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Use of VectorAutoregressive Model toAnalyze the Stock Market Behavior in Indonesia

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ABSTRACT

The purpose of this study was to determine the relationship between the stock index stock market index of the world, namely the DJI index, the FTSE 100 index, the Hang Seng, Nikkei 225, Hang Seng index .The method of analysis used in this study were Multivariate Time Series, in particular the Vector Autoregression (VAR). Besides research, whether there is a case of outliers in the data. To detect outliers performed multivariate analysis using Mahalanobis Distance. This study uses monthly data from the years 2001 - 2011 for each study variable. The results of this study using T^2 shown Oulier no data, so that the VAR modeling is done and it can be concluded that there is a relationship between the overall stock price index, JKSE, the DJIA index, the FTSE 100 index , the Hang Seng, Nikkei 225, and the STI index.

KEYWORDS : Vector Autoregression, Stock Market, Outlier.

INTRODUCTION

In a stock exchange in the capital market , which is most in demand by investors is stock . Shares are securities that shows ownership of the company, so that shareholders have a right to dividend or other distribution of profit sharing as well as by the company to its shareholders.The capital market is an indicator of economic progress and support the economy of a country . In this decade , the stock market has experienced rapid growth due to the pressure of technological change, liberalization, and globalization. These changes affect the behavior of the stock market and cause long-term balance and encourage the creation of relations between the world's capital markets . Stated capital markets are interconnected if the two separate markets have the same movement and has a correlation between the movement of the index .Capital markets in the region tend to have the same movement and contagion effects is high (Climent and Meneu 2003) . During the observation period , years 2001 - 2011 , a phenomenon in which the movement of the JKSE is not always the same and has a correlation with the stock market index movement world.Hal is also supported by the differences found in the results of some previous studies .

Composite Index (JCI) is a share index of the most frequently noted investors when investing . This is due to the index lists of all shares listed on the Indonesia Stock Exchange . With the movement of the joint-stock index investors can see whether market conditions moving passionate or lethargic. Many factors affect the behavior of the stock market index coupling medium diantarananya world stock market index, ie the DJIA index , the FTSE 100 index , the Hang Seng , Nikkei 225 , Hang Seng index .

Multivariate Time Series, in particular the Vector Autoregression (VAR) is a statistical method that is appropriate for modeling the behavior of the stock market in the Indonesian economy. Because the method can be known pattern of simultaneous relationship between the variables stock index, the DJI index, the FTSE 100 index, the Hang Seng, Nikkei 225, and the STI index , both the influence at the time and in times past . As for knowing each fluctuation of stock price index used approach Mahalanobis distance (Mahalanobis Distance) which exist in the multivariate analysis .

Problem in this study isHow does the pattern of relationship between stock index , the DJIA index , the FTSE 100 index , the Hang Seng , Nikkei 225 , and STI indices simultaneously by using a VAR and How to model the relationship pattern of JCI , the DJI index, the FTSE 100 index, the Hang Seng, Nikkei 225 and Hang Seng index in case of fluctuations in the data by using VARX (VAR model with no outliers)

MATERIALS AND METHODS

VAR Model

VAR model is actually a composite of several models of autoregressive (AR) , where these models form a vector between the variables affect each other . This model describes the relationship between observations on a particular variable at a time with observations on the variable itself at the times previously and also its association with observations on other variables at previous times (Wei , 1990) .

There are two important assumptions that must be considered from the time series data to be shaped into the VAR model , namely : (1) stationary, (2) normality and independence of errors . Unit root test (Unit Root Test)

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is one way to test stationarity . Before performing simultaneous estimation of parameters in the model , it must first be determined what the maximum lag length of the model .
The general form of the VAR model (p) according to (Hamilton , 1994) is

$y_t = c + \Phi(B)y_t + \varepsilon_t$
$y_t = c + (\Phi_1 B + \Phi_2 B^2 + \Phi_3 B^3 + \ldots + \Phi_p B^p)y_t + \varepsilon_t$ with assumtion $\varepsilon_t \sim N(0, \Sigma)$

Identification of the VAR Model
VARmodel identificationis donebypatternorstructure ofthe samplecorrelationmatrixfunction(MACF) andpartial correlationfunctions ofthe samplematrix(MPACF) afterappropriatetransformationtostabilize thevariance, andordifferencingtostabilizethe average, ifthe datais notstationaryin thevarianceandthe average(Wei, 1990).

Best Model Selection Criteria
There are other ways to determine the appropriate VAR order, in addition to seeing the pattern MPACF also consider the value of the Akaike Information Criterion (AIC). A model is said the better if its p value of the minimum AIC. The calculation of p values AIC or AIC on VAR (p) is:

$$AIC_p = \ln\left(\left|\hat{\Sigma}_p\right|\right) + \frac{2pm^2}{(n-p)}$$

Parameter Estimation of VAR
Inestimating themodel parametersVAR(p), there are twomethodsthat can beperformed, the method of Maximum Likelihood(MLE) and themethod of LeastSquares(LS) (Hamilton, 1994). Method ofMaximum Likelihood(MLE) is usedtoestimateparameters ofamodel thatis knowndensityfunction, bymaximizing thelikelihood function.
Density function for the observations is

$$f(y_t) = (2\pi)^{-m/2}\left|\boldsymbol{\Sigma}^{-1}\right|^{1/2}\exp\left[(-1/2)(\mathbf{y}-\mathbf{X}\boldsymbol{\beta})^T\boldsymbol{\Sigma}^{-1}(\mathbf{y}-\mathbf{X}\boldsymbol{\beta})\right]$$

By taking a random sample of n observations $y_1, y_2, \ldots, y_n$ obtained likelihood function

$$L(\boldsymbol{\beta},\boldsymbol{\Sigma}) = \prod_{t=1}^{n}(2\pi)^{-m/2}\left|\boldsymbol{\Sigma}^{-1}\right|^{1/2}\exp\left[(-1/2)(\mathbf{y}-\mathbf{X}\boldsymbol{\beta})^T\boldsymbol{\Sigma}^{-1}(\mathbf{y}-\mathbf{X}\boldsymbol{\beta})\right]$$

and the log likelihood function

$$\log L(\boldsymbol{\beta},\boldsymbol{\Sigma}) = -(nm/2)\log(2\pi) + (n/2)\log\left|\boldsymbol{\Sigma}^{-1}\right| - (1/2)\sum_{t=1}^{n}\left[(\mathbf{y}-\mathbf{X}\boldsymbol{\beta})^T\boldsymbol{\Sigma}^{-1}(\mathbf{y}-\mathbf{X}\boldsymbol{\beta})\right]$$

So the estimate for β

$$\hat{\boldsymbol{\beta}} = \left[\sum_{i=1}^{n}\mathbf{x}_t^T\,\mathbf{x}_t\right]^{-1}\left[\sum_{i=1}^{n}\mathbf{x}_t^T\mathbf{y}_t\right]$$

Outlier detection
Outlier is a data set that is considered to have different properties compared to most other data. Mitra (2009) using multivariate control charts to detect outliers in multivariate data sets containing outliers are indicated data. One is the use of Hotelling's T^2.
Limit the upper limit of the graph T^2.
UCL = $\left(\frac{mnp-mp-np+p}{mn-m-p-1}\right) f_{\alpha,p,(mn-m-p+1)}$

VAR models with Additive outliers
$Z_t = D_t\delta + y_t$; t = 1, 2, 3, …., n
With
$y_t = \mu + \Phi(B)y_t + \varepsilon_t$
$D_t = \begin{cases} 1, & t = T_B \\ 0, & t \neq T_B \end{cases}$
Assumed $\varepsilon_t \sim N(0, \Sigma)$.

RESULTS AND DISCUSSION

Results of descriptive analysis.
Before conducting the analysis using the VAR method, carried out a description of the qualitative data for the

six variabel JKSE, DJIA index, FTSE 100 index, Hang Seng, Nikkei 225 and Hang Seng index. Obtained the following results:

Table 1. Descriptive of Index

STOCK	Mean	Std Dev	Minimum	Maximum	Skewness	curtosis
JKSE	4103,5	154,2	3791,6	4375,2	0,02	-1,13
DJI	12975.0	307 .0	12119.0	13610.0	-0,03	-0,46
FTSE100	5747,7	159.0	5260,2	5965,6	-0,96	0,37
HSI	20502.0	1073.0	18502.0	22667.0	0,01	-0,86
N225	9108,9	490,6	8365,9	10395,2	0,71	-0,47
STI	2976,7	103,7	2711.0	3191,8	-0,74	0,16

Table 1 shows that the share price index by the average stock price is HSI, with an average daily stock price is 20 502, while the lowest average value owned by STI which has an average value of 2976.7. The size of data dissemination can be seen through the standard deviation. Standard deviation value indicates the level of the stock price data variability in each of these variables. The values of the standard deviation indicates that the level of diversity of daily stock price indices in the six variables. The highest level of diversity produced by HSI stock price index data for 1073.

Graph of daily stock price data movement in 2012 on six variables are shown in the form of time series plots in Figure below

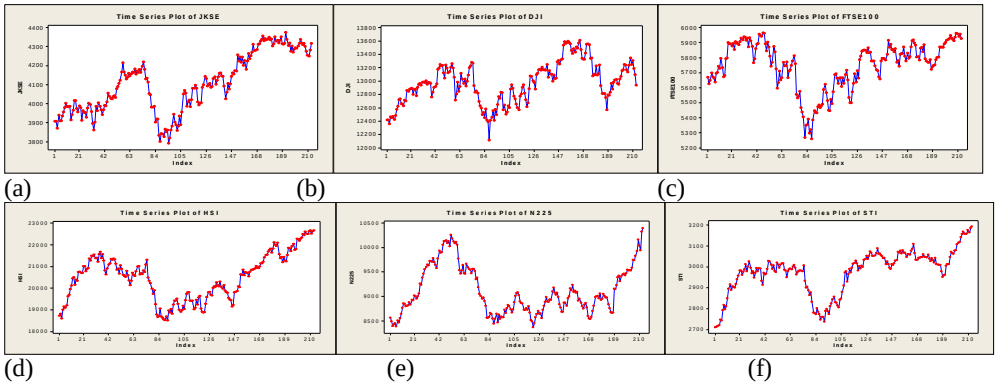


Figure 1 Plot Time Series JKSE, DJI, FTSE100, HSI, N225, STI

Based on Figure 1 that plots the time series is known to have a high fluctuation. The pattern of data movement in the stock price tends to equal the six variables. Based on plots of time series data has not alleged that the stationary, because the plot shows the data with large fluctuations.

The results of VAR analysis.

This conjecture will be analyzed further through PACF plots. ACF and PACF of its results obtained the following results:

Schematic Representation of Partial Cross Correlations

```
Var/Lag     1   2   3   4   5   6   7   8   9   10  11  12

y1      +..... ...+.. ...... ...... ...... ...... ....-. ...... ...... ...... ...... ......
y2      .+.... ...--. ...-.. ...... ...... .+.... ...... ...... ...... ...... ....-. ......
y3      ..+... ...... ...... ...... ...... ...... ...... ...... ...... ...... ...... ......
y4      ...+.. ...... ...... ...... ...... ...... ...... ...... ...... ..+... ...... ......
y5      ....+. ...... ...... ...... ...... ...... ...... ...... ...... ...... ...... ......
y6      .....+ .+.... ...... ...... ...... ...... ...-.. ...... ...... ...... ....+. ......
              + is > 2*std error,  - is < -2*std error,  . is between
```

Figure 2. Plot PACF (Partial Autocorrelation Function)

From the table above shows that the model has a lag of 1, so that the model is a VAR model (1). Furthermore, to see the trend of the six variables can be viewed through the area the following graph:

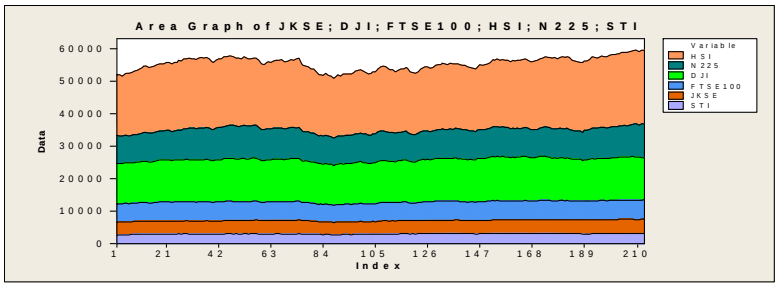


Figure 3. Graph Plot area index STI, HSI, FTSE 100, HSI, N 225, and STI

Graph of the area can be seen that each of the stock price index variables have the same trend. While the results of the analysis using the VAR method obtained the following results:

$$y_{1t} = 0,92186y_{1t-1} + 0,02813y_{2t-1}$$
$$y_{2t} = 0,97652y_{2t-1}$$
$$y_{3t} = 0,03123y_{2t-1} + 0,93019y_{3t-1}$$
$$y_{4t} = 0,33559y_{3t-1} + 0,98608y_{4t-1} - 0,08997y_{5t-1}$$
$$y_{5t} = -0,17450y_{4t-1} + 0,02994y_{5t-1}$$
$$y_{6t} = 0,03321y_{3t-1} + 0,93830y_{6t-1}$$

From the equation above shows not all variables affect each other. For example, y_{2t} only influenced by y_{2t} the last period. This shows if the model were obtained less good, since many parameters that are not included in the model. This is possible because the data may exist outliers or the data are not stationary in the average. By using T^2 Hotteling to see outliers, obtained the following results

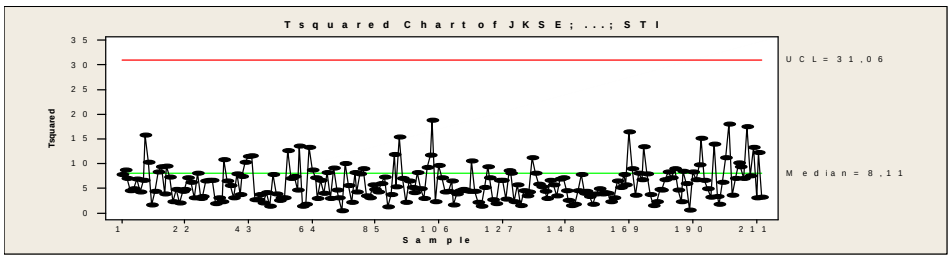
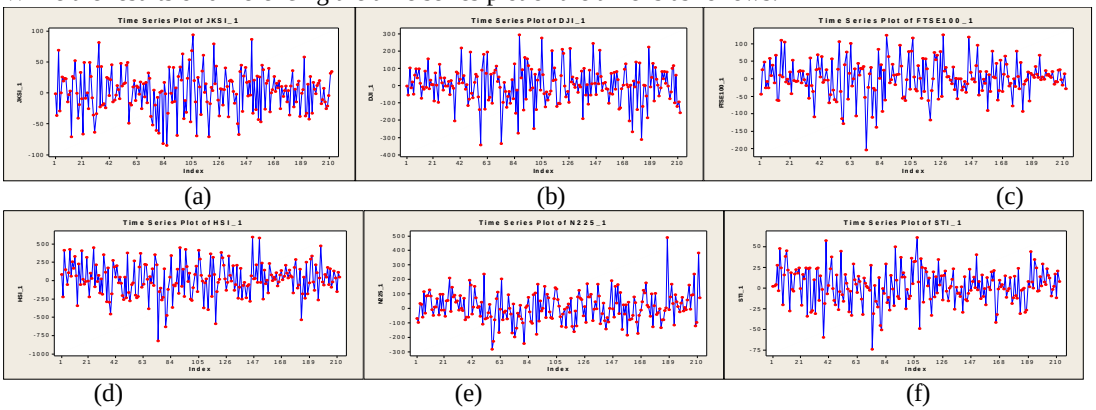


Figure 4. Outliers from the T2 Hotteling

From the picture above shows no data in the six variables that contain outliers, since all values below the lower limit of T^2 Hotteling (UCL).
While the results of differencing the time series plot of the time is as follows:



(a) (b) (c)

(d) (e) (f)

Figure 5. Plot Time Series JKSE_1, DJI_1, FTSE100_1, HSI_1, N225_1, STI_1

From the picture above shows that all six variables JKSE_1, DJI_1, FTSE100_1, HSI_1, N225_1 and STI_1 already shows a stationary pattern.
Processing results for the VAR model with the data that has been stationary is as follows:

Table.2. VAR Model Parameter Estimation

Equati	Par	Estimate	Std Err	T Ratio	P	Variable
y1	CONST1	166.88703	111.81489	1.49	0.1371	1
	AR1_1_1	0.95876	0.02873	33.37	0.0001	y1(t-1)
	AR1_1_2	0.82602	0.01411	58.58	0.0001	y2(t-1)
	AR1_1_3	0.62401	0.03112	20.05	0.0006	y3(t-1)
	AR1_1_4	0.07264	0.00533	13.63	0.0108	y4(t-1)
	AR1_1_5	0.00267	0.00085	3.14	0.0374	y5(t-1)
	AR1_1_6	0.08996	0.00690	13.03	0.0113	y6(t-1)
y2	CONST2	908.97602	339.08423	2.68	0.0079	1
	AR1_2_1	0.52301	0.03712	14.09	0.0128	y1(t-1)
	AR1_2_2	0.87996	0.04194	20.98	0.0001	y2(t-1)
	AR1_2_3	0.06201	0.00834	6.20	0.0075	y3(t-1)
	AR1_2_4	0.01291	0.00113	11.42	0.0064	y4(t-1)
	AR1_2_5	0.01361	0.00283	4.81	0.0157	y5(t-1)
	AR1_2_6	0.25691	0.13975	1.84	0.0074	y6(t-1)
y3	CONST3	384.55939	164.12436	2.34	0.0201	1
	AR1_3_1	0.94529	0.02138	44.21	0.0001	y1(t-1)
	AR1_3_2	0.01734	0.00030	57.80	0.0039	y2(t-1)
	AR1_3_3	0.95001	0.04276	22.22	0.0001	y3(t-1)
	AR1_3_4	0.00347	0.00035	9.91	0.0059	y4(t-1)
	AR1_3_5	0.01838	0.00260	7.06	0.0006	y5(t-1)
	AR1_3_6	0.05124	0.00764	6.71	0.0496	y6(t-1)
y4	CONST4	1885.90807	739.30402	2.55	0.0115	1
	AR1_4_1	0.27185	0.03168	8.58	0.0051	y1(t-1)
	AR1_4_2	0.08094	0.00314	25.78	0.0059	y2(t-1)
	AR1_4_3	0.71280	0.20469	3.48	0.0006	y3(t-1)
	AR1_4_4	0.92453	0.03476	26.60	0.0001	y4(t-1)
	AR1_4_5	0.04802	0.00512	9.38	0.0085	y5(t-1)
	AR1_4_6	0.79766	0.00963	82.83	0.0002	y6(t-1)
y5	CONST5	255.35360	348.55120	0.73	0.4646	1
	AR1_5_1	0.09077	0.00982	9.24	0.0088	y1(t-1)
	AR1_5_2	0.01183	0.04401	0.27	0.7884	y2(t-1)
	AR1_5_3	0.20278	0.09719	2.09	0.0382	y3(t-1)
	AR1_5_4	0.01670	0.00371	4.50	0.0289	y4(t-1)
	AR1_5_5	0.94529	0.02138	44.21	0.0001	y5(t-1)
	AR1_5_6	0.07381	0.00626	11.72	0.0104	y6(t-1)
y6	CONST6	78.98262	72.16902	1.09	0.2751	1
	AR1_6_1	0.08930	0.00761	11.73	0.0044	y1(t-1)
	AR1_6_2	0.00909	0.00147	6.18	0.0018	y2(t-1)
	AR1_6_3	0.05710	0.01997	2.86	0.0047	y3(t-1)
	AR1_6_4	0.00476	0.00039	12.20	0.0009	y4(t-1)
	AR1_6_5	0.08895	0.00440	20.22	0.0001	y5(t-1)
	AR1_6_6	0.91955	0.03022	30.43	0.0001	y6(t-1)

From the table above shows all the significant variables to the model, with The probability value of less than 5% or 0.05.

Can be expressed in the form of the above equation:

$$y_{1t} = 0.95876y_{1t-1} + 0.82602y_{2t-1} + 0.62401y_{3t-1} + 0.07264y_{4t-1} + 0.00267y_{5t-1} + 0.08996y_{6t-1}$$

$$y_{2t} = 908.97602 + 0.52301y_{1t-1} + 0.87996y_{2t-1} + 0.06201y_{3t-1} + 0.01291y_{4t-1} + 0.01361y_{5t-1} + 0.25691y_{6t-1}$$

$$y_{3t} = 384.55939 + 0.94529y_{1t-1} + 0.01734y_{2t-1} + 0.95001y_{3t-1} + 0.00347y_{4t-1} + 0.01838y_{5t-1} + 0.05124y_{6t-1}$$

$$y_{4t} = 1885.90807 + 0.27185y_{1t-1} + 0.08094y_{2t-1} + 0.71280y_{3t-1} + 0.92453y_{4t-1} + 0.04802y_{5t-1} + 0.79766y_{6t-1}$$

$$y_{5t} = 0.09077y_{1t-1} + 0.01183y_{2t-1} + 0.20278y_{3t-1} + 0.07264y_{4t-1} + 0.94529y_{5t-1} + 0.07381y_{6t-1}$$

$$y_{6t} = 0.08930y_{1t-1} + 0.00909y_{2t-1} + 0.05710y_{3t-1} + 0.00476y_{4t-1} + 0.08895y_{5t-1} + 0.91955y_{6t-1}$$

From the above results it appears that all six variables affect each other stock price index significantly. Model VARAO or VARX planned to be compared with the VAR model is generally not done because of lack of data outliers, so that the model VARX not obtained.

CONCLUSIONS

From the discussion, it can be concluded

1. It turns out that there is a significant relationship between the six variables that world stock price index STI, HSI, FTSE100, HIS, N225 and STI.
2. No data outliers for the six variables that world stock price index STI, HSI, FTSE100, HIS, N225 and STI.
3. VAR models can not be compared with the model VARX or VARAO because the data do not contain outliers so VARX or VARAO models can not be obtained.

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