical evidence shows that the effective exchange rate is significantly important in explaining export, import, and inflation movements. On [10], 1998: 1 - 2015: 3 for the period of nominal exchange rates in Turkey, has examined the relationship between imports and exports using quarterly data on the VAR model. Data were analyzed using variance decomposition, Granger Causality, and impulse response analysis. Causality According to the Granger test, there is a one-way relationship between imports and exports. There is no causal relationship between the nominal exchange rate and exports and imports. Details of the variance and impulse response analysis also confirm the results of the Granger causality analysis. These results indicate that the exchange rate does not have a significant effect on exports, imports, and the trade balance, and measures to limit imports will harm exports.

This research is a modification of [9] and [10] research, which is to combine, add variables and methods, partially model, and add correlation methods. The analysis used in this research is cross-correlation and Vector Autoregression (VAR), Vector Autoregression in difference form (VARD) or Vector Error Correction Model (VECM) to test the relationship between variables with the ordinary least square (OLS) method, and the causality test to test the relationship (causal relationship) between variables with the Granger Causality Test. This form of restricted access VAR is called VECM [11]. Macroeconomic variables used in this study are total export, import, inflation, interest rates, and rupiah exchange rate. Thus, this study model the Total Value of Exports, Imports, Inflation, and Interest Rates on the Rupiah Exchange Rate.

## 2. Research methods

In the research, there are five variables, namely: Amount of Export Value, Import, Level Inflation, Interest Rates, and Rupiah Exchange Rate. The data used are monthly data from January 2009 to December 2019. Types and sources of data are secondary data is data sourced from the publication of the official website of Bank Indonesia (BI) and the Central Statistics Agency (BPS).

The study approach in this study uses statistical testing using EViews software. The general steps taken are

1. Explore monthly data by looking at movements in the value of exports, imports, inflation rates, interest rates, and the rupiah exchange rate over a predetermined period.

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2. Analyzing Cross-Correlation, by calculating the cross-correlation coefficient $\rho(X_t, Y_t)$ between two variables.
3. Check the stationary data in the mean of each variable via Augmented Dickey-Fuller (ADF) in the unit root test within the confirmation test framework.
4. Determination of the candidate lag can be done by looking at the lag that has the value of Akaike Information Criterion (AIC) or Schwarz Information Criterion (SC). Optimal lag in the VAR system is chosen with the Adj value. Highest R-Squared.
5. Conduct Granger causality (GC) tests on export, import, inflation, and interest rates variables against the rupiah exchange rate.
6. If the data is stationary, the model is VAR with the order p (VAR(p)). If the data is not stationary, Johansen's cointegration test. If cointegration rank $(r) = 0$, then use the VAR model indifference with the order p (VARD(p)). But if $r > 0$, then the model used is the VECM order p rank r.
7. Estimation of parameters in the VAR (p), VARD (p), or VECM models using EViews.
8. The model diagnostic test carried out to ensure the model obtained meets the assumptions and is appropriate to use.
9. At this stage, data predictions are made using monthly data in the past 2019.
10. Evaluation of forecasting by taking into account the relative errors produced with a tolerance limit of 5%.
11. Impulse Response Function (IRF) analysis and Forecast Error Decomposition Variance (FEDV) for models that meet the classical assumptions on both systems.

The flow of research can be described as follows.

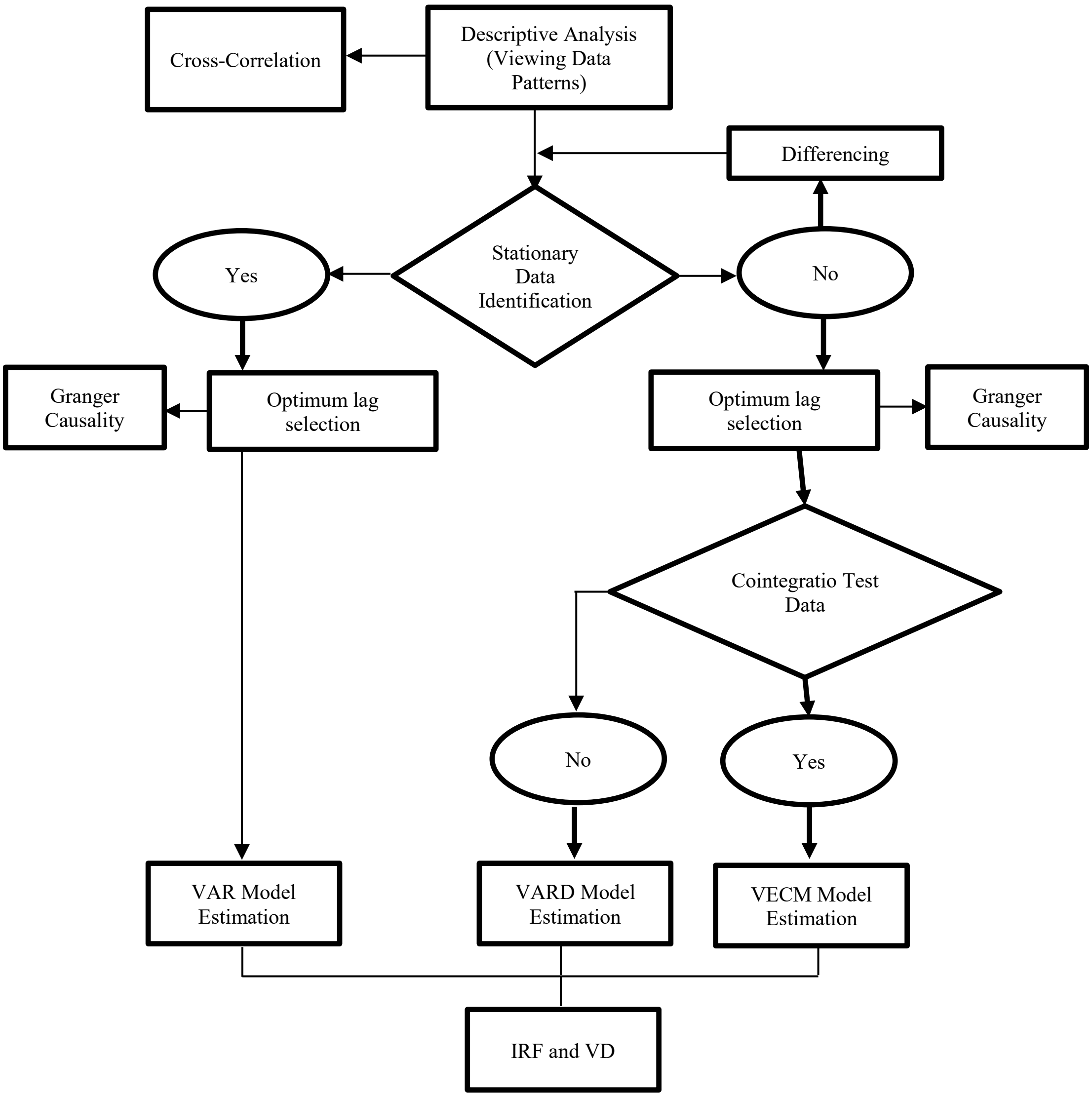


**Figure 1.** Research Flow.

## 3. Result and Discussion

### *3.1. Cross-Correlation*

The correlation in this study is the Pearson Correlation. The correlations in this study are shown in Table 1.

**Table 1.** Cross-Correlation.

| Export ↔ exchange rate | Import ↔ exchange rate | Inflation ↔ exchange rate | Interest rate ↔ exchange rate |
|---|---|---|---|
| -0.1881* (0.03081) | 0.01102 (0.9002) | -0.2349* (0.006709) | -0.2115* (0.01492) |

*significant at 5% level

Based on Table 1, it can be found that exports, imports, and interest rates are negatively related to the rupiah exchange rate at the 5% level.

### *3.2. Data stasionerity*

Non-stationary data is included in the time series data problem. The data requires special treatment to be applied in time series analysis. This is due to the potential for false regression results [13]. ADF test is used to test stationary data or not. Stationary data test results at a level with a real level of 5% are shown in Table 2.

**Table 2.** Stationary data test results at a level with a real level of 5%.

| Variable | t-Statistic | MacKinnon critical point 5% level | Prob. | Result |
|---|---|---|---|---|
| Import | -2.507625 | -3.448021 | 0.3241 | Non-stationary |
| Export | -3.948239 | -3.444756 | 0.0128 | Stationary |
| Rupiah Exchange Rate | -4.196178 | -3.444756 | 0.0060 | Stationary |
| Inflation | -2.853632 | -3.445030 | 0.1813 | Non-stationary |
| Interest Rate | -2.189573 | -3.445030 | 0.4910 | Non-stationary |

Based on Table 2, it is found that the export variables and the rupiah exchange rate are stationary at 5% level. Stationary data test results at the first difference with a real level of 5% are shown in Table 3.

**Table 3.** Stationary data at the first difference with a real level of 5%.

| Variable | t-Statistic | MacKinnon critical point 5% level | Prob. | Result |
|---|---|---|---|---|
| Import | -2.443620 | -3.448021 | 0.3555 | Non-stationary |
| Export | -11.86077 | -3.445030 | 0.0000 | Stationary |
| Rupiah Exchange Rate | -8.789074 | -3.444756 | 0.0000 | Stationary |
| Inflation | -7.901848 | -3.445030 | 0.0000 | Stationary |
| Interest Rate | -7.061221 | -3.444756 | 0.0000 | Stationary |

Table 2 shows that the variables of exports, Rupiah exchange rate, inflation, and stationary interest rates at the first difference with a real level of 5%. Stationary data test results at the second difference with a real level of 5% are shown in Table 4.

**Table 4.** Stationary data test results at the second difference with a real level of 5%.

| Variable | t-Statistic | MacKinnon critical point 5% level | Prob. | Result |
|---|---|---|---|---|
| Import | -6.864874 | -3.448681 | 0.0000 | Stationary |
| Export | -7.114187 | -3.448021 | 0.0000 | Stationary |
| Rupiah Exchange Rate | -14.27714 | -3.445308 | 0.0000 | Stationary |
| Inflation | -8.844436 | -3.446168 | 0.0000 | Stationary |
| Interest Rate | -17.44473 | -3.445030 | 0.0000 | Stationary |

Based on Table 4 it is found that, all stationary variables at the second difference with a real level of 5%. After seeing the stationary data, the next step is determining the optimum lag.

### *3.3. Optimum lag*

Determination of optimum lag through lag that has the value of AIC or SC. Optimal lag in the VAR system is also chosen with a model that meets all assumptions and lag that has Adj value. Highest R-Squared. The optimal lag for each model is shown in Table 5. After determining the optimal lag, cointegration testing is then determined.

**Table 5.** Optimal lag.

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| Model | Lag |
|---|---|
| Exports and Rupiah Exchange Rate | 2 |
| Import and Rupiah Exchange Rate | 3 |
| Interest Rates and Rupiah Exchange Rate | 1 |
| Inflation and Rupiah Exchange Rate | 2 |

### *3.4. Cointegration test*

Cointegration testing is carried out for all models except export models and the rupiah exchange rate. Cointegration test results are performed with the largest adj R-square model value and the VAR, VARD, or VECM models meet the assumption that errors are normal, errors do not have autocorrelation and errors are homogeneous. The cointegration test for the model is shown in Table 6.

**Table 6.** Cointegration test.

| Model | Trend deterministic | Number of cointegration |
|---|---|---|
| Import and Rupiah Exchange Rate | None intercept no trend | 1* |
| Interest rate and Rupiah Exchange Rate | - | No |
| Inflation and Rupiah Exchange Rate | None intercept no trend | 1* |

* significant at 5% level

Based on Table 6, it is obtained that the import model and the rupiah exchange rate and the inflation and rupiah exchange rate models use the VECM model, while the interest rate and rupiah exchange rate use the VARD model.

### *3.5. Export models and exchange exchange*

The model between exports and the rupiah exchange rate is the VAR (2) model. The autoregressive vector model between exports and the rupiah exchange rate has 2 models: the first model is the exchange rate as the dependent variable and the second model is export as the dependent variable. Based on Breusch-Pagan-Godfrey, it was found that both models have homogeneous residuals at the 5% significance level. Based on the Breusch-Godfrey Serial Correlation LM Test, it was found that both models did not have autocorrelation in the error at the 5% significance level. As well as using the central limit proposition, it is found that the residuals approach the normal distribution.

The VAR model between exports and the rupiah exchange rate is as follows:

$$\text{exchange rate}_t = -0.841198 + 1.249865 \text{ exchange rate}_{t-1} - 0.247587 \text{ exchange rate}_{t-2} - 0.007795 \text{ export}_{t-1} + 0.042957 \text{ export}_{t-2} + v_{1t} \quad (1)$$

$$\text{export}_t = 5.491093 + 0.276099 \text{ export}_{t-1} + 0.521740 \text{ export}_{t-2} + 0.226299 \text{ exchange rate} -0.307998 \text{ exchange rate}_{t-2} + v_{2t} \quad (2)$$

The coefficient and significance of the autoregressive vector (VAR) model with the exchange rate as the dependent variable are shown in Table 7.

**Table 7.** Model (VAR) with the exchange rate as the dependent variable.

| Variable | Coefficient |
|---|---|
| A constant | −0.841198* |
| exchange rate(−1) | 1.249865* |
| exchange rate(−2) | −0.247587* |
| export(−1) | −0.007795 |
| export(−2) | 0.042957* |

* significant at the 5% level

Table 7 reveals that the exchange rate variable in the first slowdown depends positively on the exchange rate and is statistically significant at the 5% level of 1.249865. The second level exchange rate variable has a negative relationship with the exchange rate and is statistically significant at the level of -0.247587. The export variable in the second lag has a positive relationship with the exchange rate at the 5% level of 0.042957. The coefficient and significance of the autoregressive vector (VAR) model with exports as the dependent variable are shown in Table 8.

**Table 8.** Autoregressive vector model (VAR) with export as the dependent variable.

| Variable | Coefficient |
|---|---|
| A constant | 5.491093* |
| export(−1) | 0.276099* |
| export(−2) | 0.521740 |
| exchange rate(−1) | 0.226299 |
| exchange rate(−2) | -0.307998* |

* statistically significant at the 5% level

Based on Table 8, it was found that the export variable in the first lag had a positive effect on exports at the 5% level of 0.276099. The exchange rate variable in the second lag has a negative relationship to exports and is statistically significant at the 5% level of -0.307998. The forecasting model for forecasting exports is shown in Table 9.

**Table 9.** Forecasting models for forecasting exports.

| Month | Forecast value | Exact value | Relative Error |
|---|---|---|---|
| January 2020 | 23.32249 | 23.33569 | 0.06% |
| February 2020 | 23.32209 | 23.36666373 | 0.19% |
| March 2020 | 23.32169 | 23.36716144 | 0.19% |
| April 2020 | 23.32131 | 23.22167262 | 0.43% |
| May 2020 | 23.32093 | 23.07785497 | 1.05% |

Based on Table 9, forecasting using a research model shows that each month the relative error is less than 5% as a tolerance limit. Thus, this research model is said to be good for forecasting exports if it uses past data from exports and the rupiah exchange rate. The forecasting model for forecasting exchange rates is shown in Table 10.

**Table 10.** Forecasting models to forecast exchange rates.

| Month | Forecast value | Exact value | Relative Error |
|---|---|---|---|
| January 2020 | 9.511059 | 9.527501 | 0.17% |
| February 2020 | 9.511821 | 9.530694 | 0.20% |
| March 2020 | 9.512565 | 9.628693 | 1.21% |
| April 2020 | 9.513293 | 9.672024 | 1.64% |
| May 2020 | 9.514004 | 9.609532 | 0.99% |

Based on Table 10, forecasting using the research model shows that each month of the error is relatively less than 5% as a tolerance limit. Thus, this research model is said to be good for forecasting the exchange rate if using past data from exports and the exchange rate.

The contribution of each variable to the shock it causes to the main endogenous variables observed is explained by forecasting error variance decomposition (FEVD). The proportion of other variables to explain the variability of the main endogenous variables of the study [12]. The Variance Decomposition of the VAR model (2) is shown in Table 11 and Table 12. The period in projecting this FEVD is 48 months (Four years).

**Table 11.** Variance Decomposition of export.

| Period | Export | Rupiah Exchange Rate |
|---|---|---|
| 1 | 100.0000 | 0.000000 |
| 2 | 99.77225 | 0.227748 |
| 3 | 99.82406 | 0.175943 |
| 4 | 99.83057 | 0.169430 |
| 5 | 99.83245 | 0.167548 |
| 6 | 99.80969 | 0.190309 |
| ⋮ | ⋮ | ⋮ |
| 48 | 85.41715 | 14.58285 |

Based on Table 11, an important source of export variation is shocking from exports themselves, while shocks from exchange rates are relatively small. In the first month of the shock, 100% of the export variation was contributed by the export itself. In the second month, 99.77% of export prediction value variations were contributed by exports and only 0.23% of export prediction value variations were explained by the exchange rate. And so on, in the 48th month of shocks, 85.41% of the variation in the predicted value of exports was contributed by exports and 14.58% of the variation in the prediction value of exports was explained by the exchange rate. The illustration for FEVD export from VAR (2) mode is shown in Figure 2.

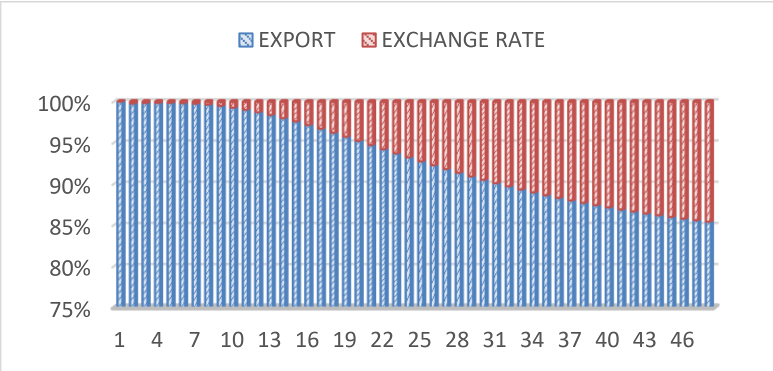


**Figure 2.** FEVD Export.

**Table 12.** Variance Decomposition of Rupiah Exchange Rate.

| Period | Export | Rupiah Exchange Rate |
|---|---|---|
| 1 | 1.190591 | 98.80941 |
| 2 | 0.866074 | 99.13393 |
| 3 | 2.369822 | 97.63018 |
| 4 | 3.763384 | 96.23662 |
| 5 | 5.721380 | 94.27862 |
| 6 | 7.647119 | 92.35288 |
| ⋮ | ⋮ | ⋮ |
| 48 | 39.53161 | 60.46839 |

Based on Table 12, an important source of exchange rate variations is shocking from the exchange rate itself, while shocks from exports are relatively small. In the first month of the shock, variations in the predicted exchange rate of 98.81% were contributed by the exchange rate and only 1.19% of the variation in the predicted exchange rate was explained by exports. In the second month of the shock, variations in the predicted exchange rate of 99.13% were contributed by the exchange rate and only 0.87% of the variation in the predicted exchange rate was explained by exports. And so on, in the 48th month of shocks, variations in the predicted exchange rate 60.46839% were contributed by the exchange rate, and 39.53161% variation in the predicted exchange rate was explained by exports. The illustration for the FEVD exchange rate from VAR mode (2) is shown in Figure 3.

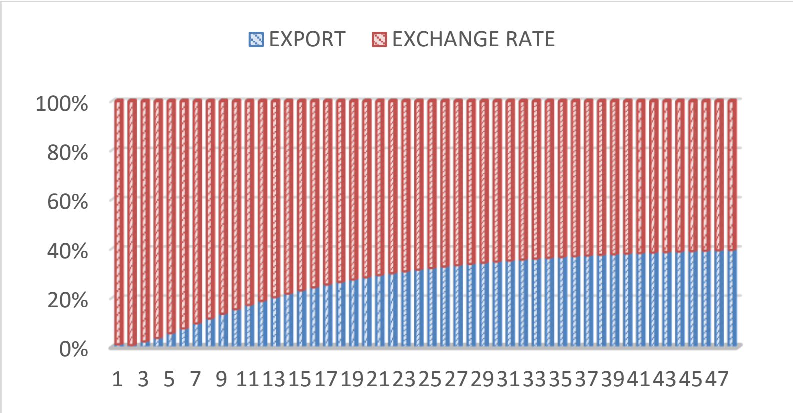


**Figure 3.** FEVD Exchange Rate.

The IRF for this model is shown in Figure 4. The duration of the IRF used for this study is the next 48 months (four years).

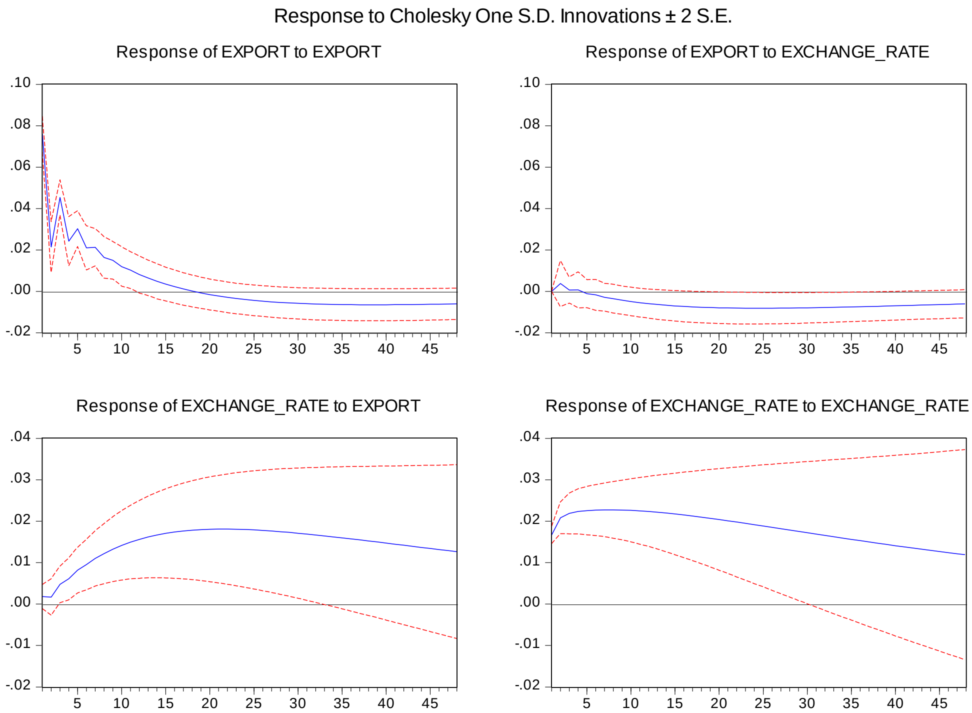


**Figure 4.** IRF for the model.

Figure 4 shows that an export shock of one standard deviation in the first month will cause an increase in exports of 7.5978 percent. Until the 18th month, export shocks were positively responded by exports themselves, even though the response was increasingly reduced. For example, in the 18th month, exports increased by only 0.0108 percent. But in the 19th month, shocks to exports caused exports to decrease by 0.0783 percent. From the 19th to the next 48 months, exports respond negatively to export shocks, and the longer these shocks cause exports to decrease in ever greater amounts. For example, in the 36th

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month, the shock caused a decline in exports of 0.6461 percent. In the 48th month, the shock caused a decline in exports of 0.6075 percent.

Based on Figure 4, it is obtained that the exchange rate shocks of one standard deviation have not been responded to by exports in the first month. In the second, third, and fourth month, the shocks were responded positively by exports respectively by 0.3771 percent, 0.0622 percent, and 0.0675 percent. However, in the fifth month, exchange rate shocks were responded negatively by exports, which was marked by a decline in exports of 0.1171 percent. The decline in exports increased in the long run until the 25th month. Starting from the 26th month to the 48th month, exports increased compared to the previous period. In the 48th month, the shock caused a decline in exports of 0.6073 percent.

Based on Figure 4, it was found that export shocks of one standard deviation in the first month responded positively by the exchange rate of 0.1829 percent. However, starting from the second month, export shocks responded positively by the exchange rate, which was marked by an increase in the exchange rate of 0.1694 percent. The increase in exchange rates continued to increase in the long run until the 22nd month. In the 23rd month, export shocks responded positively by the exchange rate marked by an increase in the exchange rate of 1.8047 percent. Starting in the 23rd month, the exchange rate decreased until the 48th period. Starting in the 47th month, the exchange rate responded positively to export shocks at around 1.2 percent.

Figure 4 shows that an exchange rate shock of one standard deviation in the first month will cause an exchange rate increase of 1.6664 percent. From the second month to the 21st month, the exchange rate responded positively to exchange rate shocks in the range of 1.2 percent. Starting in the 22nd month, the decline in the exchange rate will increase in the long run. Until its long-term period, the exchange rate responded positively to exchange rate shocks in the range of 1.1 percent. The GC test for exchange rates and exports is shown in Table 13.

**Table 13.** GC test for exchange rates and exports.

| $H_0$ | F-Statistic | Prob. |
|---|---|---|
| Rupiah Exchange Rate does not Granger cause export | 2.47990 | 0.0879 |
| Export does not Granger cause Rupiah Exchange Rate | 9.17974 | 0.0002 |

Based on Table 13, the value of exports has a significant effect on the rupiah exchange rate at a significant level of 5%. Meanwhile, the rupiah exchange rate does not significantly influence the value of exports. Therefore, there is no two-way causality between the rupiah exchange rate and the export value.

### *3.6. Model of import and Rupiah exchange rate*

The model between imports and the rupiah exchange rate is a VECM with lag 3, the deterministic trend used is none intercept no trend and there is 1 significant cointegration at the 5% level. The VECM model between imports and the rupiah exchange rate has 2 models: the first model is the exchange rate as the dependent variable and the second model is the import as the dependent variable. Based on Breusch-Pagan-Godfrey, it is found that only the model with imports as the dependent variable has a homogeneous residual at a real level of 5%. Based on the Breusch-Godfrey Serial Correlation LM Test, it was found that the model with import as the dependent variable contained no autocorrelation in the error at the 5% significance level. As well as using the central limit proposition, it is found that the residuals approach the normal distribution. Thus, the model with import as the dependent variable is said to be good.

Estimated VECM with import as target variable are as follows:

$$\begin{aligned}\Delta\text{import}_t = &-0.045767\text{ect}_{t-1} + 0.055499\Delta\text{exchange rate}_{t-1} - 0.497272\Delta\text{exchange rate}_{t-2} \\ &+ 0.169064\Delta\text{exchange rate}_{t-3} - 0.668844\Delta\text{import}_{t-1} \\ &- 0.454356\Delta\text{import}_{t-2} - 0.157471\Delta\text{import}_{t-3}\end{aligned} \tag{3}$$

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The import VECM estimation results that show the relationship of short-term variables are shown in Table 14.

**Table 14.** Import VECM estimation results showing short-term variable relationships.

| Variable | Coefficient |
|---|---|
| CointEq1 | −0.045767* |
| D(Exchange Rate(-1)) | 0.055499 |
| D(Exchange Rate (-2)) | −0.497272 |
| D(Exchange Rate (-3)) | 0.169064 |
| D(Import(-1)) | −0.668844* |
| D(Import(-2)) | −0.454356* |
| D(Import(-3)) | −0.157471 |

* statistically significant at 5% level

Based on Table 14, it is found that in the short run, the statistically significant variable at the 5% level of import is the import in the first lag and imports in the second lag. Cointegration of errors that are statistically significant at 5% significance level and has a negative value indicates that there is an adjustment mechanism from the short term to the long term.

The cointegrating equation (long-run model) is as follows:

$$ect_{t-1} = 1.000000exchange\ rate_{t-1} + 4.046333import_{t-1} - 103.7762 \qquad (4)$$

The import VECM estimation results that show the long-term relationship of variables are shown in Table 15.

**Table 15.** Import VECM estimation results showing long-term variable relationships.

| Variable | Coefficient |
|---|---|
| C | −103.7762* |
| Exchange Rate(-1) | 1.000000 |
| Import(-1) | 4.046333* |

* statistically significant at 5% level

Based on Table 15, it was found that imports in the previous month had a positive and statistically significant effect at the real level of 5%, ie when there was an increase of one percent in the previous month's imports, it would increase imports this month by 4.046333 percent. The forecasting of this VECM model is shown in Table 16.

**Table 16.** Forecasting of the VECM model.

| Month | Forecast value | Exact value | Relative Error |
|---|---|---|---|
| January 2020 | 23.41836 | 23.38133 | 0.16% |
| February 2020 | 23.41837 | 23.16978676 | 1.07% |
| March 2020 | 23.41837 | 23.314947 | 0.44% |
| April 2020 | 23.41837 | 23.25180652 | 0.72% |
| May 2020 | 23.41838 | 22.85649693 | 2.46% |

Based on Table 16, forecasting using the VECM model shows that the relative error in each month is less than 5%. Thus, the VECM model is said to be good for forecasting imports. The GC test for exchange rates and imports is shown in Table 17.

**Table 17.** GC test for exchange rates and imports.

| $H_0$ | F-statistic | Prob. |
|---|---|---|
| D(Exchange Rate,2) does not Granger cause D(Import,2) | 0.46580 | 0.7067 |

| | | |
|---|---|---|
| D(Import,2) does not Granger cause D(Exchange Rate,2) | 1.59690 | 0.1937 |

Based on Table 17, the rupiah exchange rate does not significantly influence imports and imports do not significantly influence the exchange rate. Therefore, there is no two-way causality relationship between the rupiah exchange rate and imports.

### *3.7. Models for interest rate and exchange exchange*

The model between the interest rate and the rupiah exchange rate is VARD with a lag 1. The VARD model between the interest rate and the rupiah exchange rate has 2 models: the first model is the exchange rate as the dependent variable and the second model is the interest rate as the dependent variable. Based on Breusch-Pagan-Godfrey, it is found that only the model with interest rates as the dependent variable has a homogeneous residual at a real level of 5%. Based on the Breusch-Godfrey Serial Correlation LM Test, it was found that the model with interest rates as the dependent variable had no autocorrelation in the error at the 5% significance level. And based on the central limit theorem it is found that the residuals approach the normal distribution. Thus, a model with an interest rate as the dependent variable is said to be good.

VARD between the interest rate and the rupiah exchange rate with the interest rate as the dependent variable is as follows:

$$D(\text{interest rate})_t = -0.000140 + 0.440618\ \mathrm{D}(\text{interest rate})_{t-1} + 0.009382\ D(\text{exchange rate})_{t-1} + v_{6t} \tag{5}$$

The coefficient and significance of the VARD with the interest rate as the dependent variable are shown in Table 18.

**Table 18.** Coefficients and significance of the VARD model with interest rates as the dependent variable.

| Variable | Coefficient |
|---|---|
| A constant | -0.000140 |
| D(interest rate(-1)) | 0.009382* |
| D(exchange rate(-1)) | 0.440618 |

*statistically significant at the 5% level

Based on Table 18, it was found that the previous interest rate variable had a positive relationship with current interest rates and was statistically significant at the 5% level of 0.009382. The forecasting model for interest rates is shown in Table 19.

**Table 19.** Forecasting model for interest rates.

| Month | Forecast value | Exact value | Relative Error |
|---|---|---|---|
| January 2020 | 0.0498620 | 0.05 | 0.28% |
| February 2020 | 0.0496344 | 0.0475 | 4.49% |
| March 2020 | 0.0494068 | 0.045 | 9.79% |
| April 2020 | 0.0491791 | 0.045 | 9.29% |
| May 2020 | 0.0489515 | 0.045 | 8.78% |

Based on Table 19, forecasting using the VARD (1) model shows that the first two months of the error are relatively less than 5% as the tolerance limit, while the following months the relative error is more than 5%. Thus, the VARD (1) model is said to be not good for predicting interest rates if it uses past data from interest rates and the rupiah exchange rate. The GC test for exchange rates and interest rates is shown in Table 20.

**Table 20.** GC test for exchange rates and interest rates.

| $H_0$ | F-Statistic | Prob. |
|---|---|---|
| D(Exchange Rate) does not Granger Cause D(Interest Rate) | 1.49866 | 0.2231 |

| | | |
|---|---|---|
| D(Interest Rate) does not Granger Cause D(Exchange Rate) | 16.5065 | 8.E-05 |

Based on Table 20, the interest rate has a significant effect on the rupiah exchange rate at a significant level of 5%. Meanwhile, the rupiah exchange rate has no significant effect on interest rates. Therefore, there is no two-way causality between the rupiah exchange rate and the interest rate.

### *3.8. Models of inflation and Rupiah exchange rate*

The model between inflation and the rupiah exchange rate is a VECM with lag 2, the deterministic trend used is none intercept no trend and there is 1 significant cointegration at the 5% level. The VECM model between inflation and the rupiah exchange rate has 2 models: the first model is the exchange rate as the dependent variable and the second model is inflation as the dependent variable. Based on Breusch-Pagan-Godfrey, it is found that only the model with inflation as the dependent variable has a homogeneous residual at a real level of 5%. Based on the Breusch-Godfrey Serial Correlation LM Test, it was found that the model with inflation as the dependent variable did not have autocorrelation in the error at the 5% significance level. As well as using the central limit proposition, it is found that the residuals approach the normal distribution. Thus, the model with inflation as the dependent variable is said to be good.

Estimated VECM with inflation as the target variable is as follows:

$$\begin{aligned}\Delta\text{inflation}_t = &-0.006317\text{ect}_{t-1} + 0.062503\Delta\text{exchange rate}_{t-1} + 0.059444\Delta\text{exchange rate}_{t-2} \\ &+ 0.381347\Delta\text{inflation}_{t-1} - 0.186312\Delta\text{inflation}_{t-2}\end{aligned} \tag{6}$$

The cointegrating equation (long-run model) is as follows:

$$ect_{t-1} = 1.000000\text{exchange rate}_{t-1} + 19.62497\text{inflation}_{t-1} - 10.18340 \tag{7}$$

The results of the inflation VECM estimation that show the short-term variable relationship are shown in Table 21.

**Table 21.** VECM estimation results for the short-run variable relationship.

| Variable | Coefficient |
|---|---|
| CointEq1 | $-0.006317^*$ |
| D(Exchange Rate(-1)) | $0.062503^*$ |
| D(Exchange Rate (-2)) | $0.059444^*$ |
| D(Inflation(-1)) | $0.381347^*$ |
| D(Inflation(-2)) | $-0.186312^*$ |

* statistically significant at the 5% level

Based on Table 21, it is found that in the short run, all variables are statistically significant at the 5% level of inflation. Cointegration of errors that are statistically significant at 5% significance level and has a negative value indicates that there is an adjustment mechanism from the short term to the long term. The forecasting of the VECM model for predicting inflation is shown in Table 22.

**Table 22.** Forecasting the VECM model for predicting inflation.

| Month | Forecast value | Exact value | Relative Error |
|---|---|---|---|
| January 2020 | 0.041223 | 0.0268 | 53.82% |
| February 2020 | 0.041223 | 0.0298 | 38.33% |
| March 2020 | 0.041223 | 0.0296 | 39.27% |
| April 2020 | 0.041223 | 0.0267 | 54.39% |
| May 2020 | 0.041223 | 0.0219 | 88.23% |

Based on Table 22, forecasting using a research model shows that each month the error is relatively more than 5%. Thus, the VECM research model is said to be not good for predicting inflation. The GC test for exchange rates and inflation is shown in Table 23.

**Table 23.** GC test for exchange rates and inflation.

| $H_0$ | F-Statistic | Prob. |
|---|---|---|
| D(Exchange Rate) does not Granger Cause D(Inflation) | 2.61816 | 0.0770 |
| D(Inflation) does not Granger Cause D(Exchange Rate) | 2.82092 | 0.0634 |

Based on Table 23, the rupiah exchange rate does not significantly influence inflation and inflation does not significantly influence the rupiah exchange rate. Therefore, there is no two-way causality between the rupiah exchange rate and inflation.

## 4. Conclusion

The conclusions of this study are:

1. Based on the correlation analysis, it is obtained that exports, imports, and interest rates have a negative and statistically significant relationship at the real level of 5% of the rupiah exchange rate.
2. Exports and the rupiah exchange rate using the VAR (2) model is said to be good for forecasting exports and the rupiah exchange rate because the relative error every month is less than 5%. Based on the GC, there is no two-way causality relationship between the rupiah exchange rate and the export value.
3. Imports and the rupiah exchange rate using the VECM with lag 3, there is 1 cointegration and the deterministic trend none intercept no trend is said to be good for predicting imports because the relative error at each month is less than 5%. Based on GC, there is no two-way causality relationship between the rupiah exchange rate and imports.
4. Interest rates and the rupiah exchange rate using the VARD (1) is said to be not good for predicting a relative error rate not less than 5% per month. Based on GC, there is no two-way causality relationship between the rupiah exchange rate and the interest rate.
5. Inflation and the rupiah exchange rate using the VECM with lag 2, the deterministic trend none intercept no trend and there is 1 cointegration said to be not good for predicting inflation because each month the relative error is more than 5%. Based on the GC, there is no two-way causality relationship between the rupiah exchange rate and inflation.

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