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THE EFFECT OF COVARİANCE AND CORRELATİON AMONG SECURİTİES İN A PORTFOLİO AND PORTFOLİO RİSK REDUCTİON

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Abstract. *The risk of a portfolio can be minimized by increasing the number of securities held in the portfolio. Some studies concluded that risk, as measured by the standard deviation of return and the number of securities held in a portfolio are inversely proportional. However, there are some limitations to this approach. First, an investor can only hold a limited amount of securities before it becomes unmanageable and not economically viable. Second, the rate of risk reduction diminishes quickly as portfolio size increases due to the nature of the relationship and therefore further increase in portfolio size will only bring minor risk reduction. In order to reduce risk while maintaining the size of the portfolio, a new approach will be needed. This paper will examine the relationship between the covariance and correlation among portfolio components and risk by using multiple linear regression, with risk as the dependent variable and covariance and correlation as the independent variable. The findings of this paper suggest that there is a relationship between risk and correlation and covariance of portfolio components. It implies that risk reduction can be achieved without increasing portfolio size by appropriately matching the correlation and covariance of the securities in a portfolio.*

Keywords: *Diversification, Risk Reduction, Portfolio Selection, Covariance, Correlation, Capital Market*

INTRODUCTION

In traditional portfolio theory, investors are trying to maximize the return as well as minimize the risk (Yuan, 2014). One way to minimize risk is through diversification. Diversification is the process of allocating capital in a way that reduces the exposure to any one particular asset or risk (O'Sullivan, Arthur; Sheffrin, Steven M., 2003). Evans and Archer (1968) examined the rate of risk reduction as a function of the number of securities included in the portfolio through observations of securities from the Standard and Poor's Index in the period between January 1958 to July 1967. Evans and Archer (1968) concluded that there is a relatively stable and predictable relationship between the number of securities held in a portfolio and the level of portfolio dispersion, which takes the form of a rapidly decreasing asymptotic function. Yuan Zhao (2014) recreated the previous study using recent data from the securities in Standard and Poor's 500 Index for the period of December 2008 to December 2013, which reached similar conclusion. The original study also concluded that there were some doubts over the economic justification of increasing portfolio sizes beyond 10 securities as the rate of risk reduction is diminishing (Evan and Archer, 1968).

The rate of risk reduction as a function of the number of securities included in a portfolio diminishes quickly due to the nature of a decreasing asymptotic function and it would not be worthwhile to hold a large number of securities in a portfolio to reduce risk as the risk reduction will only be incremental. Therefore, a new approach of diversification must be taken in order to gain risk reduction while limiting the number of securities held in a portfolio. This paper will examine the relationship between risk reduction (dependent variable) and the covariance and correlation (independent variable) by using multiple linear regression. First, the mean monthly returns and standard deviation is calculated for each pair of group of stocks in the study. Then, the correlation and covariance for each group is calculated. Lastly, a multiple linear regression equation is calculated by using the standard deviation of each pair as the dependent variable and the correlation and covariance as the independent variable. The multiple linear regression model supports the hypothesis that a portfolio with a given number of securities can have a varying level of risk which is dependent on the covariance and correlation between its component. The result suggests that higher correlation and covariance between securities in a portfolio will likely increase the risk of the portfolio

LITERATURE REVIEW

According to Sharpe (1963), risk can be categorized into two type which are systematic risk and unsystematic risk. Systematic risk is largely associated with the market while unsystematic risk is due to the variations of each individual securities. Unsystematic risk can be reduced through diversification. Evans and Archer (1968) examines the relationship between risk reduction and the number of securities in a portfolio. Evans and Archer (1968) found that the relationship to be a decreasing asymptotic function. Yuan (2014) replicated the study and came to the same conclusion about the relationship between risk reduction and portfolio size. Two of these studies confirm that the relationship is robust because the relationship still holds despite of a different set of data used in the study. Both Yuan (2014) and Evans and Archer (1968) noted that an ideal portfolio should consists of 10 or less securities because larger portfolio size would only bring insignificant risk reduction and if the cost of increasing portfolio is taken into account,

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then it might not be economically viable to increase portfolio size beyond 10 securities. Also, in the study by Yuan (2014) the scatter plot shows that the level of portfolio risk with a given number of securities varies and these variations decreases as the number of securities in the portfolio increase. Therefore, it implies that there is a possibility of reducing risk without increasing portfolio size by diversifying in a certain manner.

Aksoy, Karatepe, Seçme and Benli (2013) studied the integration between Turkish and European stock markets. Aksoy et al. (2013) analyzes the correlation coefficient of returns between Turkey and Italy, Portugal, Greece, Ireland and Spain. Aksoy et al. (2013) found that countries that is strongly connected geographically and economically have higher correlations and vice versa. “A low return correlation coefficient among markets is considered as a sign of potential diversification benefits, and an opportunity for portfolio risk reduction” (Aksoy et al., 2013). Thangamuthu and Parthasarathy (2015) studied the stock market interdependence among South Africa, India and the USA and found that although the countries shows strong correlation, there is no long term relationship. Therefore, these markets offer possible diversification options. The two studies highlighted the role of correlation and subsequently covariance in diversification. Combining assets with low return correlation can be an option for investment diversification. However, as implied by Thangamuthu and Parthasarathy (2015) the degree of correlation would likely only be useful in the short-term rather than the long term.

METHODOLOGY

The study uses monthly prices from the components of the sectoral indices in the Indonesia Stock Exchange. There are ten industrial sectors, which are agriculture, mining, consumer, finance, infrastructure, manufacture, basic industry, property, trade and miscellaneous industry. A hypothetical portfolio of five stocks that consists of five companies with the largest market capitalization in the industry is created for each sectoral index. The study uses the data from five companies for each sector for all of the ten sectors, which totals to 50 companies. First, the mean monthly return for each sector is calculated. Then, a hypothetical two-sector portfolio that consists of 10 stocks is constructed by pairing each sector with one another. The combined mean return of each pair is calculated for each month and then the mean and standard deviation of return for each pair throughout the period of study is calculated geometrically. Geometric standard deviation which measures the variability of return serves as an indicator of risk for the portfolio. A higher number indicates a level of risk and vice versa. After the geometric standard deviation of return between each pair has been calculated, the covariance and correlation of return between each pair are calculated. The period of time being studied is between January 2014 and December 2018. A five year period is chosen because as noted by Gallagher (1995) and Thangamuthu and Parthasarathy (2015) correlation is only useful in examining the short-term relationship.

The calculation results provided the geometric standard deviation, correlation and covariance of return between each pair of sectors. This variable is then used to build a multiple linear regression model with geometric standard deviation as the dependent variable and correlation and covariance as the independent variable. Multiple linear regression is used to examine the relationship between risk and correlation and covariance between the components of a portfolio. The formula of the multiple linear regression model is:

$$\hat{y} = 5.026 + 0.169x_1 - 5.401x_2$$

where y is the geometric standard deviation, $x_1$is the covariance and $x_2$is the correlation between each pair of sector portfolio. The model is constructed using the geometric standard deviation, covariance and correlation from each of the 45 pairs of sector portfolio. The R Square or the coefficient of determination measures the fitness of data to the regression model. In this case, the model fits quite well with the data. The R Square value 0.865. The scatter plot for the data is given in Figure 1 below.

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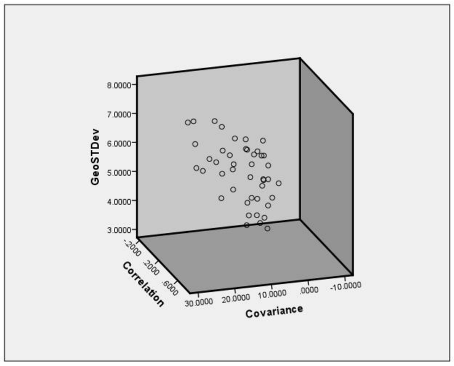

Figure 1. Scatter Plot of Geometric Standard Deviation, Correlation and Covariance

Lastly, the assumption of the multiple linear regression model is tested to ensure the robustness of the model. The assumption of linearity, normality, homoscedasticity, non-multicollinearity and no autocorrelation has been satisfied.

FINDINGS AND ARGUMENT

The model suggests that there is a positive linear relationship between covariance and risk and a negative linear relationship between correlation and risk. An increase of covariance between the pair of sector by 1 is expected to increase the geometric standard deviation of return by 0.169% and that the increase of correlation between a pair of sector by 0.1 (up to 1) is expected to decrease the geometric standard deviation by 0.54%. In order to illustrate this point, 10 pairs of sector are randomly selected and the calculation for the geometric standard deviation, correlation, covariance and expected geometric standard deviation for each sector is summarised in Table 1 below.

Table 1. Summary of Correlation, Covariance, Geometric Standard Deviation and Expected Geometric Standard Deviation

Sector Pair		Correlation	Covariance	Geometric SD	Expected Geometric SD
AGRICULTURE	INFRASTRUCTURE	0.282	13.087	5.73	5.71
INFRASTRUCTURE	BASIC INDUSTRY	0.251	13.49	6.71	5.95
AGRICULTURE	PROPERTY	0.151	10.816	6.54	6.04
CONSUMER	INFRASTRUCTURE	0.246	5.155	3.71	4.57
FINANCE	INFRASTRUCTURE	0.295	9.264	4.55	5.00
FINANCE	TRADE	0.24	5.954	3.98	4.74
MINING	PROPERTY	0.182	14.788	7.05	6.54
MANUFACTURE	BASICIND	0.413	25.051	7	7.03
MANUFACTURE	TRADE	-0.016	-0.422	3.78	5.04
PROPERTY	TRADE	0.044	1.575	4.79	5.05

As we can see from the table above, the sector pair with a higher level of covariances such as the infrastructure-basic industry, manufacture-basic industry and mining-property tend to have a higher level of risk. The reverse is also true, sector pair such as property-trade, manufacture-trade and finance-trade have a lower level of risk. This implies that the level of risk increases as the covariance between sector increase.

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Covariance measures the strength of the linear relationship between two numerical variables (Berenson et.al, 2015). Higher covariance between sector pair corresponds to a stronger linear relationship of return between two sector pairs, which means that these sectors tend to generate a similar return over a period of time.
On the other hand, the sector pair which has lower covariance tends to generate a return that is different between them. The difference in return would have an offsetting effect on each other which can reduce the extent of variability in return.

Figure 2 provides an illustration of this effect. Figure 2 shows the monthly return between January 2014 (Month 1) and December 2018 (Month 60) for Infrastructure-Basic Industry pair and Infrastructure-Consumer pair with a mean monthly return of 2.02% and 1.56% respectively. The Infrastructure-Consumer pair has a covariance of 5.15 while the Infrastructure-Basic Industry pair has a covariance of 13.49. The monthly return for the Infrastructure sector serves as a reference for when there is no diversification involved, with a mean monthly return of 0.62%. Diversifying into the basic industry sector which has a high covariance with the infrastructure sector caused higher volatility in return as compared to diversifying into the consumer sector which has low covariance. This is due to the fact that the infrastructure and basic industry sector move jointly and therefore lack the offsetting effect mentioned earlier. It can be seen from Figure 2 that the return for Infrastructure-Basic Industry pair tends to fluctuate more than the Infrastructure-Consumer pair. The range also shows that the Infrastructure-Basic Industry pair has a wider fluctuation than the Infrastructure-Consumer pair, with each having a range of 19.47% and 31.82% respectively.

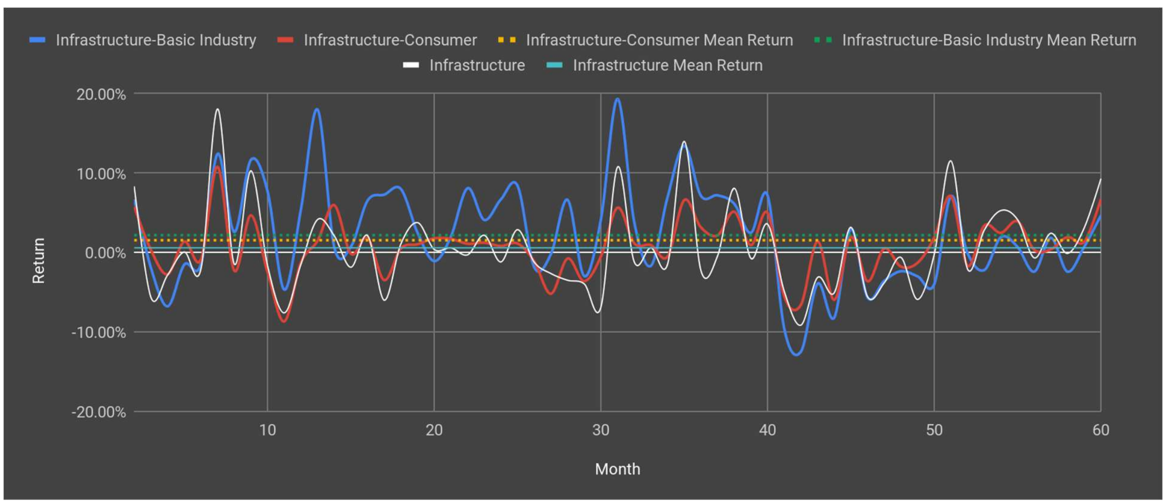

Figure 2. Monthly Return for the Infrastructure-Basic Industry and Infrastructure-Consumer sector pair

CONCLUSIONS

The result of the analysis suggests that a potentially predictable relationship between the level of risk and the covariance and correlation among the components of the portfolio, which implies that constructing a portfolio with components that have covariance and correlation that follows the model suggestion (preferably high correlation and low covariance) will result in a lower portfolio risk for a given number of securities in the portfolio. This is due to the fact that securities which have low covariance between them generate a different return and this difference creates an offsetting effect that reduces the fluctuation in return. However, there are some limitations to the methodology that was used in this paper. The methodology in this paper in this paper is useful for determining the relationship between a pair of securities in terms of risk, covariance and correlation but when it comes to a portfolio with more than two securities, the interaction between covariance and correlation among the components and its effect on portfolio risk is beyond the scope of this paper. Also, because covariance and correlation between any pair of securities tend to change over time, the reliability of the model in the changing market conditions would be uncertain. Therefore, some recommendations for further study are to develop a methodology that is able to examine how covariance and correlation between more than two securities affect the portfolio risk and replicate the study with a different set of data in order to test whether the model will hold.

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