Modelling of Export, Import, Gross Domestik Product (GDP) of Indonesia and Exchange Rate In 2005-2015

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Abstract— The limitation of capability and variation of sources in a country requires the exchange of goods across countries namely international trade, including export and import. In practice, exchange rate of a country will affect the export and import magnitude that also influences the magnitude of GDP. This research aims to identify the best model explaining the correlation between export, import and GDP with covariate of exchange rate of rupiah. Data employed was quarterly data 2005-2015 from Bank of Indonesia. Based on testable result of ADF, it is proven that there was cointegration between variables thus the modelling used the method of vector error correction model with exogenous variable (VECM-X). The best modelling result was VECM-X (10). Based on that model, result depicted that an increase of rupiah exchange rate led to an increase (decrease) in export and import (GDP). The most impactful endogenous variable on export magnitude was the change of import and GDP of three previous quarters. The most impactful endogenous variable on change of import was the magnitude of export of one previous quarter. The most impactful variables on change of GDP were change in export value, change in import value, and change in GDP on nine previous quarters.

Index Terms— Cointegration, VECM, Exogenous Variables, GDP, Export, Import, Time Series

1 INTRODUCTION

The limitation of capability and variation of sources in a country requires the exchange of goods across countries namely international trade, including export and import. Export development will influence commerce relation of Indonesia and the change of macroeconomic indicators either direct or indirectly. The export magnitude of a country is related to import magnitude because export and import are main parts of balance of payment in a country. The fluctuation of export and import will influence economic growth including GDP [1]. In contrast, stimulus on economic growth will encourage export and import [2].

In practice, exchange rate will affect export and import of a country which also influence the magnitude of GDP. The exchange rate of rupiah is an important macro economic variable. Researchers have proven that there is a long-run equilibrium relationship between export, import and GDP that is affected by exchange rate [2]. Exchange rate has negative impact on export value of a country. However, depreciation of exchange rate of rupiah will positively impact on export. This is consistent with Falianty [3] showing that deprecation of exchange rate which existed in crisis period (1998/1999) caused an increase in export value. Similar finding is also discovered in other country by Sandu and Ghiba [4] showing negative association between exchange rate and export volume in Romania.

The common understanding of correlation between export, import, GDP and exchange rate is crucial on economy decision making, especially in encouraging GDP growth and export. One way to study the pattern of correlation between export, import GDP and exchange rate is through data modelling between variables. One approach to study the correlation between variables (multivariate) is *Vector Autoregressive* (VAR). VAR model requires all variables to be stationary and not to be cointegrated.

Usually, variables in economics are not stationary and have long-run equilibrium relationship between variables (cointegrated) including export, import, GDP and exchange rate [2]. *Vector Error Correction Model* (VECM) is a form of restricted VAR since data existence is not stationary yet cointegrated. VECM is also acknowledged as VAR for time series data that has cointegration. The specification of VECM restricts the long-run relationship of endogenous variables to converge in cointegration relationship, but still letting the existence of short run dynamics. VECM modelling which includes exogenous variables is known as VECMX [5]. This research aims to determine the best model that can describe the correlation between export, import and GDP with covariate of exchange rate.

2 RESEARCH METHOD

2.1 Data

Data used in this research was quarterly data of export, import, exchange rate to US dollar (USD) and GDP from 2005-2015 collected from Bank of Indonesia and Central Bureau of Statistics of Indonesia. List of variables based on type in this research can be seen in Table 1.

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TABLE 1
LIST OF VARIABLES

No	Variables	Explanation	Type of Variables
1	Ekspor	The export value of Indonesia (in thousand of USD)	Endogenous
2	Impor	The import value of Indonesia (in thousand of USD)	Endogenous
3	PDB	The Gross Domestic Product (in billion Rupiah)	Endogenous
4	NTR	The exchange rate of rupiah (USD)	Exogenous

2.2 Methods of Data Analysis

Data analysis in this research used descriptive analysis and vector error correction model with exogenous variable (VECMX).

Following are the detailed steps of data analysis employed in this research:

1. Descriptive Analysis
   Descriptive analysis which used the line diagram was applied to see the general description of data pattern.
2. Determination of Optimal Lag Length
   Lag length was a model with lag creating the most minimum values of *Hannan quinn criteria* (HQC), *Akaike information criteria* (AIC), and *Schwarz bayesian criteria* (SBC).
3. Test of Stationary of Data
   Test of stationary was used to see the existence of unit root or not in a variable. Test of statistic employed was ADF test based on the following equation :

$$\Delta Y_t = \mu_0 + \mu_1 t + \phi Y_{t-1} + \sum_{j=1}^{p} \alpha_j \Delta Y_{t-j} + \varepsilon_t, t = p+1 \dots T$$

   where lag p from ΔY_{t-j} was added to diminish the serial correlation of residual. If data were not stationary, test of cointegration was further conducted.
4. Test of Cointegration
   Test of cointegration was conducted with *Johansen's Cointegration Test* with *Trace test statistics*.

$$\lambda_{\text{trace}}(r) = -T\sum_{i=r+1}^{n} \ln(1-\lambda_i)$$

   where:
   λ_i = *trace* in-i of matrix(Π)
   $\prod = \sum_{i=1}^{p-1} A_i - I$
   T = number of observations

   Through this test, cointegration rank formed was also observed, thus model estimation was later applied if cointegration was found.
5. Model Estimation
   Model estimation was used to estimate the model coefficient of VECMX.
6. Test of Model Diagnostic
   Test of model diagnostic was used to ensure that the model fulfilled all of assumptions
7. Model Evaluation
   Evaluating the forecasting with noticing the magnitude of MAPE was generated using equation.

3 RESULT AND DISCUSSION

3.1 General Overview of Data

The data from Bank of Indonesia and Central Bureau of Statistics of Indonesia shows that the economic movement of Indonesia experiences fluctuation every year. This study focuses on Indonesian economic aspects of export, import, GDP and exchange rate of rupiah. Description on quarterly data pattern in 2005-2015 is provided in Figure 1.

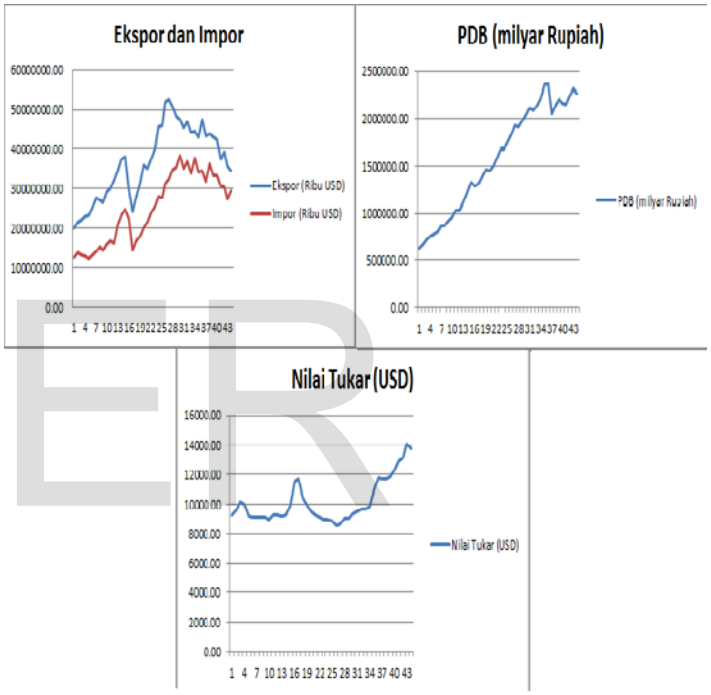

Fig 1. Data Plot from 2005 to 2015

Based on Fig 1, it can be seen that there is fluctuated movement in data pattern. This indicates that the data was not stationary both in variance and mean. Besides, variables found to have similar pattern in every period was an indication there was cointegration between export, import and GDP. Thus *Vector Error Correction Model With Exogenous Variable (VECMX)* was used in further analysis.

3.2 Optimal Lag-Length

To define the optimal lag length, it is required to use model VAR (P). P values were obtained by choosing the best model with identifying the most minimum values of HQC, AIC and SBC on Table 2.

TABLE 2

SUMMARY STATISTIC OF VAR(P) MODEL

VAR (p)	HQC	AIC	SBC
1	3621	3609.31	3641.01
2	3544.4	3527.21	3574.12
3	3467.32	3444.86	3506.55
4	3391.61	3364.13	3440.13
5	3322.27	3290.04	3379.87
6	3246.01	3209.3	3312.47
7	3163.04	3122.15	3238.14
8	3047.97	3003.2	3131.47
9	2930.78	2882.46	3022.44
10	2766.97	2715.43	2866.54

Based on Table 4.1, it can be seen that the most minimum statistical value of model criteria to be tested in the further analysis was lag 10.

3.3 Test of Data Stationary

Test of stationary was conducted with unit root test in each variable (export, import, GDP and exchange rate). The method used for unit root test in this research was *Augmented Dickey-Fuller Test* (ADF Test) with hypothesis:

H_0: ρ = 0 (*unit roots* exists; variable is not stationary)

H_1: ρ ≠ 0 (*unit roots* do not exist; variable is stationary)

When H_0 cannot be rejected, thus the variable contains *unit root* and is not stationary. The result of stationary test is in Table 3 below.

TABLE 3
SUMMARY STATISTIC OF ADF WITH MODEL OF VAR (10)

Variables	Augmented Dickey-Fuller	
	t-statistic	P-value
Ekspor	-0.8512	0.7937
Impor	-1.5281	0.5095
PDB	-1.4008	0.5731
NTR	-1.8416	0.3560

Values of ADF for each variable can be seen in Table 3 The principle of hypothesis testing here is the same as the usual hypothesis testing that is H_0 is rejected when values of statistical calculation > critical value of table statistical test or when *p*-value < α. Using significant level of 5%, it can be seen that all variables had *p*-values > 0.05, so it can be concluded that every variable had unit root or was not stationary. This is similar with previous expectation when gazing the pattern of previous discussion in Figure 1.

3.4 Test of Cointegration

Test of cointegration was conducted to find whether there will be long-run equilibrium or not, that is whether there are similar movement and stability of correlation between endogenous variables in this research. In this case, test of cointegration was conducted using *Johansen's Cointegration Test*. The result can be seen in Table 4 below.

TABLE 4
SUMMARY OF JOHANSEN'S COINTEGRATION TEST

Ho : Rank=r	H1 : Rank>r	Trace	P-value
0	0	135.9450	<.0001
1	1	45.6224	<.0001
2	2	0.0310	0.8855

Test of hypothesis was conducted by comparing *Trace test statistics* with *critical values*. The first row tested the following hypothesis:

H_0: r = 0 (cointegration does not exist)

H_1: r > 0 (cointegration exists > 0)

Based on values obtained, *p*-values (<.0001) < alpha 5% (0.05). This means that there was cointegration with rank > 0. Therefore, test for bigger rank was proceeded in the second row. Test for the second row was conducted to test the hypothesis:

H_0: r = 1 (cointegration exists in rank 1)

H_1: r > 1 (cointegration exists in rank > 1)

As *p*-value (<.0001) < alpha 5% (0.05), cointegration with rank > 1 existed, so test for bigger rank was proceeded in the third row. Test for the third row was conducted to test the hypothesis:

H_0: r = 2 (cointegration exists in rank 2)

H_1: r > 2 (cointegration exists in rank > 2)

Result of *p*-value (0.8855 > alpha 5% (0.05) means there was cointegration in rank 2.

Based on the hypothesis test, there were two cointegrations in significant level of 5% for variables in this research. Therefore, result from cointegration test indicates that there was stable/equilibrium relationship between export, import and GDP, and similar movement of those variables in the long run. In other word, all variables tend to adjust each other in the short run to reach equilibrium in the long run.

3.5 Empirical Model of VECMX

The VECMX model design was performed after the cointegration test was performed. The significance of lag of a variable upon other endogenous variable can be evaluated with comparing P-Value with significance level (α). Lag is significant if P-Value is bigger than 0.05.

Based on VECMX model from coefficient estimation if written in linear equation, three equations are obtained as follow:

1. $\Delta Ekspor_t$ = - 1145.91873 NTR_t – 0.04408 $Ekspor_{t-1}$ + 0.91463 $Impor_{t-1}$ – 9.31196 PDB_{t-1} + 0.21258 $\Delta Ekspor_{t-1}$ – 0.85761 $\Delta Impor_{t-1}$ + 32.94758 ΔPDB_{t-1} – 0.55347 $\Delta Ekspor_{t-2}$ – 1.61462 $\Delta Impor_{t-2}$ + 35.72809 ΔPDB_{t-2} + 0.91031 $\Delta Ekspor_{t-3}$ – 2.55870 $\Delta Impor_{t-3}$ + 48.3818148 ΔPDB_{t-3} + 0.23761 $\Delta Ekspor_{t-4}$ – 1.28449 $\Delta Impor_{t-4}$ + 24.12456 ΔPDB_{t-4} + 0.62690 $\Delta Ekspor_{t-5}$ – 2.24360 $\Delta Impor_{t-5}$ + 35.57973 ΔPDB_{t-5} + 0.40724 $\Delta Ekspor_{t-6}$ – 1.56607 $\Delta Impor_{t-6}$ + 14.24349 ΔPDB_{t-6} + 0.63972 $\Delta Ekspor_{t-7}$ – 1.65828 $\Delta Impor_{t-7}$ + 35.73406 ΔPDB_{t-7} + 0.37008 $\Delta Ekspor_{t-8}$ –

1.42095 $\Delta Impor_{t-8}$ + 10.18961 ΔPDB_{t-8} + 0.93505 $\Delta Ekspor_{t-9}$ – 2.08905 $\Delta Impor_{t-9}$ + 32.98038 ΔPDB_{t-9}

2. $\Delta Impor_t$ = – 845.21356 NTR_t – 2.78743 $Ekspor_{t-1}$ – 3.32738 $Impor_{t-1}$ + 2.10448 PDB_{t-1} – 1.68878 $\Delta Ekspor_{t-1}$ + 1.90507 $\Delta Impor_{t-1}$ – 36.92670 ΔPDB_{t-1} – 1.84942 $\Delta Ekspor_{t-2}$ + 2.38630 $\Delta Impor_{t-2}$ – 68.04491 ΔPDB_{t-2} – 2.31074 $\Delta Ekspor_{t-3}$ + 2.99534 $\Delta Impor_{t-3}$ – 56.18611 ΔPDB_{t-3} – 2.30051 $\Delta Ekspor_{t-4}$ + 2.62823 $\Delta Impor_{t-4}$ – 39.19361 ΔPDB_{t-4} – 1.30701 $\Delta Ekspor_{t-5}$ + 1.49779 $\Delta Impor_{t-5}$ – 38.69642 ΔPDB_{t-5} – 1.10317 $\Delta Ekspor_{t-6}$ + 1.75258 $\Delta Impor_{t-6}$ – 61.87799 ΔPDB_{t-6} – 1.81364 $\Delta Ekspor_{t-7}$ + 2.45702 $\Delta Impor_{t-7}$ – 53.13826 ΔPDB_{t-7} – 1.63553 $\Delta Ekspor_{t-8}$ + 2.24896 $\Delta Impor_{t-8}$ – 48.06201 ΔPDB_{t-8} – 0.74668 $\Delta Ekspor_{t-9}$ + 0.63792 $\Delta Impor_{t-9}$ + 0.00722 ΔPDB_{t-9}

3. ΔPDB_t = 22.56641 NTR_t – 0.03292$Ekspor_{t-1}$ + 0.01681 $Impor_{t-1}$ + 0.21719 PDB_{t-1} – 0.03538 $\Delta Ekspor_{t-1}$ + 0.02067 $\Delta Impor_{t-1}$ – 1.15951 ΔPDB_{t-1} – 0.01728 $\Delta Ekspor_{t-2}$ + 0.03524 $\Delta Impor_{t-2}$ – 0.17863 ΔPDB_{t-2} + 0.01483 $\Delta Ekspor_{t-3}$ – 0.00479 $\Delta Impor_{t-3}$ + 1.08063 ΔPDB_{t-3} + 0.02726 $\Delta Ekspor_{t-4}$ – 0.01209 $\Delta Impor_{t-4}$ + 0.22800 ΔPDB_{t-4} + 0.02702 $\Delta Ekspor_{t-5}$ – 0.01028 $\Delta Impor_{t-5}$ – 0.07472 ΔPDB_{t-5} – 0.01452 $\Delta Ekspor_{t-6}$ + 0.03888 $\Delta Impor_{t-6}$ + 0.23567 ΔPDB_{t-6} – 0.00523 $\Delta Ekspor_{t-7}$ + 0.00330 $\Delta Impor_{t-7}$ – 1.38786 ΔPDB_{t-7} + 0.02447 $\Delta Ekspor_{t-8}$ – 0.04479 $\Delta Impor_{t-8}$ + 1.64504 ΔPDB_{t-8} + 0.03882 $\Delta Ekspor_{t-9}$ – 0.05746 $\Delta Impor_{t-9}$ + 1.81792 ΔPDB_{t-9}

In first equation, it can be seen that exchange rate in period t and magnitude of GDP in one previous quarter influenced export value negatively. Similar thing also occurred in change of import value that influencing negative export value. In contrary, the change of GDP in several previous quarters affected change of export value in period t positively. Whereas the correlation pattern with itself was generally positive, but not significant.

The second equation shows that change in import value at time t was affected negatively by exchange rate in the same period and positively by export in one previous period. The correlation of change in import in time t with its self in previous period was generally positive, except with import in one previous period that influenced negatively. Meanwhile, change in GDP and change in export in previous several quarters generally influenced negatively on change in import value.

In third equation, it can be seen that exchange rate gave positive effect on change of GDP in the same period. Export value in previous quarter influenced negatively while GDP gave positive effect. The magnitude of export change generally affected positively on change in GDP, except in the second and sixth previous quarters. The magnitude of change in import gave positive effect in first lag, but gave negative effect in last lag. Change in GDP was also affected by itself which negatively impacted in one previous lag and positively in several previous periods.

Equation results above indicate that an increase in exchange rate of rupiah will cause an increase in export and import, but will decrease the magnitude of GDP. The most impactful endogenous variables on change in export are change in import and change in GDP in three previous periods. The most impactful endogenous variables on import are the magnitude of export in one previous period, magnitude of import in one previous period and change in GDP in three previous periods. Endogenous variables which are the most impactful upon GDP are change in export, change in import, and change in GDP in nine previous periods.

3.6 Test of Model Diagnostic

Test of model diagnostic was conducted to ensure that result from VECMX model fulfilled all of assumptions. Assumption that must be passed by VECM model is similar assumption as ordinary least square (OLS) which is residual values check (data - forecasting result) from models, those are:

1. Normality Test of Residual

   Normality test of residual was conducted to see whether the variation of residuals was normally distributed or not. Normality test of residual of export variable can be seen in Fig 2.

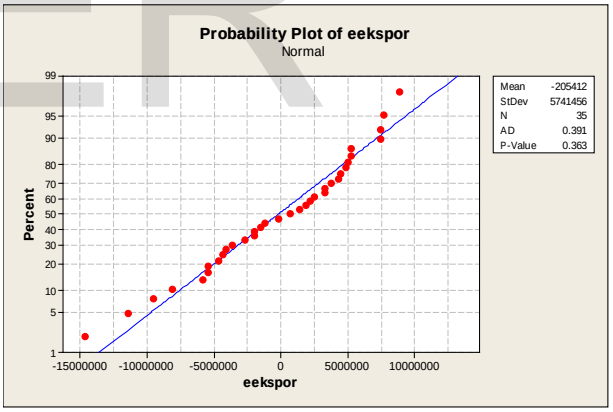

Fig 2. Normality test of residual of export variable

Based on the plot test of export normality above, it can be seen that *p*-value = 0.363> α=0.05, so residual of export was normally distributed. Similar finding was discovered in testing assumption of normality in residual at other variables for import and GDP.

2. Test of Heteroscedasticity of Residuals

   Test of heteroscedasticity was employed to determine whether there was disturbance of assumption in the form of difference in variance of residuals in all observations of the model. Test of heteroscedasticity used Breusch-Pagan test is provided in Table 5.

TABLE 5

HETEROSCEDASTICITY TEST

	Ekspor	Impor	PDB
LM (Observed value)	0.614	2.222	1.630
LM (Critical value)	3.841	3.841	3.841
DF	1.000	1.000	1.000
p-value (Two-tailed)	0.433	0.136	0.202

Based on Table 5, result of Breusch–Pagan test for all variables was found to have p-value > α=0.05, thus it can be concluded that the residual was homogenous.

3. Test of Autocorrelation of Residuals
Autocorrelation test was performed to see whether there was correlation between residual in period t and residual in the previous period (t-1). Test of autocorrelation by using statistics test of *Durbin-Watson* is in Table 6.

TABLE 6
AUTOCORRELATION TEST

	Ekspor	Impor	PDB
DW	2.912	1.929	1.849
p-value	0.998	0.417	0.394
Alpha	0.05	0.05	0.05

Based on Table 6, it can be seen that statistics of Durbin-Watson test for all variables resulted in p-value > α=0.05, so it can be concluded that there was no autocorrelation of residuals in all variables.

4 Conclusion

Based on result generated, this research found that endogenous variables were not stationary and had cointegration thus the model designed is VECMX model. The model used to explain export, import, GDP and exchange rate of rupiah is VECMX (10). Based on this model, result reported that an increase in exchange rate of rupiah will cause an increase in export and import value, but a decrease in GDP value. The most impactful endogenous variables on change in export value were change in import and change in GDP in three previous quarters. Endogenous variables which created the most impactful effect upon change in import were export value in one previous quarter, import value in one previous period and change in GDP in three previous quarters. Endogenous variables that affected the change in GDP the most were change in export, change in import and change in GDP in nine previous quarters.

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