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Relationship of Macroeconomics Variables in Indonesia Using Vector Error Correction Model

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Abstract

This study aims to analyze the relationship between macroeconomic variables in Indonesia, namely GDP with money supply, exchange rate of rupiah to US Dollar, exports, imports and interest rates. The background problem is to analyze the best method to influence government targets or policies on economic growth by studying the relationship of macroeconomic variables. Previous studies analyzing the relationship between macroeconomic variables in Indonesia have used multiple linear regression analysis. Using VECM analysis we can find out the short-term and long-term effects on the relationship between macroeconomic variables in Indonesia. The analysis used in this study is the Vector Error Correction Model with Maximum Likelihood estimation. Based on the result, the cointegration test found that there is a long-term relationship. Based on the VECM model (3), in the short term there is a relationship between macroeconomic variables and in the long run there is a long-term causality relationship in the GDP and export models. It is expected that the Government and the Central Bank will work together cooperatively in making policies to keep control of the money supply, exchange rate of rupiah to US Dollar and interest rates to enable to stimulate the economy.

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INTRODUCTION

The Indonesia experienced quite rapid economic growth. This is due to the continuity of changes in the Indonesian economy which include economic growth, price stability, and the achievement of a trade balance. Economic growth is one of the macroeconomic indicators to assess the success of a country's development. Economic growth is the development of activities in the economy that causes the goods and services produced to increase so that the prosperity of the community can increase and will accelerate the welfare of life for the country's population. To influence the government targets or policies so that economic growth increases by studying the relationship of macroeconomic variables. In addition, to see monetary stability, so as to avoid an economic crisis. Therefore, studying the relationship of macroeconomic variables is very important.

Economic growth is a short and long term economic problem as it is affected by various factors in the short and long term (Esen & Bayrak, 2017; Mankiw, 2009). Economic growth in Indonesia can be seen from the variable of Gross Domestic Product (GDP), which is the value of the production of goods and services produced by all residents in the region, both production activities by their own citizens or from foreign citizens (Divya & Devi, 2014; Mankiw, 2009). Economic growth can also be seen from macroeconomic variables other than GDP, namely the money supply, interest rates, exports, the exchange rate and others because the GDP variables are also affected by these macroeconomic variables (Syed & Shaikh, 2013). The relationship studied in macroeconomics is a causal relationship between macroeconomic variables as a whole. This is to see economic growth in the short and long term periods.

GDP is affected by the exchange rate, exports and imports together. Rupiah exchange rates affect exports and imports. According to (Machmud, 2016), rupiah depreciation could theoretically increase exports. The increase in exports of certain commodities shows that the weakening of the rupiah has a positive effect on exports. The development of exports occurred because a large depreciation of the rupiah caused exporters to be more interested in selling products on the international market rather than on the domestic market. GDP is also affected by the money supply. The increase of money supply will result that the public will spend some of the funds for consumption, thus making producers to produce more goods. In turn, the production demand will increase. This will affect gross domestic product and will increase economic growth.

On the other hand, GDP also affects other macroeconomic variables. According to Williamson (2018) GDP affects exports, which can be explained through the concept of vent for surplus, an increase in the production surplus which is marked by GDP growth. It will encourage exports to increase because excess domestic output will be channelled through exports. GDP can also affect imports, namely high GDP resulting in high imports. GDP can also affect interest rates. An increase in GDP leads to an increase in interest rates. An increase in interest rates is needed to reduce the amount of money people want to keep and establish equilibrium (Amzal, 2016).

The money supply can affect several macroeconomic variables other than GDP, namely the rupiah exchange rate, interest rates and exports. First, the money supply affects the rupiah exchange rate of rupiah to US Dollar (Tarsilohadi, 2017). The higher the money supply will cause the domestic currency to depreciate. Second, the money supply can affect interest rates. An increase in the money supply by the central bank results in a decrease in interest rates and will increase the current money supply (Mankiw, 2009; Rachman, 2019). Third, the money supply can affect exports (Kurniasih, 2019). The money supply increases, the higher the amount of exports.

In the economic field time series analysis is usually used. One of the multivariate time series models is the Vector Autoregressive (VAR) model which was introduced by Christopher A. Sims in 1980 as an alternative to macroeconomic analysis (Gujarati & Porter, 2009). The VAR model has a weakness that can only be used to analyze stationary variables. In addition, it can only analyze short-term effects whereas macroeconomic variables always have short-term and long-term effects.

In 1990, Johansen and Juselius developed a vectored Error Correction Model (VECM) or VAR (Enders, 2015). VECM is an analysis for economic variables with non stationary long-term and short-term data. The variables in VECM have a long term relationship and is called cointegration. Cointegration is a linear combination of non-stationary variables a resulting stationary time series in the long run with the same degree of integration. Estimating VECM parameters often used a classic methods such as Least Square and Maximum Likelihood Estimation (MLE). These methods have the advantage of being easier to apply for large numbers of observations (Verbeek, 2017).

Previous studies on the analysis of the relationship between macro- economic variables used only a few variables. Asnawi & Fitria (2018) using multiple linear regression analysis concluded that the variables money supply, rate interest and inflation have a positive effect and simultaneously had a significant effect on GDP. The weakness of the multiple regression analysis is only to conclude a one-way relationship even though there are economic variables that have a two-way relationship or affecting each other and assume that all variables are endogenous variables. In addition, the regression analysis does not consider about the affect of the previous time or lag. VAR analysis is used to show the relationship between endogenous variables. Research by Wardhono (2015) using VAR analysis shows that in the short term Interest rates, inflation and oil prices all affect fiscal sustainability in Indonesia. However, the VAR model has a weakness, it can only be used for stationary variables and can only analyze short-term effects, whereas macro-economic variables have short-term and long-term effects. This can be overcome by VECM (Gujarati & Porter, 2009).

Based on this background, then to analyze the relationship between many macroeconomic variables which also have a long-term relationship Vector Error Correction Model can be used. The purpose of this study is to determine the relationship between GDP macro-economic variables, the money supply, the rupiah exchange rate of rupiah to US Dollar, exports, import values and interest rates in Indonesia. Another goal is also to get the contribution of each endogenous variable using Variance Decomposition. Estimation of parameters in this study uses Maximum Likelihood.

RESEARCH METHODS

This The data used in this study are secondary data from the Indonesian Central Bureau of Statistics and www.bi.go.id. The variables used in this study are six macroeconomic variables in Indonesia in the first quarter of 2010 until the fourth quarter of 2019. Macroeconomic variables to be analyzed are GDP at constant 2010 prices (GDP), the money supply in broad terms (M2), the rupiah exchange rate of rupiah to US Dollar (kurs), total export income (exp), total import income (Imp) and interest rates from Bank Indonesia Certificates (SBI). Data used from 2010 due to limited GDP data at constant prices. GDP at constant prices starting in 2010. This research method is quantitative analysis with the model used is a time series model with a Vector Error Correction Model (VECM) approach. This study uses VECM because it aims to analyze the short-term and long-term relationships of macroeconomic variables, economic growth is a short and long term economic problem as it is affected by various factors in the short and long term and if the data used has cointegration (Gujarati dan Porter, 2009). The general model of VECM(p-1) where p is the lag of the endogenous variable with cointegration rank ≤r is as follows:

$$\Delta \boldsymbol{Y}_t = \prod \boldsymbol{Y}_{t-1} + \boldsymbol{\Gamma}_1 \, \Delta \boldsymbol{Y}_{t-1} + \cdots + \boldsymbol{\Gamma}_p \, \Delta \boldsymbol{Y}_{t-p+1} + \boldsymbol{\varepsilon}_t$$

This metohod is processed using Gretl program as software that helps in analyzing the variables. The first step that must be done in the analysis of economic models with time series data is to test the stationarity of the data. Visually to see this can be done by using a time series plot, namely by looking at data fluctuations from time to time . The hypothesis underlying the data stationarity test is as follows (Gujarati & Porter, 2009):

$H_0 : \delta = 0$ (Data is nonstationary)

$H_1 : \delta < 0$ (Data is stationary)

The test statistics used is the t-statistics

$$t = \frac{\hat{\delta}}{se(\hat{\delta})}$$

with the reject criteria H_0 if t-statistics > $t_{\alpha(T-1)}$ or p-value $<\alpha$, where T is the number of observation (Gujarati & Porter, 2009).

Then, determine the length of the lag (p) can be done by using several information criteria. According to Enders (2015), information criteria that are often used by Akaike Information Criterion (AIC). The selected lag length can be determined through the minimum value of the AIC criteria.

Verbeek (2017) defined a cointegration test is a method used to test whether there is a cointegration or long-term relationship in a time-series data variable. The cointegration test approach which is often used in the VECM method is the Johansen approach. The value of r can be determined through the Johansen test. The hypothesis underlying cointegration testing is:

$H_0 : rank = r$

$H_1 : rank \leq r + 1$

The test statistics used are called the maximum Eigenvalues, namely:

$$\lambda_{max}(r, r+1) = -T \log(1 - \hat{\lambda}_{r+1})$$

Where; $\hat{\lambda}_{r+1} =$ Eigenvalue matrix obtained from the estimator matrix $\prod$; and T = number of observations.

Criteria for acceptance of H_0 if the statistics λ_{max} is less than the critical value λ_{max}. The VECM model is compiled if the cointegration rank (r) is greater than zero (Verbeek, 2017).

To test the parameters of the VECM model it can be done using t-test statistics with the following hypotheses:H_0:$\beta_j = 0$ vs H_1:$\beta_j \neq 0$ and test statistics $t = \frac{\beta_j}{se(\beta_j)}$. Where the test criterion is H_0 is rejected if the t-statistic $\geq t_{\frac{\alpha}{2},T-k}$ or p-value < α with T = number of observations and k is the number of endogenous variables.

VECM can also show dynamic behavior or long-term effects through the response of each variable to the shock of that variable or other endogenous variables. One of them is through Variance Decomposition which is used to arrange total variance based on variance from other variables so that they get a portion of the variance of a certain variable against total variance or to measure how big a variable contributes to explaining for other variables or the variable itself (Silatchom, 2017).

Model diagnostic testing performed on the VECM model is residual multivariate normality and residual autocorrelation (Lutkepohl, 2007). The residual normality test uses a multivariate normality test with skewness test and kurtosis chi-square distribution approach. In the autocorrelation test using the Portmanteau Autocorrelation test (Lutkepohl, 2007).

RESULTS AND DISCUSSION

The initial step of time series analysis is to plot data. The following is a time series plot of variables of the money supply, rupiah exchange rate of rupiah to US Dollar, exports, imports, and GDP.

Figure 1 shows the development of GDP, the money supply, the exchange rate of rupiah to US Dollar, exports, imports and interest rates in Indonesia during the 2010 quarter 1 to 2019 quarter 4. Based on the original plot of data (above), we can see that the GDP variable, the money supply and the exchange rate of rupiah to US Dollar has the same trend which is the rising trend. The export, import and interest rate plots also have similar fluctuation patterns. The data used in this study are the natural logarithm transformation to make the range of the value of each variable is small. Based on the picture 1, the six variables tend to have the same trend, which is an increasing trend. The GDP variable and the money supply have the same fluctuation trend. Besides, the export, import, exchange rate of rupiah to US Dollar and interest rate variables also have fluctuations that are almost the same.

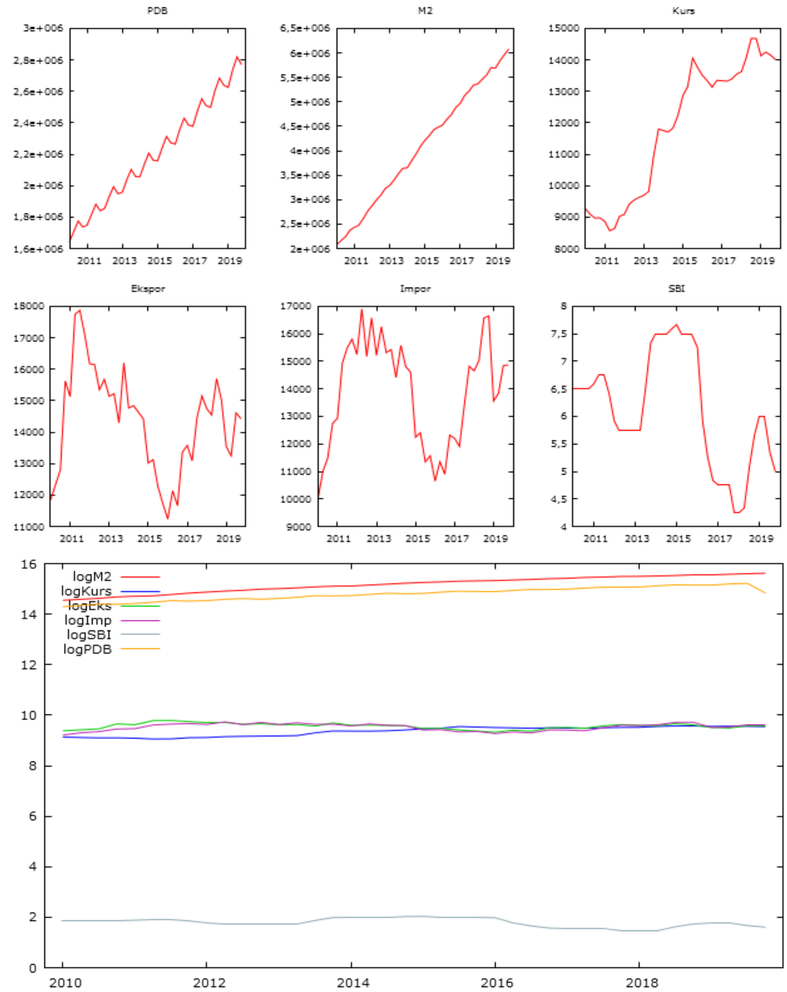

Figure 1. Time Series Plot
Source: Data Processed (2010q1-2019q4)

The same pattern of fluctuation or trend can indicate cointegration or there is a long-term relationship (Enders, 2015).

The average stationarity can be tested by the Augmented Dickey Fuller because it is easier to be used. Following the output of each variable can be seen in Table 1.

Table 1. Stationary Test Result

Variable	Level	Diff
Money Supply	0.9062	<0.00001*
Exchange Rate	0.7866	0.01149*
Export	0.2628	<0.00001*
Import	0.4798	<0.00001*
Interest Rate	0.1982	0.05451*
GDP	0.5451	0.00352*

Source: Data Processed (2010q1-2019q4)

Detail table of calculation can be seen in appendix 1. Table 1 shows that the p-values of all variables in the original data (level) are more than α = 10%, meaning that they are not stationary. After the first differencing, the data becomes stationary, seen from a p-value of less than 10%. Therefore, all variables have the same integration order, I (1) (Gujarati & Porter, 2009).

Table 2. Cointegration Test Result

Hipotesis	Statistik *Trace*	Nilai Kritis 10%	Nilai Kritis 5%
$r = 0$	237.94	85.18	90.39
$r \leq 1$	133.74	66.49	70.60
$r \leq 2$	77.58	45.23	48.28
$r \leq 3$	39.49	28.71	31.52
$r \leq 4$	10.85	15.66	17.95
$r \leq 5$	0.20	6.50	8.18

Source: Data Processed (2010q1-2019q4)

Johansen's test is used to test for cointegration. At this stage, we will look how many rank cointegration that can be formed and obtain in the Table 2.

The cointegration rank hypothesis 1, it can be seen that the Eigenvalue is 133.74, greater than the critical value α 10% and 5%. Then the decision is to reject H0, which means the cointegration rank is more than 1. Therefore, it is continued to next hypothesis rank. In the rank hypothesis cointegration 4 shows Eigenvalue is 10.85 less than the critical value of α 10% and 5%, then the decision is to accept H0. Thus, based on this analysis it can be concluded that the results cointegration test using the Eigen maximum statistics indicates that there is a maximum of 4 cointegration equation that can be formed (Verbeek, 2017). Previous cointegration tests have concluded that all the six macroeconomic variables are cointegrated or have a long-term relationship, so the analysis conducted is VECM analysis (Lutkepohl, 2005). Based on the optimum lag analysis results, the estimated form of the VECM equation is VECM(3). The following are the estimated results of the VECM parameters in Table 3.

After obtaining estimated parameters for each model, it is necessary to retransform all estimators using an exponential transformation to test the parameter estimates. Based on Table 3, the variables that significantly affect GDP are GDP one to three previous quarters, the money supply in the previous second quarter, the exchange rate of rupiah to US Dollar in the previous first quarter, exports in the previous second quarter and imports in the previous one to three quarters. The coefficient of the money supply is positive then the relationship between the money supply to the GDP is positive which is similar to the research findings of Asnawi & Fitria (2018) and Tambunan dkk. (2015). As the money supply increases, the public will place a portion of the funds for consumption, resulting producers produce more goods. Then the production demand will increase. This will affect GDP and economic growth will increase.

The coefficient on the exchange rate of rupiah to US Dollar and exports are positive, the relationship between the exchange rate of rupiah to US Dollar and exports on GDP are positive. The relationship between the exchange rate of rupiah to US Dollar, exports and GDP is mutually sustainable. This is consistent with the explanation of Machmud (2016) and research by Ismanto dkk. (2019) that the depreciation of the rupiah could theoretically increase exports and causing an increase in production volume. The increase exports of certain commodities shows that the weakening of the rupiah has a positive effect on exports. The development of exports occurred because a large depreciation of the rupiah caused exporters to be more interested in selling products on the international market rather than on the domestic market. Therefore, exports increase, GDP also increases. This is also following the Keynesian theory of the equation Y = C + G + I + (X-M) that increasing exports will increase GDP (Mankiw, 2009) and similar to the research findings of Udin & Khanam (2017).

The positive coefficient of imports means the relationship between imports and GDP is positive. This is relevant with the research of Astuti & Ayuningtyas (2018) that imports have a positive and significant effect on GDP and also in accordance with the statement of Machmud (2016) that the higher the GDP, the higher the possibility to import. On the other hand, Keynesian theory states imports will reduce Y or GDP. But Machmud (2016) provide an opinion that in the long run if a country prioritizes the import of capital goods which support the process of producing goods for export purposes it will positively impact the country's economic growth.

The variables that affect exports are GDP in the previous second quarter, exports in the previous third quarter and imports in the previous third quarter. The positive GDP coefficient means the relationship between GDP and exports is positive. This is similar to the research findings of Risma dkk. (2018) when Indonesia's GDP increases, exports will increase or have a positive effect. This means that if the Indonesian economy improves, Indonesia will be able to produce more goods which will have an impact on increasing the supply of more goods so that exports will increase. The positive coefficient of imports, the relationship between imports and exports is positive. It can also be seen in Figure 1 that exports and imports have the same fluctuating pattern and tend to rise. According to Williamson (2018), imports have a positive influence on exports where every business or policy that supports an increase in imports will cause exports to increase, especially if the imported goods are capital goods aiming support the growth of production of export goods.

The variables that affect imports are GDP in the previous third quarter and imports one to three in the previous quarter. The coefficient of GDP is positive means positive relationship between GDP and imports. The results of this study are also consistent with the study of Junaidi dkk. (2018) that GDP has a significant effect on Indonesian imports. Increased gross domestic product will increase public consumption. The increased public consumption while the availability of domestic goods can not meet the needs of the community. Therefore, people will choose to fulfil their needs through imported goods. Indonesia is unable to meet all the needs of its people because the development of domestic industries has not been able to meet the needs of import substitution caused by Indonesia being unable to produce capital goods and supporting raw material

The variables that affect the money supply are the money supply in the previous first quarter. The exchange rate of rupiah to US Dollar and interest rate variables are not significantly affected by other macroeconomic variables. This is not in accordance with research of Irman (2016) that the exchange rate and imports affect the amount of money in circulation in Indonesia 2010-2014. In addition, it is also contrary to research of Samosir (2012) that exports have an effect on the money supply.

A significant Error Correction Term (ECT) value is then proven by an adjustment mechanism from the short term to the long term. The GDP model has a significant ECT coefficient. This means that there is a long-term causality relationship from the money supply, the exchange rate of rupiah to US Dollar, exports, imports and interest rates to GDP. The export mode ECT coefficient is also significant, so there is a long-term causality relationship of GDP, the money supply, the exchange rate of rupiah to US Dollar, imports and interest rates to interest rates. As an example, the variables affecting GDP in the long run can be seen in Table 4

Table 4. VECM Estimation Results in Long-Term for GDP

Variable	ECT	
	Coefficient	t-statistics
D(logGDP(-1))	1.000	
D(logM2(-1))	-0.5309	-4.4574*
D(logKurs(-1))	0.3677	3.8584*
D(logEks(-1))	-0.0634	-1.0474
D(logImp (-1))	0.0740	1.3923
D(logSBI(-1))	0.1517	5.3441*

Source: Data Processed (2010q1-2019q4)

Based on the estimation of the short-term VECM parameters in Table 3 and the long-run in Table 4, the model of VECM(3) for the GDP variable is as follows:

$$\begin{aligned}\Delta GDP = 0.169(&GDP_{t-1} - 0.5309M2_{t-1} + 0.3677Kurs_{t-1} - 0.0634Eks_{t-1} + 0.0740Imp_{t-1}\\ &+ 0.1517SBI_{t-1}) - 1.0522\Delta GDP_{t-1} - 1.0844\Delta GDP_{t-2} - 0.9793\Delta GDP_{t-3}\\ &+ 0.0366\Delta M2_{t-1} + 0.0616\Delta M2_{t-2} + 0.0235\Delta M2_{t-3} + 0.0200\Delta Kurs_{t-1}\\ &- 0.0081\Delta Kurs_{t-2} + 0.0097\Delta Kurs_{t-3} + 0.0025\Delta Eks_{t-1} - 0.0168\Delta Eks_{t-2}\\ &- 0.0072\Delta Eks_{t-3} + 0.0096\Delta Imp_{t-1} - 0.0211\Delta Imp_{t-2} + 0.0137\Delta Imp_{t-3}\\ &+ 0.0008\Delta SBI_{t-1} + 0.0025\Delta SBI_{t-2} + 0.0086\Delta SBI_{t-3} - 0.0012\end{aligned}$$

Table 4 is the result of the VECM estimation, it shows the long term relationship between variables. Variables that affect GDP in the long term are significantly affected by the money supply, exchange rate of rupiah to US Dollar and interest rates. The money supply, the exchange rate of rupiah to US Dollar and interest rates have a positive effect on GDP. The relationship between the money supply and the exchange rate to GDP is consistent with the studies described in the short-term relationship. The monetary authorities should continue to control the money supply, because the money supply effected the GDP in the short and long term. Interest rates have a positive effect on GDP. This is relevant to research of Asnawi & Fitria (2018) where interest rates have a positive effect on GDP, in turn providing evidence that interest rates are a function of investment. Low-interest rates can increase investments and will ultimately increase economic growth.

Variance Decomposition can estimate how much the contribution of a variable to change the variable itself and other variables in the coming periods, where the value is measured as a percentage (Silatchom, 2017). Therefore, which variable is expected to have the largest contribution to a particular variable will be known. The results of the Variance Decomposition analysis for the next 10 quarters of each variable can be seen in Appendix 3.

Analysis Variance Decomposition of GDP in Appendix 3.1 based on the average shows which variable are expected to have the largest to smallest contribution to GDP in the next 10 months. They are money supply then GDP itself, imports, the exchange rate of rupiah to US Dollar, exports and interest rate. The biggest contribution is money supply. This is relevant with the research of He (2017). The highest contribution in the short term is 91.43% in period 2, then increased to 93.13% in period 10. The next contribution that affected GDP is the variance of its own growth. Contribution in the short term is 0.09% but in the long term it greatly increases to 15.51% in period 10. Variable of the money supply analysis of Variance Decomposition in Appendix 3.2 based on the average shows that the variable is expected to have the largest to smallest contribution to the money supply in the next 10 months is the money supply itself, the exchange rate of rupiah to US Dollar, imports, GDP, exports and interest rates. The biggest contribution that affects the money supply is the growth variance itself. Contributions in the short term amounted to 9.22% in period 2, subsequently greatly increased to 93.24% in period 10. The next contribution to money supply is the exchange rate of rupiah to US Dollar. The contribution in the short term is 86.19% but in the long term it has decreased to 0.05% in the 10th period.

Analysis Variance Decomposition of the exchange rate of rupiah to US Dollar variable in Appendix 3.3 based on the average shows that the variable expected to have the largest to smallest contribution to the exchange rate of rupiah to US Dollar in the next 10 months is the money supply, exports, the exchange rate of rupiah to US Dollar itself, interest rates, imports and GDP. The biggest contribution is the money supply. Contribution in the short term amounted to 1.34 %% in period 2, then increased to 93.22% in period 10. The next contribution that affected the exchange rate of rupiah to US Dollar is exports. Contribution in the short term was 53.72%. However, in the long term it declined to 1.86% in the 10th period. Analysis of Variance Decomposition of export variables in Appendix 3.4 based on the average shows that the money supply, imports, the exchange rate of rupiah to US Dollar, interest rate, exports themselves and GDP are expected to have the largest to smallest contribution to exports in the next 10 months. The biggest contribution that affects exports comes from the money supply. Contribution in the short term is 35.64% in period 2, then in the long term it increased to 93.41% in period 10. The next contribution to exports is imports which in the short term is 47.63% but in the long term it decreases to 2.21% in period 10.

Analysis Variance Decomposition of the import variables in Appendix 3.5 based on the average shows that the money supply, interest rate, the import itself, GDP, exports and the exchange rate of rupiah to US Dollar are expected to have the largest to smallest contribution to imports in the next 10 months. The biggest contribution that affects GDP is the money supply.

Contribution in the short term is 60.62% in period 2, then increased to 93.22% in period 10. The next contribution to GDP is the variance of its own growth. Contribution in the short term is 13.15% but in the long term it decreases to 2.30% in period 10. Analysis of Variance Decomposition of the interest rate variable in Appendix 3.6 based on the average shows that the money supply, exports, imports, GDP, interest rates themselves, and the exchange rate of rupiah to US Dollar are expected to have the largest to smallest contribution to interest rates in the next 10 months. The biggest contribution is the money supply. The highest contribution in the short term was 38.60% in period 2, then increased to 92.99% in period 10. The next contribution to GDP is exports. Contribution in the short term is 21.98% but in the long term it decreased to 2.06% in period 10.

Diagnostic tests model is performed on the VECM model are normality of residual and autocorrelation of residual. Following are the results of the two model diagnostic tests which are presented in Appendix 4. Based on the portmanteau correlation test, the p-value of each lag is less than $\alpha = 0.01$, rejecting H0 means there is a residual autocorrelation.

Based on the skewness test p-value less than $\alpha = 0.05$ then reject H0 and it means that the residual does not have a multivariate normal distribution. Kurtosis test obtained p-value more than $\alpha = 0.05$, accepting H0 means multivariate normal distribution of residuals. Skewness and kurtosis tests are interrelated, if one has a decision to reject H0 then it can be concluded that residuals are not normally multivariate distributed, so it can be concluded that the diagnostic model is not fulfilled (Lutkepohl, 2007).

If the residuals do not meet multivariate normal assumptions and there are residual autocorrelations then the model is not suitable. This unsuitable model is caused by the incorrect selection of lags (Lutkepohl, 2007). The maximum lag used for the test to determine the optimum lag can only be up to lag 4, this is caused by over-parameterization. Overparameterization is a case where too many parameters have to be estimated or the amount of data is less than the number of parameters to be estimated. Estimation methods Maximum Likelihood and other classical methods such as Least Square cannot overcome the problem of overparameterization (Tahir, 2014; Villani, 2005) . Therefore, Tahir's research (2014) uses the Bayesian parameter estimation method in VAR model to avoid the problem of over-parameterization in economic data and provide diagnostic results of the VAR model with the Bayesian approach provides a suitable forecast.

CONCLUSION

This study has the advantage of being able to analyze the relationship between the many macroeconomic variables in Indonesia in the short and long term. Some studies that have been done usually use the VAR model but the model can only be used for stationary variables and can only analyze short-term effects. Based on the analysis, the more suitable model is the VECM(3). The variables which significantly affect GDP in the short term are GDP, money supply, exchange rate of rupiah to US Dollar, exports and imports. The variable that affects the money supply is the money supply. The variables that affect exports are GDP, exports and imports. The variables that affect imports are GDP and imports. Also, there is long-term causality relationship in the GDP and export models.

The amount of data in this study is less than the number of parameters that causes overparameterization problems. Therefore, in the next research, the estimation of VECM parameters was developed to overcome the problem of overparameterization it is suggested to the Bayesian approach.

Based on the results of the study, it is suggested to consider the follow to increase the economic growth. First, the monetary authorities continue to control the money supply, because the money supply has a very large influence on GDP in the short and long term. Second, the

Central Bank's policy of being able to reduce interest rates and maintain exchange rate stability which will facilitate export activities. This will affect the economic growth that will increase.

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APPENDIX

Table 3. VECM Estimation Results in Short-Term

Variable	D(GDP)	D(M2)	D(Kurs)	D(Eks)	D(Imp)	D(SBI)
ECT	0.1639	-0.7545	-1.5542	6.8379	2.7768	3.3302
	(0.0682)**	(0.6793)	(1.9264)	(2.9145)**	(3.6674)	(3.5312)
C	-0.0012	0.0026	0.0082	-0.0388	-0.0212	-0.0169
	(0.0004)**	(0.0041)	(0.0116)	(0.0175)**	(0.0220)	(0.0212)
D(GDP(-1))	-1.0522	0.5706	1.5730	-2.6314	2.7148	-1.6417
	(0.0570)****	(0.5679)	(1.6104)	(2.4364)	(3.0658)	(2.9519)
D(GDP(-2))	-1.0844	0.4445	0.9893	-2.9110	-0.6763	-1.4078
	(0.0356)****	(0.3551)	(1.0072)	(1.5238)*	(1.9174)	(1.8462)
D(GDP(-3))	-0.9793	0.1106	0.4509	0.6724	3.7125	-1.0789
	(0.0342)****	(0.3403)	(0.9651)	(1.4602)	(1.8374)*	(1.7691)
D(M2(-1))	0.0366	-0.6349	-0.7047	0.5786	-0.6890	-0.1635
	(0.0324)	(0.3231)*	(0.9164)	(1.3864)	(1.7445)	(1.6797)
D(M2(-2))	0.0616	-0.3993	-0.2937	1.3395	-0.2203	0.3718
	(0.0322)*	(0.3211)	(0.9105)	(1.3775)	(1.7334)	(1.6690)
D(M2(-3))	0.0235	-0.2110	0.2513	0.7868	-0.1976	0.8917
	(0.0261)	(0.2596)	(0.7363)	(1.1139)	(1.4016)	(1.3496)
D(Kurs(-1))	0.0200	-0.1261	-0.1859	-0.0237	-0.0813	0.6350
	(0.0112)*	(0.1116)	(0.3164)	(0.4786)	(0.6023)	(0.5799)
D(Kurs(-2))	-0.0081	-0.1132	-0.1828	-0.7516	-0.1275	0.7456
	(0.0105)	(0.1048)	(0.2972)	(0.4496)	(0.5657)	(0.5447)
D(Kurs(-3))	0.0097	-0.0493	-0.1092	-0.1582	0.3348	0.1917
	(0.0116)	(0.1160)	(0.3291)	(0.4978)	(0.6264)	(0.6032)
D(Eks(-1))	0.0025	-0.0100	-0.1435	-0.3251	0.4424	-0.0685
	(0.0067)	(0.0669)	(0.1896)	(0.2869)	(0.3610)	(0.3476)
D(Eks(-2))	-0.0168	-0.0184	-0.1446	0.0349	0.3115	0.0371
	(0.0070)**	(0.0702)	(0.1992)	(0.3013)	(0.3792)	(0.3651)
D(Eks(-3))	-0.0072	-0.0243	-0.1937	0.4085	0.4903	-0.0149
	(0.0053)	(0.0523)	(0.1484)	(0.2245)*	(0.2825)	(0.2720)
D(Imp(-1)	0.0096	-0.0487	-0.0045	-0.0790	-0.9640	0.2930
	(0.0054)*	(0.0542)	(0.1537)	(0.2325)	(0.2926)***	(0.2817)
D(Imp(-2))	0.0211	-0.0238	0.0720	-0.4939	-0.9470	0.5366
	(0.0070)***	(0.0699)	(0.1983)	(0.3001)	(0.3776)*	(0.3635)
D(Imp(-3))	0.0137	-0.0172	0.2330	-0.5127	-0.5877	0.5072
	(0.0059)**	(0.0586)	(0.1662)	(0.2514)*	(0.3164)*	(0.3046)
D(SBI(-1))	0.0008	0.0188	-0.0345	0.1960	-0.1707	-0.1349
	(0.0047)	(0.0472)	(0.1339)	(0.2026)	(0.2550)	(0.2455)
D(SBI(-2))	0.0025	-0.0684	-0.2103	0.1460	-0.1671	0.0133
	(0.0051)	(0.0507)	(0.1438)	(0.2175)	(0.2737)	(0.2635)
D(SBI(-3))	0.0086	0.0159	-0.0142	-0.2893	-0.1653	-0.2369
	(0.0053)	(0.0524)	(0.1486)	(0.2248)	(0.2829)	(0.2723)

Note: Standard error in parenthess, Signif. codes: 0'****' 0.001 '***' 0.01 '**' 0.05 '*'

Source: Data Processed (2010q1-2019q)

1. **Test of Stationary**

Money Supply

Augmented Dickey-Fuller test for logM2
testing down from 3 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including 0 lags of (1-L)logM2
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
estimated value of (a - 1): -0,0422372
test statistic: tau_ct(1) = -1,15313
p-value 0,9062

Augmented Dickey-Fuller test for d_logM2
testing down from 3 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including 0 lags of (1-L)d_logM2
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
estimated value of (a - 1): -1,12212
test statistic: tau_ct(1) = -6,66913
p-value 1,03e-005

Exchange Rate

Augmented Dickey-Fuller test for logKurs
testing down from 3 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including one lag of (1-L)logKurs
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -0,122032
test statistic: tau_ct(1) = -1,61708
asymptotic p-value 0,7866

Augmented Dickey-Fuller test for d_logKurs
testing down from 3 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including 0 lags of (1-L)d_logKurs
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
estimated value of (a - 1): -0,648549
test statistic: tau_ct(1) = -4,16335
p-value 0,01149

Export

Augmented Dickey-Fuller test for logEks
testing down from 3 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including 0 lags of (1-L)logEks
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
estimated value of (a - 1): -0,253021
test statistic: tau_ct(1) = -2,64764
p-value 0,2628

Augmented Dickey-Fuller test for d_logEks
testing down from 3 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including 0 lags of (1-L)d_logEks
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
estimated value of (a - 1): -1,15627
test statistic: tau_ct(1) = -6,93477
p-value 4,338e-006

Import

Augmented Dickey-Fuller test for logImp
testing down from 3 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including 2 lags of (1-L)logImp
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -0,217663
test statistic: tau_ct(1) = -2,21653
asymptotic p-value 0,4798

Augmented Dickey-Fuller test for d_logImp
testing down from 2 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including 0 lags of (1-L)d_logImp
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
estimated value of (a - 1): -1,2061
test statistic: tau_ct(1) = -7,36933
p-value 9,47e-007

Interest Rate

Augmented Dickey-Fuller test for logSBI
testing down from 3 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including one lag of (1-L)logSBI
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -0,159321
test statistic: tau_ct(1) = -2,7972
asymptotic p-value 0,1982

Augmented Dickey-Fuller test for d_logSBI
testing down from 3 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including 0 lags of (1-L)d_logSBI
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + e
estimated value of (a - 1): -0,422738
test statistic: tau_ct(1) = -3,02826
p-value 0,05451

GDP

Augmented Dickey-Fuller test for logPDB
testing down from 3 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including 2 lags of (1-L)logPDB
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
estimated value of (a - 1): 0,731607
test statistic: tau_ct(1) = 1,17191
asymptotic p-value 0,5451

Augmented Dickey-Fuller test for d_logPDB
testing down from 3 lags, criterion AIC
unit-root null hypothesis: a = 1
with constant and trend
including one lag of (1-L)d_logPDB
model: (1-L)y = b0 + b1*t + (a-1)*y(-1) + ... + e
estimated value of (a - 1): -2,47073
test statistic: tau_ct(1) = -4,26287
asymptotic p-value 0,003524

2. Lag Optimum

VAR system, maximum lag order :

lags	loglik	p(LR)	AIC
1	411,84868		-21,134,210
2	436,79107	0,06180	-20,502,347
3	468,35558	0,00343	-20,248,890
4	528,82873	0,00000	-21,647356*

3. Variance Decomposition

1.1 Variance Decomposition of GDP

Period	D(PDB)	D(M2)	D(Kurs)	D(Eks)	D(Imp)	D(SBI)
1	0,045629	100,0000	0,000000	0,000000	0,000000	0,000000
2	0,088230	91,42797	0,206705	3,112031	5,237246	0,003009
3	0,156438	91,43563	1,036886	2,326755	4,667544	0,246774
4	0,284539	91,79084	0,355991	1,927418	2,714650	3,032624
5	0,601703	94,03472	0,145343	1,582036	1,800706	2,035293
6	1,182110	93,49445	0,120424	1,941171	2,562664	1,368844
7	2,228419	93,07877	0,104835	2,067991	2,675933	1,551477
8	4,213921	92,94947	0,055085	1,994717	2,474968	2,036745
9	8,105211	93,15013	0,056559	1,933381	2,373511	1,975213
10	15,50953	93,12636	0,061608	1,979712	2,452734	1,849210
average	3,534892	93,448834	0,214344	1,886521	2,695996	1,409919

3.2 Variance Decomposition of The Money Supply

Period	D(PDB)	D(M2)	D(Kurs)	D(Eks)	D(Imp)	D(SBI)
1	0,013601	0,204338	99,79566	0,000000	0,000000	0,000000
2	0,015112	9,221526	86,18770	1,868420	0,598594	1,643327
3	0,018181	27,17315	63,15675	4,074051	2,482783	1,264427
4	0,022820	48,92571	41,81136	2,888677	4,200874	0,879304
5	0,038804	76,94783	16,74755	1,408067	2,819540	1,359956
6	0,080328	90,46780	4,089846	1,527618	2,325420	1,177235
7	0,158238	92,97799	1,054785	1,640196	2,535975	1,157978
8	0,296757	92,96730	0,307119	1,862109	2,809757	1,512982
9	0,563069	93,07408	0,090689	1,818067	2,515664	1,989651
10	1,085972	93,24483	0,048206	1,864412	2,406790	1,921017
average	0,2292882	62,520455	31,32897	1,895162	2,26954	1,2905877

3.3 Variance Decomposition of Exchange Rate

Period	D(PDB)	D(M2)	D(Kurs)	D(Eks)	D(Imp)	D(SBI)
1	0,032710	0,064901	44,49429	55,44080	0,000000	0,000000
2	0,041477	1,344821	41,45592	53,72359	1,046048	0,310839
3	0,049704	12,68178	38,46180	41,99898	1,529622	3,742824
4	0,082562	57,64955	19,05734	15,57606	1,723532	4,316314
5	0,142773	81,06309	8,026767	5,695762	2,070039	1,716772
6	0,262298	90,50317	3,105225	2,007525	1,817591	1,462810
7	0,497428	92,81915	1,044295	1,313972	2,164725	1,878180
8	0,980899	93,79756	0,417312	1,382760	2,156285	1,568922
9	1,885052	93,44120	0,199999	1,732921	2,441714	1,588747
10	3,596712	93,22519	0,121406	1,857650	2,461781	1,775316
average	0,7571615	61,659041	15,63844	18,073	1,741134	1,8360724

3.4 Variance Decomposition of Export

Period	D(PDB)	D(M2)	D(Kurs)	D(Eks)	D(Imp)	D(SBI)
1	0,066194	1,448115	12,32263	3,848263	82,38099	0,000000
2	0,088157	35,64190	11,81162	2,180317	47,63538	2,720006
3	0,116535	52,83602	9,592171	2,126064	27,42663	7,906396
4	0,188786	75,03079	6,715102	1,373497	11,37139	3,301350
5	0,309000	85,87047	2,560821	1,766243	4,406058	4,552223
6	0,683566	94,22306	1,265869	0,918935	1,504745	1,099846
7	1,287241	93,50410	0,426554	2,176620	2,137488	1,043924
8	2,460618	93,69378	0,275796	2,007219	2,063871	1,346150
9	4,656920	93,21220	0,103988	1,966298	2,241949	1,949998
10	9,003421	93,40870	0,091393	1,912893	2,206062	1,830738
average	1,8860438	71,886914	4,516594	2,027635	18,33746	2,5750631

3.5 Variance Decomposition of Import

Period	D(PDB)	D(M2)	D(Kurs)	D(Eks)	D(Imp)	D(SBI)
1	0,076200	0,594079	0,952929	0,039945	42,20571	56,20733
2	0,142436	60,61969	6,208987	1,502576	13,14953	16,55049
3	0,186500	70,63415	3,835607	3,276290	10,92860	9,663434
4	0,321384	86,53190	3,047491	1,500897	3,738863	3,608995
5	0,556303	87,31457	1,110678	1,658485	2,049814	7,242206
6	1,199714	93,69158	0,684745	1,133908	1,271383	2,368416
7	2,252991	93,02047	0,235301	1,986966	2,398800	1,674789
8	4,266141	93,15524	0,169529	1,975566	2,334254	1,773260
9	8,076009	92,96630	0,068436	1,929433	2,333726	2,178839
10	15,57042	93,22260	0,074538	1,910927	2,298494	1,950246
average	3,2648098	77,175058	1,638824	1,691499	8,270917	10,3218005

3.6 Variance Decomposition of Interest Rate

Period	D(PDB)	D(M2)	D(Kurs)	D(Eks)	D(Imp)	D(SBI)
1	0,067840	5,655936	1,060778	27,81304	11,91134	0,027112
2	0,106903	38,60654	1,070711	21,98682	6,991092	1,273026
3	0,202977	66,39120	0,486242	18,20622	3,577874	1,575730
4	0,392501	84,67938	0,234676	8,416231	2,565822	1,464116
5	0,723752	89,20956	0,069458	4,660758	3,216678	2,041658
6	1,408182	91,99337	0,040119	2,876879	2,475601	2,210538
7	2,747159	92,75444	0,046014	2,434396	2,488628	1,912772
8	5,293464	92,91530	0,062377	2,265474	2,542527	1,786623
9	10,10000	92,93195	0,054362	2,153162	2,513032	1,884887
10	19,28313	92,99463	0,053240	2,060811	2,455847	1,946535
average	4,0325908	74,813231	0,317798	9,287379	4,073844	1,6122997

4. Diagnostic Model Test

4.1 Residual Autocorrelation Test Results

Lags	Q-Stat	Prob.*	Adj Q-Stat	Prob.*	df
1	26,53094	---	27,31126	---	---
2	48,50429	---	50,61633	---	---
3	80,98351	---	86,14047	---	---
4	107,3745	0,0010	115,9367	0,0001	66
5	148,9621	0,0017	164,4556	0,0001	102
6	185,0053	0,0047	207,9561	0,0001	138
7	222,8710	0,0073	255,2881	0,0001	174
8	255,0250	0,0183	296,9693	0,0001	210
9	286,8969	0,0375	339,8737	0,0001	246
10	310,1522	0,1198	372,4312	0,0002	282

4.2 Residual Normality Test Results

Component	Skewness	Chi-sq	df	Prob.*
1	-0.175503	0.174540	1	0.6761
2	-0.083892	0.039881	1	0.8417
3	0.586321	1.948040	1	0.1628
4	-0.180605	0.184836	1	0.6673
5	-0.973456	5.369824	1	0.0205
Joint		7.717121	5	0.1725

Component	Kurtosis	Chi-sq	df	Prob.
1	5.915363	12.04073	1	0.0005
2	2.304348	0.685571	1	0.4077
3	3.883260	1.105210	1	0.2931
4	2.139061	1.050056	1	0.3055
5	4.770089	4.438721	1	0.0351
Joint		19.32029	5	0.0017