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Comparison the Error Rate of Autoregressive Distributed Lag (ARDL) and Vector Autoregressive (VAR) (Case study: Forecast of Export Quantities in DIY)

Perbandingan Tingkat Kesalahan Metode Autoregresif Distribusi Lag (ARDL) dan Vektor Autoregresif (VAR) (Studi Kasus: Peramalan Jumlah Ekspor di DIY)

Dewi Kusumaningrum[1,a], Sugiyarto Surono[1,b]

[1]*Faculty of Mathematics and Natural Sciences, Universitas Ahmad Dahlan, Jl. Ringroad Selatan Tamanan, Banguntapan Bantul, Daerah Istimewa Yogyakarta, Indonesia, 55191, 0823-3018-6929[2]alamat afiliasi*
[a]dewikusuma848@gmail.com, [b]sugiyartophd@gmail.com

Abstract

Forecasting is estimating the size or number of something in the future. Regression model that enters current independent variable value, and lagged value is called distributed-lag model, if it enters one or more lagged value, it is called autoregressive. Koyck method is used for dynamic model which the lagged length is unknown, for the known lagged length it is used the Almon method. Vector Autoregressive (VAR) is a method that explains every variable in the model depend on the lag movement from the variable itself and all the others variable. This research aimed to explain the application of Autoregressive distributed-lag model and Vector Autoregressive (VAR) method for the forecasting for export amount in DIY. It takes export amount in DIY and inflation data, kurs, and Indonesia's foreign exchange reserve. Forecasting formation: defining Koyck and Almon distributed-lag dynamic model, then the best model is chosen and distribution-lag dynamic forecasting is performed. After that it is performed stationary test, co-integration test, optimal lag examination, granger causality test, parameter estimation, VAR model stability, and performs forecasting with VAR method. The forecasting result shows MAPE value from ARDL method obtained is 0.475812%, while MAPE value from VAR method is 0.464473%. Thus it can be concluded that Vector Autoregressive (VAR) method is more effective to be used in case study of export amount in DIY forecasting.

Keywords: *Koyck, Almon, Lag, Autoregressive Distributed-Lag, Vector Autoregressive;*

Abstract

Peramalan merupakan kegiatan memperkirakan apa yang terjadi pada masa yang akan datang. Model regresi yang memasukkan nilai variabel bebas saat ini, dan nilai masa lalu (lagged) disebut model terdistribusi-lag, apabila model tersebut memasukkan satu atau lebih nilai lagged disebut autoregresif. Metode Koyck digunakan untuk model dinamis yang panjang lagged tidak diketahui, untuk yang diketahui digunakan metode Almon. Vector Autoregressive (VAR) merupakan metode yang menjelaskan setiap variable dalam model tergantumg pada pergerakan masa lalu dari variabel itu sendiri dan juga seluruh variabel lainnya. Penelitian ini bertujuan untuk menjelaskan penerapan model Autoregressive terdistristribusi-lag dan metode Vektor Autoregresif (VAR) untuk peramalan jumlah ekspor di DIY. Penelitian ini mengambil data jumlah ekspor di DIY dan data inflasi, kurs, serta cadangan devisa Indonesia.Pembentukan Peramalan: Menentukan model dinamis terdistribusi-lag Koyck dan Almon, lalu dipilih model terbaik dan dilakukan Peramalan dinamis terdistribusi-lag. Setelah itu melakukan uji stasioneritas, uji kointegrasi, pemeriksaan lag optimal, uji kausalitas granger, estimasi parameter, stabilitas model VAR, dan melakukan peramalan metode VAR. Hasil peramalan diperoleh nilai MAPE metode ARDL sebesar 0.475812%, sedangkan untuk metode VAR diperoleh nilai MAPE sebesar 0.464473%. Sehingga dapat disimpulkan bahwa metode Vektor Autoregresif (VAR) lebih efektif untuk digunakan dalam studi kasus peramalan jumlah ekspor di DIY.

Kata Kunci: Koyck, Almon, Lag, Autoregresif Distribusi Lag, Vektor Autoregresif.

Introduction

Forecasting is estimating the size or number of something in the future according to the lag that is analyzed naturally, especially using statistic method (Sudjana, 1986). Time series data are often used as input or output data for performing forecasting process. Some forecasting method that can be applied to perform forecasting according to the time series data include: naïf approach method, moving average, exponential smoothing method, and trend projection method. The data used in this research is the historical data of export amount in DIY. Therefore, it will be performed a linear regression analysis that considers the time. The regression model whose dependent variable is influenced by the independent variable at the present time, and also influenced by the independent variable at the previous time is called the distributed lag model. If the dependent variable is influenced by the independent variable at the present time, and also influenced by the dependent variable itself at the previous time then the model is called autoregressive. Autoregressive model is also known as dynamic model if it describes the time line of the dependent variable in relation to its past value. Time difference or lag is the time required for the variable X in affecting the dependent variable Y. Koyck method is used for defining the estimation of distributed-lag dynamic model when the lag length is not known. Almon method is used for defining the estimation of distributed-lag dynamic model when the lag length is known. Vector Autoregressive (VAR) is one of regression analysis method which explains that every variable exist in a model is depend on the previous movement from the variable itself and also the previous movement of the whole variable inside the system. In VAR analysis, the system model sought between time series variables in vector form to be used to determine the causality relationship (interrelation) of the variables (Gujarati, 2003). This research will compare the forecasting result between using Distributed-lag Autoregressive method and Vector Autoregressive (VAR) for the forecasting case study of export amount in DIY according to its error value. The variables used are inflation, exchange rate and foreign exchange reserve because it is suspected to have an effect towards the export amount in DIY.

Materials and Methods

Ordinary Least Squares Method

Least squares method (Ordinary Least Square/OLS) is a method to calculate a and b in the regression equation as α and β approximation, such that the sum of error squares has the smallest value. The estimation of β_0, β_1 is obtained the following formula (1)

$$\hat{\beta} = (X^T X)^{-1} X^T y \qquad (1)$$

There are two testing parameter that is used for knowing whether the independent variables inside the regression model significantly influence the dependent variable, regression significance test (F test) and individual regression coefficient test (t test). The important things in classic assumption test are normality test, heteroscedasticity test, autocorrelation test, multicollinearity test, and error dependency test (Gujarati, 2003).

Stationarity Test of Time Series Data

In time series analysis, stationarity assumption of the data is an important character. In stationary model, the future statistics characteristics can be forecasted according to the historical data that has happened in the past. After the stationary test at the data then co-integration test, optimal lag test, Granger causality test, parameter estimation, and VAR model stability test are performed (Rosadi, 2012).

Optimal Lag Examination

Optimal Lag Examination is used to determine optimal lag length which be used to determine the parameter estimation of VAR model. This can be caused by causal relationship and VAR model which are sensitive toward the lag length, so it is necessary to determine the proper optimal lag length (Widarjono, 2007). To determine the optimal lag length in VAR model, it can be used information criteria as Akaike Information Criteria (AIC). The calculation of AIC is written as follows (2) :

$$\text{AIC} = \ln(\frac{\text{RSS}}{n}) + \frac{2k}{n}) \quad (2)$$

with

RSS = residual sum of squares
k = sum of estimated parameters
n = number of observations

The optimal lag is on the smallest value obtained in calculation (Widarjono, 2007).

Autoregressive Distributed Lag Model

Dynamic model is a model that describes the movement of the dependent variables which is influenced by the value from the past. The required time for independent variable X in influencing dependent variable Y is called time difference or lag or time-lag. There are 2 kinds of linear regression model that pays attention to the time influence, there are:

1. Distributed Lag Model

When a dependent variable is influenced by the independent variable in the current time, and if it is also influenced by the independent value in the previous time, then it is called distributed lag model. There are 2 kinds of distributed lag:

a. Infinite Lag Model

Equation (3)

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \ldots + \varepsilon_t \quad (3)$$

b. Finite Lag Model

Equation (4)

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \ldots + \beta_k X_{t-k} + \varepsilon_t \quad (4)$$

2. Autoregressive Model

If the dependent variable is affected by the independent variable in the current time, and also affected by dependent variable itself in the previous time, so it called autoregressive model.

$$Y_t = \alpha + \beta_1 X_t + \beta_2 Y_{t-1} + \varepsilon_t \quad (5)$$

This is the example of autoregressive model, which is also known as dynamic model, because it is figure out the timeline from the dependent variable with the value from the previous time (Gujarati, 2003).

Koyck Method

Koyck Method usually used to determine the estimated dynamic distributed lag model, which the length of the lag is unknown (3)

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \ldots + \varepsilon_t$$

Koyck assumed that β coefficient was decreasing geometrically as follow:

$$\beta_k = \beta_0 \lambda^k,\ k = 0,1, \ldots \text{ dan } 0 < \lambda < 1 \quad (6)$$

Where λ is the decreasing of distributed-Lag, Koyck Model was written as follow:

$$Y_t = \alpha(1-\lambda) + \beta_0 X_t + \lambda Y_{t-1} + V_t \quad (7)$$

Which $Vt = \varepsilon_t - \lambda\varepsilon_{t-1}$.

Pay attention to this Koyck scheme features:

1) By assuming the value of λ is not important, Koyck tooe a side of β's by the change the sign;
2) By assuming the value of λ<1 , He gave small integrity to β's which is far from now;
3) He define that the value of β's is a sum of limited long term (Gujarati, 2003).

Almon Method

Almon method used to determine the estimated of dynamic distributed-lag, which the length of the lag is known. The model that used in the almon method is finite lag (3) method as follow:

$$Y_t = \alpha + \beta_0 X_t + \beta_1 X_{t-1} + \beta_2 X_{t-2} + \ldots + \beta_k X_{t-k} + \varepsilon_t$$

or

$$Y_t = \alpha + \sum_{i=0}^{k} \beta_i X_{t-i} + \varepsilon_t \quad (8)$$

Based on the mathematics theory which is well known as Weir-Strass's Theorem, Almon assumed that βi can be approached by a certain polynomial in the i which has degree, With i is the length of the lagged. That Polynomial degree could be 0, 1, 2, … etc. For example, if β i was following polynomial of second degree of the model, so it can be written as:

$$\beta_i = \alpha_0 + \alpha_1 i + \alpha_2 i^2 \quad (9)$$

By distributing equation (2) to (1), obtained

$$Y_t = \alpha + \sum_{i=0}^{k} (\alpha_0 + \alpha_1 i + \alpha_2 i^2) X_{t-i} + u_t$$

$$= \alpha + \alpha_0 \sum_{i=0}^{k} X_{t-i} + \alpha_1 \sum_{i=0}^{k} i X_{t-i} + \sum_{i=0}^{k} i^2 X_{t-i} + u_t \quad (10)$$

If defined:

$$Z_{0t} = \sum_{i=0}^{k} X_{t-i}$$
$$Z_{1t} = \sum_{i=0}^{k} i X_{t-i} \quad (11)$$
$$Z_{2t} = \sum_{i=0}^{k} i^2 X_{t-i}$$

So it will be:

$$Y_t = \alpha + \alpha_0 Z_{0t} + \alpha_1 Z_{1t} + \alpha_2 Z_{2t} + \varepsilon_t \quad (12)$$

Equation (11) can be predicted by OLS Procedure. The probability of $\hat{\alpha}$ and $\hat{\alpha}_1$ that will be possess the desired properties if only the error u_t full filled the classic assumption. After all $\hat{\alpha}_1$ predicted from equation (10), coefficient β can be calculated using equation (9) as follow:

$$\hat{\beta}_k = \hat{\alpha}_0 + k\hat{\alpha}_1 + k^2\hat{\alpha}_2 \quad (13)$$

So the estimation of distributed lag model is:

$$\hat{\hat{Y}}_t = \hat{\alpha} + \hat{\beta}_0 X_t + \hat{\beta}_1 X_{t-1} + \hat{\beta}_2 X_{t-2} + \ldots + \hat{\beta}_k X_{t-k} \quad (14)$$

Vector Autoregressive Method (VAR)

Vector Autoregressive (VAR) is a system of dynamic equation that used to test the connection between the variables by using minimum assumption based on the structure. Vector Autoregressive (VAR) was first up come by Sims (1980). VAR explains that every variable is depend on the movement from the previous time of its variable, and also depends on the previous time movement of all variables that exist in the system. In the VAR analysis, determined the equation of a model system from the pull out times variables in the form of vector, this will be used to find out the interrelationship from the variables (Gujarati, 2003). The scale of pull out times y_t can be written in the autoregressive as follow:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 Y_{t-2} + \ldots + \beta_p Y_{t-p} + \varepsilon_t \quad (15)$$

Then from the equation above it will be obtained these following vectors:

$$\begin{aligned} y_t &= (y_{1t}\ y_{2t} y_{3t} \cdots y_{nt}) \\ y_{1t-1} &= (y_{11t-1} y_{12t-1} y_{13t-1} \cdots y_{1nt-1}) \\ y_{1t-2} &= (y_{11t-2} y_{12t-2} y_{13t-2} \cdots y_{1nt-2}) \\ &\vdots \\ y_{1t-p} &= (y_{11t-p} y_{12t-p} y_{13t-p} \cdots y_{1nt-p}) \end{aligned} \quad (16)$$

And vector ($\alpha_1\ \alpha_2\ \alpha_3 \ldots \alpha_n$) as α.

$\alpha_1\ \alpha_2\ \alpha_3 \ldots \alpha_n$ estimated by formula:

$$\hat{a} = \frac{(\Sigma\, y_t)\,(\Sigma\, y_{t-1}^2) - (\Sigma\, y_{t-1})(\Sigma\, y_{t-1} y_t)}{n\,\Sigma\, y_{t-1}^2 - (\Sigma\, y_{t-1})^2}$$

$\beta_{11}, \beta_{12}, \beta_{13}, \ldots, \beta_{nn}$ estimated by formula:

$$\hat{\beta} = \frac{n(\Sigma\, y_{t-1} y_t) - (\Sigma\, y_{t-1})(\Sigma\, y_t)}{n\,\Sigma\, y_{t-1}^2 - (\Sigma\, y_{t-1})^2}$$

So, obtained the matrix

$$\beta_n = \begin{bmatrix} \beta_{11(-p)} & \beta_{12(-p)} & \cdots & \beta_{1n(-p)} \\ \beta_{21(-p)} & \beta_{22(-p)} & \cdots & \beta_{2n(-p)} \\ \cdots & \cdots & \cdots & \cdots \\ \beta_{n1(-p)} & \beta_{n2(-p)} & \cdots & \beta_{nn(-p)} \end{bmatrix}$$

Vector ($\varepsilon_{1t}\ \varepsilon_{2t}\ \varepsilon_{3t} \ldots \varepsilon_{nt}$) as ε_t

Discussion

Koyck Model Formation

In order to makes analysis become easier the researcher using software Eviews 10.

Table 1. Estimated of Koyck model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.6336	0.3907	6.7407	0.0000
KURS	1.1E-05	2.9E-06	3.8128	0.0004
LOGEKSPOR(-1)	-0.0173	0.1504	-0.1149	0.9091
R-squared	0.3162	Mean dependent var		2.7204
Adjusted R-squared	0.2851	S.D. dependent var		0.0245
S.E. of regression	0.0207	Akaike info criterion		-4.8569
Sum squared resid	0.0188	Schwarz criterion		-4.7388
Log likelihood	117.1365	Hannan-Quinn criter.		-4.8124
F-statistic	10.1710	Durbin-Watson stat		1.9867
Prob(F-statistic)	0.0002			

Based on the table 1 Obtained the analysis result:

Y_t=-2.633554+0.0000109 X_t-0.017276Y_{t-1}

So the predicted lagged model is :

$\hat{Y}$ = 2.58882938 + 0.0000109 X_t- 0.0000001883084 X_{t-1} + 0.000000003253215918 X_{t-2} - 0.0000000000562026 X_{t-3} + 0.000000000000970955 X_{t-4}

On the estimated equation it can be seen that the effect of lag Y does not decrease geometrically. Estimated dynamic equation does not fulfiled the criteria of Koyck method which assumed that β coefficient decrease geometrically so the Koyck method cannot be used.

Almon Method Formation

Based on the table result, it was obtained that the estimated equation of Almon regression:

$\hat{Y}$ = 2.596293+0.0000163Z_{0t} - 0.0000479Z_{1t} +0.0000166Z_{2t}

Table 2. Estimated of Almon model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	2.5963	0.0319	81.3465	0.0000
Z0T	1.6E-05	9.5E-06	1.7142	0.0940
Z1T	-4.8E-05	2.3E-05	-2.1148	0.0406
Z2T	1.7E-05	7.4E-06	2.2382	0.0307
R-squared	0.3598	Mean dependent var		2.7217
Adjusted R-squared	0.3130	S.D. dependent var		0.0240
S.E. of regression	0.0199	Akaike info criterion		-4.9086
Sum squared resid	0.0163	Schwarz criterion		-4.7480
Log likelihood	114.4428	Hannan-Quinn criter.		-4.8487
F-statistic	7.6824	Durbin-Watson stat		1.9513
Prob(F-statistic)	0.0004			

Based on the table of F test it is concluded that Z_{0t}, Z_{1t}, Z_{2t} significantly affected to the dependent variable of export amount. Based on the t test it is concluded that the value of Z_{0t}, is not significant so variable Z_{0t} does not used. Then the estimated equation of almon regression become:

$\hat{Y}$ = 2.596293-0.0000479Z_{1t}+ 0.0000166Z_{2t}

So it will obtain the estimated lagged model:

$\hat{Y}$= 2.596293-0.0000313X_{t-1}- 0.000046 X_{t-2}-0.0000422 X_{t-3}

Classic assumption test (non-autocorelation, homoskedastisitas) was fulfilled, meanwhile multicolinearity test was not fulfilled because determined from the degree of polynomial. Obtained the MAPE value of data training on the Almon method is about 0.513211%, MAPE value of data testing is 0.335563%, and MAPE value of 2013 to 2017 is 0.475812%.

VAR Model Formation

Based on the optimal lag test it is obtained the value of optimal lag on the lag 1.

Table 3. Optimal Lag Test

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-560.98	NA	3037916	26.28	26.44	26.34
1	-427.10	236.62	12685.57	20.80	21.61	21.10*
2	-419.72	11.67	19339.73	21.20	22.67	21.74
3	-409.29	14.56	26414.27	21.55	23.59	22.24
4	-397.53	14.22	35706.06	21.65	24.44	22.68
5	-376.97	21.04	34653.19	21.44	24.88	22.71

Table 4. VAR parameters estimation

	LOG EKSPOR	INFLASI	KURS	CD
LOG EKSPOR (-1)	-0.219508	-0.073686	1807.829	18597.36
	(0.15818)	(0.06354)	(2106.38)	(22622.7)
	[-1.38773]	[-1.15973]	[0.85826]	[0.82207]
INFLASI (-1)	-0.220970	0.870072	4138.902	-5448.456
	(0.18971)	(0.07621)	(2526.35)	(27133.2)
	[-1.16475]	[11.4175]	[1.63830]	[-0.20080]
KURS (-1)	9.35E-06	-1.73E-06	0.942374	0.391501
	(2.6E-06)	(1.0E-06)	(0.03447)	(0.37017)
	[3.61209]	[-1.66375]	[27.3423]	[1.05764]
CD (-1)	1.36E-06	1.48E-07	0.002546	0.840177
	(6.3E-07)	(2.5E-07)	(0.00845)	(0.09072)
	[2.14460]	[0.57978]	[0.30145]	[9.26109]
C	3.071490	0.213186	-4646.665	-37907.98
	(0.39607)	(0.15910)	(5274.31)	(56646.5)
	[7.75488]	[1.33999]	[-0.88100]	[-0.66920]
R-squared	0.427907	0.840026	0.963340	0.811450
Adj. R-squared	0.373422	0.824791	0.959848	0.793493
Sum sq. resids	0.015754	0.002542	2793577.	3.22E+08
S.E. equation	0.019367	0.007779	257.9026	2769.896
F-statistic	7.853670	55.13574	275.9146	45.18822
Log likelihood	121.3296	164.1979	-325.0182	-436.5954
Akaike AIC	-4.950195	-6.774378	14.04333	18.79130

Table 4. VAR parameters estimation (Continued)

	LOG EKSPOR	INFLASI	KURS	CD
Schwarz SC	-4.753371	-6.577554	14.24015	18.98812
Mean dependent	2.720352	0.058513	12311.04	106397.0
S.D. dependent	0.024467	0.018585	1287.077	6095.317
Determinant resid covariance (dof adj.)		7103.760		
Determinant resid covariance		4529.956		
Log likelihood		-464.5944		
Akaike information criterion		20.62104		
Schwarz criterion		21.40834		
Number of coefficients		20		

Rely on the table of estimated result of VAR method it is obtained VAR(1) model as follow:

$\text{ekspor}_t =$

$3.071490 - 0.219508\ \text{ekspor}_{t-1} - 0.220970\ \text{inflasi}_{t-1} + 0.00000935\text{kurs}_{t-1} + 0.00000136\text{CD}_{t-1}$

$\text{inflasi}_t =$

$0.213186 - 0.073686\ \text{ekspor}_{t-1} + 0.870072\text{inflasi}_{t-1} - 0.00000173\text{kurs}_{t-1} + 0.000000148\text{CD}_{t-1}$

$\text{kurs}_t =$

$-4646.665 + 1807.829\text{ekspor}_{t-1} + 4138.902\text{inflasi}_{t-1} + 0.942374\text{kurs}_{t-1} + 0.002546\text{CD}_{t-1}$

$\text{CD}_t =$

$-37907.98 + 18597.36\ \text{ekspor}_{t-1} - 5448.456\ \text{inflasi}_{t-1} + 0.391501\text{kurs}_{t-1} + 0.840177\text{CD}_{t-1}$

Based on the result of VAR stability test from the table it is obtained all of modulus value is less than one, so it can be concluded that VAR system is stable. The MAPE value of data training on the VAR model is 0.4734%, MAPE value of data testing is 0.4338% and MAPE value of 2013 to 2017 is 0.464473%.

Determination of the best method

The determination of the best method was done by comparing the MAPE value from the Auto regressive Distributed-Lag (ARDL) and Vector Autoregressive (VAR) method. The MAPE value of data training on the Almon method is about 0.513211%, MAPE value of data testing is 0.335563%, and MAPE value of 2013 to 2017 is 0.475812%. Meanwhile for the VAR method it is obtained the MAPE value of data training on the VAR model is 0.4734%, MAPE value of data testing is 0.4338% and MAPE value of 2013 to 2017 is 0.464473%. So it can be concluded that Vector Autoregressive (VAR) method was more effective to be used in case study of export amount in DIY forecasting. The forecasted result of 2018 and the comparison of MAPE value can be seen on the table 5:

Table 5. Forecasted result of 2018

Month	ARDL	VAR	Month	ARDL	VAR
1	2.7341	2.7370	7	2.7339	2.7369
2	2.7341	2.7369	8	2.7339	2.7369
3	2.7339	2.7369	9	2.7339	2.7369
4	2.7337	2.7369	10	2.7340	2.7369
5	2.7338	2.7369	11	2.7340	2.7369
6	2.7338	2.7369	12	2.7340	2.7369

Table 6. The Comparison of MAPE Value

	MAPE Data Training	MAPE Data Testing	MAPE 2013-2017
ARDL	0.5132%	0.3356%	0.4758%
VAR	0.4734%	0.4338%	0.4645%

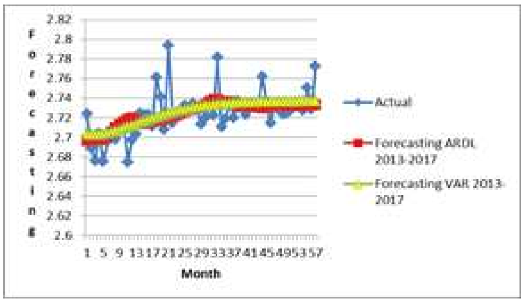

Figure 1 Graphic Forecasting of ARDL and VAR

Conclusion

Based on the test it is concluded that Autoregressive distributed-Lag model cannot be used because the Koyck assumption does not fulfilled. So to overcome the calculation of Autoregressive Distributed Lag method used Autoregressive distributed-Lag Almon method with the length of lagged is three and polynomial degree is two, For Vector Autoregressive method obtained VAR(1) model. Based on the estimated result it is obtained the MAPE value of data training on the Almon method is about 0.513211%, MAPE value of data testing is 0.335563%, and MAPE value of 2013 to 2017 is 0.475812%. Meanwhile for the VAR method it is obtained the MAPE value of data training on the VAR model is 0.4734%, MAPE value of data testing is 0.4338% and MAPE value of 2013 to 2017 is 0.464473%. So it can be concluded that Vector Autoregressive (VAR) model is more effective to be used in case study of forecasting of export amount in DIY.

References

Ansofino, dkk., 2016, *Buku Ajar Ekonometrika, Edisi pertama.* Yogyakarta: Deepublish.

p. ISSN: 1411-1047
e. ISSN: 2503-2364

Anton H., dan Susilo I., 2000, *Aljabar Linear Elementer*. Jakarta: Erlangga.

Djuraidah, Anik., Dewi Retno Sari Saputro., dan Aji Hamin Wigena, 1993, *Model Vektor Autoregressive (VAR) Untuk Peramalan Curah Hujan di Indramayu*. Forum Statistika dan Komputasi, 7-11.

G.S Madala., 1992, *Introduction to Econometrics,* Edisi 2. New York; Mac Millan PC.

Gujarati, Damodar N., 2003, *Basic Econometrics*. Singapura: McGraw-Hill,Inc.

Ispriyanti, Dwi., Firdha Rahmatika Pratami., dan Sudarno, 2016, *Peramalan Dinamis Produksi Padi di Jawa Tengah Menggunakan Metode Koyck dan Almon.* Jurnal Gaussian, 5, 91-97.

Makridakis., 1999, *Metode dan Aplikasi Peramalan, Edisi 2.* Jakarta: Binarupa Aksara.

Prasetya, Hery., 2009, *Manajemen Operasi.* Jakarta: Yogyakarta : MedPress.

Rosadi, Dedi., 2012, *Ekonometrika Dan Nalisis Runtun Waktu Terapan Dengan Eviews.* Yogyakarta: Penerbit Andi.

Setiawan., dan Desi Mustika., 2014, *Peramalan Penjualan Sepeda Motor di Jawa Timur dengan Menggunakan Model Dinamis.* Jurnal Sains dan Seni Pomits, 3, 224-229.

Sudjana.,1986., *Metode Statistika.* Tarsito: Bandung.

Sugito., Wilis Ardiana Pradana., dan Rita Rahmawati, 2016, *Analisis Pengaruh Kurs Rupiah Terhadap Indeks Harga Saham Gabungan Menggunakan Distributed-lag Model.* Jurnal Gaussian, 5, 221-227.

Supranto, J., 1995, *Pengantar Statistik bidang hukum*. Jakarta: Rineka Cipta.

Widarjono, Agus., 2007, *Ekonometrika Teori dan Aplikasi untuk Ekonomi dan bisnis*, *Edisi kedua.* Yogyakarta: Fakultas Ekonomi UII.