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**Lasso Technique Application In Stock Market Modelling: An
Empirical Evidence In Indonesia**

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Abstract: The stock market has captured the attention of many investor and scholars. It has become one of the most crucial aspects of a modern market economy. This study aims to determine the LASSO technique applications on the stock market in Indonesia. Furthermore, this research also compare linear regression techniques using the least squares method and using the LASSO approach to find out which model is the most appropriate and simple in making the estimation. The data is composed of daily closing stock price over the period from January 1, 2000 to December 31, 2014. The results suggest that the best model in Indonesia Stock Market data of 2000-2014 is using LASSO techniques due to more simpler and the result of estimation relatively similar with least square regression model.

Keywords: Stock Market Modelling; LASSO Regression; Linear Regression Analysis; Stock Market in Indonesia.

Introduction

Stocks are one of the instruments in the capital market that attract attention, both market practitioners and academics. Stock prices became the most frequently analyzed economic data in recent years (Grager, 1992). Shares can be defined as proof of company ownership, either by individuals or corporations. According to Fontanils et al (2001) stock market is a place to facilitate the buying and selling of shares of the company. The stock market first began operating in the 12th century in France by trading government's obligation (Faghani et al, 2013). According to Desjardins (2016) there are currently 60 major stock exchanges spread across the world with a value of US \$ 69 trillion.

The global stock market as an affecting relative variable on this research is represented by the G7 country's stock market, which are countries with the largest economic power of the world's number 1 to 7. These countries are America, Germany, Japan, Italy, France, Canada and the United Kingdom. Considerations for choosing G7 stock market as described by

Morana (2008), are; (1) the G7 stock market plays an important role in global stock markets for more than three decades, (2) the movement of the stock market prices of the G7 countries is related to each other. This reflects a fundamentally macroeconomic relationship between G7 member countries.

In the context of the Association of Southeast Asian Nations (ASEAN), the cumulative ASEAN share market has a market capitalization of US \$ 2.1 trillion with the number of listed companies of 3,600 companies as of August 2012 (Deloitte, 2016). The Indonesian stock market through the Indonesia Stock Exchange (BEI) has one of the prevailing index indicators, namely the Jakarta Composite Index (JCI). Currently, according to the Financial Services Authority (OJK), Indonesia's stock market has 15 market indices and 10 sectoral indices. There are 553 companies listed on the BEI with a market capitalization of \$ 478 billion in July 2017. The market development and movement caused JCI to experience an up and down period. On March 6, 2015, JCI reached its highest level in history that closed up 1.17 percent to the highest level of 5,514.78.

The development of the capital market leads to increasing inter-state relations. Technological advances promote globalization that removes borders between countries. Globalization occurs also in the economic aspect, where economic transactions evolve with the involvement of foreign investors in the funding and trading system (Kowanda et al., 2014). Involvement of foreign parties in capital markets driven by technological advances makes the capital market more integrated (Christa and Pratomo, 2015). The integration of capital markets with other countries' capital markets can be seen from the spillover effect occurred when shocks hit one market and affect other markets (Kim et al., 2012).

This research tries to see the influence of G7 and ASEAN-4 stock market on Indonesian stock market by using LASSO model. Stock market estimation method had been conducted such as Stock Market Forecasting Using LASSO Linear Regression Model (Roy et al., 2015) and Mali et al., (2017) on Open Price Prediction of Stock Market Using Regression Analysis. Modeling with the independent variables condition that are generally numerous and not mutually free having problems. The problem to be faced is the problem of ill-conditional data, in this case multicollinearity and high correlation between variables. High correlated data cases cause the linear regression coefficient estimators obtained have a large variety. This can cause inconsistent coefficient marks, such as one that should be positive become negative and vice versa, so the resulting model is not feasible to use.

The problem of high correlated data in linear regression cannot be handled directly by the least squares method (MKT). The solution to this problem can be using variable selection and shrinkage in guessing the models (Soleh and Aunuddin, 2013). Subset selection techniques such as best subsets, forward selection, backward elimination, stepwise, shrinkage such as LASSO and gulud regression, and dimensional transformations such as PCA and PLS (Hastibe et al., 2008). Tibshirani (1996) introduced the Least Absolute Shrinkage and Selection Operator (LASSO) method which can shrink the parameter coefficients and perform variable selection on the linear regression model by changing the penalty in gulud regression with norm L_1 (regularization L_1). LASSO also began to be known after Efron et al. (2004) invented Least Angle Regression (LARS) algorithm method. Some studies using LASSO techniques have been widely practiced as in Tibshirani (2007) titled *on the "degrees of freedom" of the LASSO*, and Zhao and Yu (2006) on *On model selection consistency of LASSO*.

Meanwhile, stock market estimation using LASSO model in Indonesian context is still very limited. Based on this consideration, research related to LASSO technique applications on

the stock market in Indonesia needs to be conducted. Furthermore, this study will also compare linear regression techniques using the least squares method and use the LASSO approach to find out which model is the most appropriate and simple in making the estimation of Indonesian stock prices.

Literature Review

Stock Price Index

Stock index is the average value of the stock market capitalization of the stock value in a specific and relatively static (Lo, 2016). The stock index is used for analytical purposes and avoids the negative impact of the use of stock prices in rupiah. Each Stock Exchange will assign a different index base number, namely, some start with a base of 100, 500, or 1,000. Index types can be grouped into 3, ie individual stock price index, partial stock price index, and composite share price index (Samsul, 2009).

The composite stock price index is a composite index of all types of shares listed on the Stock Exchange. Composite Stock Price Index (IHSG) is published by the Stock Exchange. The calculation of IHSG is equal to the partial stock price index, which different only on the number of issuers. IHSG is calculated daily or every second during trading hours as needed. The formula used to calculate the partial stock price index is:

$$\text{IHSG} = \frac{\text{Market value}}{\text{Basic value}} \times 100$$

HSG changes daily due to daily price changes and additional stocks. The increase in the number of outstanding shares comes from new emissions, namely the entry of new listed companies listed on the Stock Exchange, or corporate actions, in the form of stock split, rights, warrants, stock dividends, bonus shares and convertible shares (Samsul, 2006).

ASEAN and G7 Stock Markets

The co-operation of the Association of Southeast Asian Nations (ASEAN) began in 1967. Initially, ASEAN was more of a political cooperation, then it expanded more extensively, one of them is in the economic field. At the ASEAN Summit in October 2003 in Bali, the ASEAN Concord II (Bali Concord II) declaration agreed on the establishment of the ASEAN Economic Community (AEC) which began in late 2015 (Almekinders et al., 2015). The AEC is a realization of ASEAN aspirations as an open, inclusive, dynamic, and resilient area by 2020 (ASEAN, 2008; Guerrero, 2010).

In order to facilitate the achievement of the AEC in accordance with the target, the ASEAN Finance Ministerial Meeting was held in 2003 in Makati City Philippines. The meeting agreed on the ASEAN Financial Integration Roadmap (RIA) which covers several fields, one of which is the capital market sector. ASEAN capital market is experiencing rapid growth. According to the Deloitte report (2016), there are 3,600 companies listed on the Stock Exchange in ASEAN countries, with a market capitation of US \$ 2.1 trillion.

The G7 market shares which consist of United States, Germany, Japan, Italy, France, Canada and the UK are stock markets that have the largest market capitalization value in the world. Accumulatively, the G7 countries' stock market has a market capitalization value of US \$ 115 billion (UN, 2017). When viewed from the strength of the stock market of G7 countries, according to Jakpar et al (2013) explains that any phenomenon that occurs in the

market country will create a domino effect and quickly able to affect the stock market of other countries around the world.

Methods

Linear Regression Analysis

Linear regression illustrates the relationship model between independent and dependent (Mattjik and Sumertajaya 2013). Draper and Smith (1992), defines linear regression models are linear in parameters. The linear regression model has the following form:

$$\mathbf{y} = \mathbf{X}\boldsymbol{\beta} + \boldsymbol{\varepsilon} \quad (1)$$

which in this case, \mathbf{X} is matrix of independent variable of $n \times (p + 1)$ size, \mathbf{y} is dependent variable vector of $n \times 1$ size, $\boldsymbol{\varepsilon}$ is random residual vector of $n \times 1$ size, and $\boldsymbol{\beta} = (\beta_0, \beta_1, \dots, \beta_p)^T$. One of the methods used to estimate the linear regression coefficient value ($\boldsymbol{\beta}$) is the least squares method (MKT), which minimizes the sum of the residual squares (Hastie *et al.* 2008). To obtain parameter estimation for $\boldsymbol{\beta}$, the results of estimation of equation (1) can be written as:

$$\mathbf{y} = \mathbf{X}\hat{\boldsymbol{\beta}} + \mathbf{e} \quad (2)$$

The purpose of MKT is minimizing the number of residual squares to $\hat{\boldsymbol{\beta}}$, namely:

$$\begin{aligned} \hat{\boldsymbol{\beta}} &= \underset{\boldsymbol{\beta}}{\operatorname{argmin}} \operatorname{JKS}(\boldsymbol{\beta}) \\ &= \underset{\boldsymbol{\beta}}{\operatorname{argmin}} (\|\mathbf{y} - \beta_0 \mathbf{1} - \mathbf{X}\boldsymbol{\beta}\|_2^2) \end{aligned} \quad (3)$$

so as to resulting in $\hat{\boldsymbol{\beta}}$ that have unique solution as follows:

$$\begin{aligned} \mathbf{X}^T \mathbf{X} \hat{\boldsymbol{\beta}} &= \mathbf{X}^T \mathbf{y} \\ \hat{\boldsymbol{\beta}} &= (\mathbf{X}^T \mathbf{X})^{-1} \mathbf{X}^T \mathbf{y} \end{aligned} \quad (4)$$

In the case of multicollinearity, namely and ill-conditional of matrix $\mathbf{X}^T \mathbf{X}$ namely $\mathbf{X}^T \mathbf{X}$ matrix approaching singular, then the matrix does not have invers (Draper and Smith 1992). As a result, unique estimation value cannot be obtained.

L₁ (LASSO) Regularization

The LASSO (least absolute shrinkage and selection operator) technique still may eliminate some important independent on ill-conditional data (Soleh and Aunuddin, 2013). This technique aims to overcome the problem in the accuracy of estimation. Hastie *et al.* (2008) states that the estimation of the coefficients using the LASSO technique can be written in the lagrange equation to minimize the sum of the squares remaining, with constraints:

$$\|\boldsymbol{\beta}\|_1 \leq t, \quad t \geq 0. \quad (5)$$

t value is a quantity that controls the amount of shrinkage in the coefficient estimation. If $\hat{\beta}_j$ is the least square estimator and $t_0 = \|\boldsymbol{\beta}\|_1$, then the $t < t_0$ will cause the MKT

solution to shrink to zero, and allows some coefficients to shrink to exactly zero. Hastie et al. (2008) states the estimation of the coefficients using the LASSO technique can be written in the lagrange equation to minimize the sum of the residual squares, as follows:

$$\begin{aligned}\hat{\beta}^{\text{lasso}} &= \underset{\beta}{\operatorname{argmin}} \operatorname{JKS}(\beta, \lambda) \\ &= \underset{\beta}{\operatorname{argmin}} (\|\mathbf{y} - \beta_0 \mathbf{1} - \mathbf{X}\beta\|_2^2 + \lambda \|\beta\|_1), \quad \lambda \geq 0\end{aligned}\quad (6)$$

in this case λ is the LASSO parameter with value of $\lambda \geq 0$. To obtain a coefficient estimate solution can not be obtained in closed form, but must use quadratic programming (Tibshirani 1996).

Population and Samples

The population in this study was the stock market in the region of ASEAN countries and the G7 countries stock market. The study sample covers the countries of Indonesia, Philippines, Malaysia, Singapore, Thailand, America, Germany, Japan, Italy, France, Canada and England. The reason for sampling for the five ASEAN countries mentioned above was because the capital market capitalization of the five ASEAN countries contributed 98 percent to the total capital market capitalization of ASEAN. While the G7 capital market has been a major player globally for more than decades.

Data Collecting Technique

Data collection method used was documentation method, namely data collection method by quoting or recording directly the data from daily report, financial report and website of each capital market under study. The data used in this research was stock price closing data in several countries such as Indonesia, Malaysia, Singapore, Philippines, Thailand, America, Germany, Japan, Italy, France, Canada and England. Sources of data was obtained from BEI and yahoofinance.com website.

Research Variables

The variables in this study include the Indonesian stock market as the dependent variable, while the stock market in ASEAN region such as Malaysia, Singapore, Philippines, Thailand and G7 stock markets consists of America, Germany, Japan, Italy, France, Canada and UK as independent variable. This research uses daily closing stock price over the period from January 1, 2000 to December 31, 2014.

Analysis Technique

The analytical procedures with the least squares and LASSO methods in the case of stock market data in Indonesia are as follows:

1. See the correlation between independent variables and between independent with dependent.
2. See the value of Variance Inflation Factor (VIF) to find out multicollinearity in the data.

3. Conduct the modeling analysis by linear regression using the least squares by conducting parameter estimation of $\beta_0, \beta_1, \dots, \beta_{11}$.
4. Conduct the modeling analysis by linear regression using the LASSO technique in stock market data. The steps are as follow:
 - a. Determine the optimum scale of controller parameter of LASSO (λ)
 - b. Model the linear regression using optimum λ chosen from LASSO by using glmnet package in the R statistic computation software.
5. Determine the best model from the model candidate of the results of the least square and LASSO method approach.

Findings

Multicollinearity and Correlation between Variables

If the correlation between two variables ≥ 0.50 means that the variable has a fairly strong correlation. Whereas the correlation value of +1 indicates that both variables have a perfect positive linear relationship, the correlation of -1 indicates that both variables have a perfectly negative linear relationship.

Table 1. Correlation Value of Independent Variable in 2000 – 2014

	Y	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀	X ₁₁
Y	1.00	0.51	0.84	0.95	0.97	0.80	0.56	0.75	-0.21	0.80	-0.63	0.01
X ₁	0.51	1.00	0.47	0.49	0.50	0.44	0.33	0.41	-0.06	0.44	-0.27	0.06
X ₂	0.84	0.47	1.00	0.80	0.82	0.80	0.75	0.82	0.20	0.95	-0.19	0.35
X ₃	0.95	0.49	0.80	1.00	0.96	0.85	0.55	0.70	-0.20	0.76	-0.57	0.09
X ₄	0.97	0.50	0.82	0.96	1.00	0.88	0.64	0.81	-0.11	0.78	-0.54	0.15
X ₅	0.80	0.44	0.80	0.85	0.88	1.00	0.82	0.89	0.25	0.80	-0.17	0.49
X ₆	0.56	0.33	0.75	0.55	0.64	0.82	1.00	0.92	0.67	0.76	0.25	0.72
X ₇	0.75	0.41	0.82	0.70	0.81	0.89	0.92	1.00	0.45	0.83	-0.02	0.57
X ₈	-0.21	-0.06	0.20	-0.20	-0.11	0.25	0.67	0.45	1.00	0.25	0.88	0.86
X ₉	0.80	0.44	0.95	0.76	0.78	0.80	0.76	0.83	0.25	1.00	-0.14	0.41
X ₁₀	-0.63	-0.27	-0.19	-0.57	-0.54	-0.17	0.25	-0.02	0.88	-0.14	1.00	0.68
X ₁₁	0.01	0.06	0.35	0.09	0.15	0.49	0.72	0.57	0.86	0.41	0.68	1.00

There is a substantial correlation between several variables as shown in Table 1. The fairly strong correlated variables will resulting in violation of assumptions in the data. In this case, using LASSO analysis procedure to overcome this and as a comparison linear regression modeling using the least squares method will also be conducted.

Linear Regression Model Using the Least Squares Method

Based on the regression analysis conducted the model formed from the relationship between stock market in Indonesia with 11 other variables, obtained the model as Figure 1.

Figure 1. Stock Market Model using the Least Square Method

$$Y = -424.839 + 0.003 X_1 + 0.251 X_2 + 0.245 X_3 + 0.408 X_4 - 0.059 X_5 + 0.252 X_6 + 0.137 X_7 - 0.206 X_8 + 0.109 X_9 - 0.026 X_{10} - 0.052 X_{11}$$

The parameter estimator of b_0 of -424,839 is the expected value for the average Indonesian Stock Market (Y) if the parameter estimator of all variables is zero. The parameter estimator of $b_1, b_2, b_3, b_4, b_6, b_7,$ and $b_9,$ of 0.003, 0.251, 0.245, 0.408, 0.252, 0.137, and 0.109, respectively, is the expected value of the Indonesian Stock Market (Y) if the Malaysia, Singapore, Thailand, Philippines, UK, Germany, and Canada stock markets are changing for every single unit, this value means that each increase of one-unit stock market of those countries will increase the average of Indonesian Stock Market by 0.003, 0.251, 0.245, 0.408, 0.252, 0.137, and 0.109.

The parameter estimators of b_5, b_8, b_{10}, b_{11} of -0.059, -0.206, -0.026, and -0.052, respectively, is the estimation changes in the Indonesian Stock Market (Y) if the stock market of USA, French, Italy and Japan, respectively, changing every single unit, this value means that any increase of one-unit share market of those countries will decrease the average of Indonesia Stock Market by 0.059, 0.206, 0.026, and 0.052. This is inversely related to the correlation between the Stock Market of USA and Indonesia and between Japan Stock Market with Indonesia which is positively correlated, but at the time of modeling has a negative effect or not in accordance with the actual conditions. There is a possibility of violating the assumption of a linear relationship (correlation) between the independent variables, called multicollinearity.

Table 2. VIF Value of Each Independent Variable

Variable	VIF
X_1	1.364
X_2	16.174
X_3	31.066
X_4	60.991
X_5	18.483
X_6	30.47
X_7	38.766
X_8	115.529
X_9	13.674
X_{10}	79.297
X_{11}	7.992

Multicollinearity can be detected using the Variance Inflation Factor (VIF) value. Based on regression analysis conducted in Table 1, the predictor variable X_8 has a very large VIF value, therefore, it is concluded that there is a multicollinearity problem.

Linear Regression Modeling using LASSO Technique

Based on the analysis, the model was formed by the relationship between the stock market in Indonesia with 11 other variables, which obtained the model as in Figure 2.

Figure 2. Stock Market Model Using LASSO Technique

$$Y = -296.908 + 0.311 X_2 + 0.456 X_4 + 0.043 X_6 + 0.071 X_7 + 0.104 X_9 - 0.039 X_{10} - 0.039 X_{11}$$

The parameter estimates b_0 of -296.908 is the expected value for the average of Indonesia Stock Market (Y), if the parameter estimates of all variables are zero. The parameter estimates of b_2 , b_4 , b_6 , b_7 , and b_9 , respectively of 0.311, 0.456, 0.043, 0.071, and 0.104. The expected value of Indonesia Stock Market (Y) if Stock Market consecutive Singapore, Germany and Canada are changing every single unit, this value means that any increase of one-unit Stock Market of those countries will increase the average of Indonesia Stock Market by 0.311, 0.456, 0.043, 0.071, and 0.104.

The parameter variables of b_{10} and b_{11} are -0.039 and -0.039 respectively. The estimated value of Indonesia Stock Market (Y), if the Italian and Japan Stock Market respectively change every single unit. This value means that the increase of each Stock Market will decrease the average of Indonesia Stock Market at 0.039 and -0.039. This is inversely related to the correlation between Stock Market in Japan with Indonesia are positively correlated, but at the time of modeling has a negative or not in accordance with the actual conditions.

Comparing the Regression Model Using the Least Squares Method and LASSO

Comparison of coefficient values using the least squares method and LASSO can be seen in Table 3 as follows:

Table 3. Comparison of Coefficient Values of the Least Squares Method and LASSO

Independent Variable	Least Square Method	LASSO
X_1	0.003	0.000
X_2	0.251	0.311
X_3	0.245	0.000
X_4	0.408	0.456
X_5	-0.059	0.000
X_6	0.252	0.043
X_7	0.137	0.071
X_8	-0.206	0.000
X_9	0.109	0.104
X_{10}	-0.026	-0.039
X_{11}	-0.052	-0.039

In Table 3 it is discovered that the coefficient value of the LASSO technique tends to shrink toward zero so it has little effect on the dependent variable compared to the coefficient value of the least squares method. Independent variable (predictor) detected multicollinearity problem, coefficient of X_8 and shrinking precisely equal to zero. The precise zero depletion of the LASSO coefficient results in a simpler regression model as well as overcoming multicollinearity problems. Furthermore, if the estimation is conducted to both models, obtained the following correlation results:

Table 4. The Correlation of Estimation Results Using the Least Squares and LASSO Methods

Methods	
	Y
Y	1
Y Duga (MKT)	0.9972813
Y Duga (LASSO)	0.9966154

Based on the results in table 4, the correlation coefficient value using the least squares method is relatively the same as using LASSO. In general, LASSO is better than the least squares method because it uses a simpler model and the results are relatively equally good.

Conclusion

Based on the results and discussion in this study, it can be concluded that there is a substantial correlation between several variables, so that the strong correlation among variables will result in violation of multicollinearity assumptions in the data. In the predictor variable of X_8 has a very large VIF value, it shows that there is a problem multicollinearity.

The results of linear regression model using the least squares method shows that there is a difference between the correlation and the results of analysis using this method. Differences occur between the USA stock market and Indonesia stock market, Japan stock market and Indonesia stock market. Those stock markets have a positive correlation, but at the time of modeling has a negative or not in accordance with the actual conditions.

The results of linear regression model using LASSO technique conclude that the best model in Indonesia Stock Market data of 2000-2014 is using LASSO techniques, as follows:

Table 5. The Results of Linear Regression Model using LASSO Technique

$$Y = -296.908 + 0.311 X_2 + 0.456 X_4 + 0.043 X_6 + 0.071 X_7 + 0.104 X_9 - 0.039 X_{10} - 0.039 X_{11}$$

A relatively simple model by using the Singapore, Filipino, UK, Germany, and Canada Stock Markets has been able to portray the Indonesian Stock Market. This is also evidenced by the value of correlation coefficient between Indonesia Stock Market with the result of estimation by using LASSO technique approaching 1, namely 0.9966154. This study has limitations such as we compose a daily closing stock price over the period 15 years from 2000 to 2014. Thus, this research only estimates Indonesia and G7 stock market. For further research can estimate the ASEAN stock market and global stock market with time series more than 15 years.

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