ANALYSIS OF PORTFOLIO OPTIMIZATION WITH AND WITHOUT SHORTSELLING BASED ON DIAGONAL MODEL: EVIDENCE FROM INDONESIAN STOCK MARKET

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Abstract. *Markowitz mean-variance portfolio optimization theory is implemented for all stocks listed in Indonesian stock market during 2007-2011. This re- search used Sharpes diagonal model with the assumption that the market index is the only common factor with reference to which stocks covary. Re- sults shows that both well diversified short and long portfolios provide higher returns at a specified risk level compare to portfolios consist of individual sectors stocks. However least square parameters estimates were not quite promising such as value of portfolio beta happened to be less than individual stocks as well as value of its coefficient of determination shows most of the systematic risk could not get eliminated.*

Keywords*: Diagonal Model, Diversification, Portfolio Optimization, Short Sales*

Jel Codes:

Introduction

Background

Economics defined by Jim Tobin in one word as ‡incentives‡(Aumann 2006). The incentive for investors to invest in stocks rather than in risk free assets like government treasury bills is the relatively higher returns gain from stocks. Indonesian stock market has played a significant role during post 1998 crisis period as it emerged as a vital and efficient source of international as well as domestic funds inflow for businesses, and most importantly equity financing enabled business to be less worried about repayment to investors. In addition to this a significant portion of funds from pension funds,

insurance companies and other institutional and individual investors are invested in stock market therefore its performance does have wide consequences (Suta 2000).

According to Dimson et al. (1999) from the time of Bernoulli (1700-1782) it was known that individuals favour maximizing their wealth and minimizing the risk when pursuing any potential gain. However before 1952 there did not exist any mathematical treatment regarding distribution of funds among securities in order to obtain a diversified optimal portfolio. von Neumann et al.(1953) narrated that "in economic theory certain results....may be known already. Yet it is of interest to derive them again from an exact theory". The problem of mathematical formulation of a theory for portfolio risk and return was solved by Markowtiz (1952) and Roy (1952). Markowitz narrates that "portfolio with maximum expected return is not necessarily the one with minimum variance. There is a rate at which the investor can gain expected return by taking on variance, or reduce variance by giving up expected return". Markowtiz (1952) argued for what he called not only diversification but "right kind" of diversification for the "right reason" such that investors should diversify across industries and should only invest in securities having low covariances with each other. Since 1952 the most part of research in investment theory has focused on how to implement the Markowitz portfolio theory in order to obtain better estimates of risk and returns. Markowitz (1959) proposed critical line method for its solution and for any other quadratic programming problem.

Sharpe (1963) diagonal model made it computationally convenient to imple- ment portfolio theory by assuming "that single index model adequately describes the variance-covariance structure" (Elton et al.2007). Further attempts to sim- plify implementation of portfolio theory were made by Elton et al. (1976). How- ever financial economics faced criticism as well for these models such as McGoun (2003) declares financial economics a failure, it is a science which lacks positive models to describes the phenomenon of financial markets. Keasey et al. (2007) criticized that "finance keeps itself artificially alive by taking data from the out- side world, often ignoring the rich complexities of the context which has given rise to the data".

Perold (2004) has mentioned that even though the stock and option markets existed since 1602 and insurance markets since 1700s the understanding regard- ing risk was too little before 1960s. Risk as a concept based on the theory of probability. The concept of probability have existed long before the formation of stock markets. Gambling has been practiced throughout the documented history of human being. First systematic work on probability, Liber de Ludo Aleae (The Book of Games of Chance), appeared in 1663 in Basle first written by Girolamo Cardano in 1525 and revised in 1565 which paved the way for the concept of law of large numbers and he also defined how to express probability as a fraction (Bernstein 1995). However the theory of probability had contributed two of the most widely applied concepts in almost every science during 19th century, the idea of normal distribution and the idea of regression which were developed by Gauss and Galton during 1820s and 1880s respectively (Bernstein 1995).

Problem Formulation

This paper deals with portfolio optimization problem confronted by investors when selecting securities in stock market using Sharpe's diagonal model. Furthermore, it test compare the performance of less diversified optimal portfolios by investing in a single industry versus well diversified portfolio by investing across all industries. Finally we will elaborate precision and accuracy of the expected return and risk estimates using least square method and analyze the statistical properties of the estimates of diagonal model.

Literature review

The problem of portfolio optimization was formally formulated and solved by (Markowitz 1952) and (Roy 1952). Solution of optimization problem was facilitated due to the development of operation research during Second World War in order to solve complex military problems. In the year 2006 it came into knowledge of English speaking world that de Finetti, an Italian mathematician, in 1940 proposed mean variance solution to solve the problem of reinsurance. However the problem Markowitz tried to solve was related to investment while di Finetti was dealt the problem of insurance and apart from that there is no evidence that Markowitz or anyone even in Italy ever knew about the work of de Finetti (Bernstein 2007).

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The 1952 article on portfolio selection by 25 years old Markowitz considered as the birth of modern financial theory. Markowitz (1999) later generously regarded Roy (1952) too as the father of portfolio theory along himself, but he narrated that Roy's disappearance from academic publishing might be the reason he was not chosen for 1990 noble prize in economics. This led to the emergence of a series of theories which laid the foundation of modern finance as a distinct

academic field. Since 1952 many attempts has been made to implement the Markowitz portfolio theory.

Methodology

Model

Market index is the only common factor among varying stocks that covary with each other with reference to this common factor. For a single asset *i* it is (Zivot 2012)

$$R_{it} = \alpha_i + \beta R_{M\,t} + \varepsilon_{it} \quad (1)$$

where $R_{M\,t}$ = Return on market index, ε_{it} =Error term

Assumptions of the Diagonal model are as follows

$$\text{cov}(R_{M\,t}, \varepsilon_{it}) = 0, \ \text{cov}(\varepsilon_{it}, \varepsilon_{jt}) = 0, \ \text{cov}(\varepsilon_{it}, \varepsilon_{i,t-j}) = 0 \quad (2)$$

$$R_{Mt} \sim iid\ N\ (\mu_M, \sigma_M^2\ ), \varepsilon_{it} \sim iid\ N\ (0, \sigma_{\varepsilon,I}^2) \quad (3)$$

$\alpha_i,\ \beta_i,\ \mu_M,\ \sigma_M^2,\ \sigma_{\varepsilon,i}^2$ remain constant across time.

Statistical Properties of the Diagonal model are

$$E[R_{it}] = \alpha_i + \beta_{i\mu M} \quad (4)$$

$$var(R_{it}) = \beta_i^2 \sigma_M^2 + \sigma_{\varepsilon,i}^2 \quad (5)$$

$$cov(R_{it}, R_{jt}) = \sigma_M^2 \beta_i \beta j \quad (6)$$

$$R_{it} \sim N\ (\mu_i, \sigma_i^2) = N(\alpha_i + \beta_i \mu_M + \sigma_{\varepsilon,i}^2) \quad (7)$$

We would estimate parameters α and β of equation (59) using least square method where our objective is to find a solution in order to minimize the sum of squared residual errors. The minimization problem and its solution can be written as follows (Zivot 2012):

$$minSSR(\alpha_i, \beta_i) = \sum_{t=1}^{T} \varepsilon_{it}^2 = \sum_{t=1}^{T} (R_{it} - \alpha_i - \beta_i R_{Mt})^2 \quad (8)$$

Solution

$$0 = \frac{\partial SSR(\alpha_i, \beta_i)}{\partial \alpha_i} = -2 \sum_{t=1}^{T} (R_{it} - \alpha_i - \beta_i R_{Mt})^2 = -2 \sum_{t=1}^{T} \varepsilon_{it}^2 \quad (9)$$

$$0 = \frac{\partial SSR(\alpha_i, \beta_i)}{\partial \beta_i} = -2 \sum_{t=1}^{T} (R_{it} - \alpha_i - \beta_i R_{Mt})^2)\ R_{Mt} = -2 \sum_{t=1}^{T} \varepsilon_{it}^2\ R - Mt \quad (10)$$

$$\alpha_i = \mu_i - \beta_i \mu_M \quad (11)$$

$$\beta_i = \frac{\alpha_{iM}}{\alpha_M^2} \quad (12)$$

Once optimal portfolios are computed then we conducted performance analysis of these portfolios.

Data

Five years secondary data consisting of monthly stock prices are collected through IDX monthly statistics for all stocks listed at BEI during 2007-2011. In the 9 sectors of BEI 269 stocks were listed consistly during this period. Finance with 54 stocks was the largest sector followed by the trade,

services and investment sector with 51 stocks, while lowest number of 8 stocks were in the sectors of mining and agriculture (Tabel 1).

Diagonal model used in this research is a linear model and data used are time series data, therefore three basic assumptions of classical linear regression which are normality, autocorrelation and heteroscedasticity were tested. Data for ma- jority of stocks was not normally distributed however from Breusch-Godfrey LM Test no autocorrelation was found up to 2 lags as well as White test revealed that data is homoscedastic therefore ARCH/GARCH effect was not found and ordinary least square method is considered to provide accurate estimates of pa- rameters. Econometric tests are performed following EViews manuals of Firdaus (2011) and Rosadi (2012).

Table 1 Sectors Number of Stocks consistently Listed 2007-2011

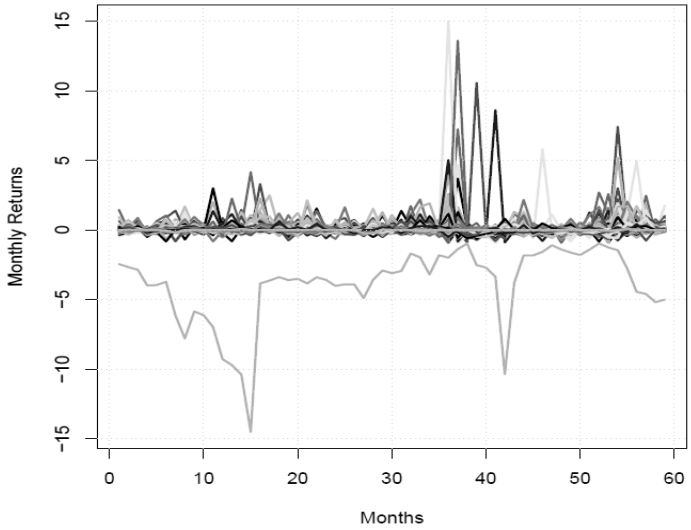
	Name of Sector	No of Stocks
1	Agriculture	8
2	Mining	8
3	Basic Industry and Chemicals	42
4	Miscellaneous Industry	32
5	Consumer Goods Industry	30
6	Property, Real Estate and Building Construction	26
7	Infrastructure, Utilities and Transportation	18
8	Finance	54
9	Trade, Services and Investment	51
	Total	269

Source: IDX Monthly Statistics (2007-2011)

Results and Discussion

Monthly returns of all 269 stocks are plotted in Figure 1, where 60 months during 2007-2011 period are shown on horizontal axis and returns on stocks are shown in percentages on vertical axis. During later half of 2009 and first half of

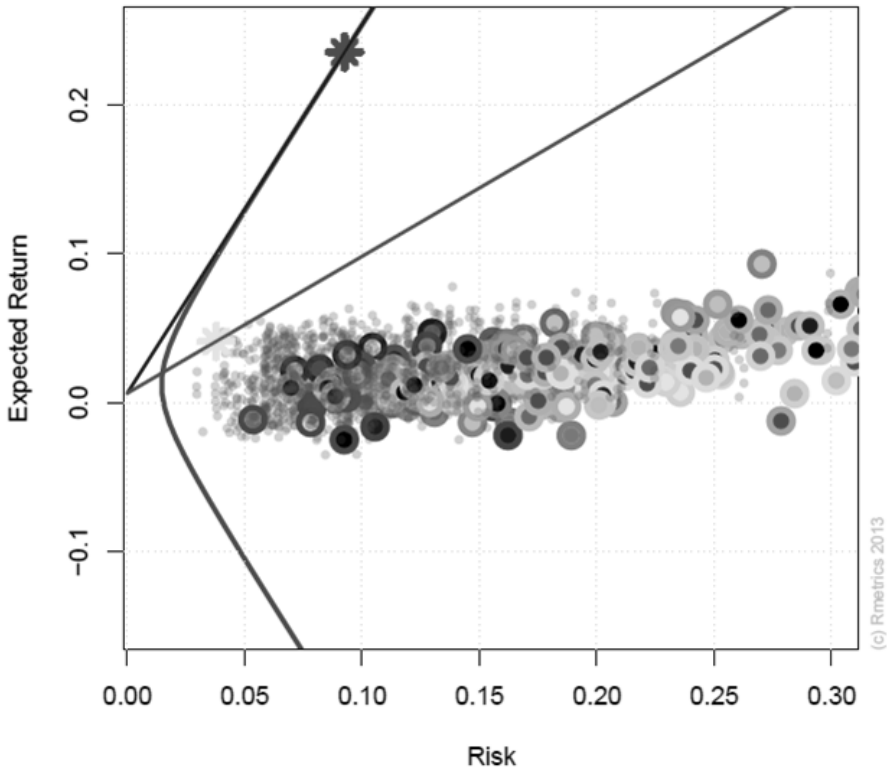
Figure 1 Return Plot of Monthly Prices of all Stocks in Indonesian Stock Market during 2007-2011



2010 the stocks provided highest returns in this duration as can be seen in the figure that 3 stocks even provided returns beyond 10%, contrary to the preceding years where monthly returns never reached upto 5 percent. In contrats to this the stock of pharmaceutical company Kimia Farma tbk from consumer goods industry constantly provided negative return. In the following we would present results and discuss the short and long portfolios consisting of all stock. Problem of portfolio optimization is solved for 2 different optimal portfolios firstly by imposing restriction that short sales is not permitted and then allowing for short sales.

Figure 2 illustrate the efficient frontiers of the two portfolios, the tangency point of short selling permitted portfolio is illustrated by the point where blue line crosses the red dot upon efficient frontier, this is the point where investor gain maximum return of 23.5 percent with the risk of 9.2 percent. In the same figure the tangency point for the portfolio with no short sales is shown where the red line crosses the yellow dot providing maximum return of 4.1 percent with the risk of 3.7 percent.

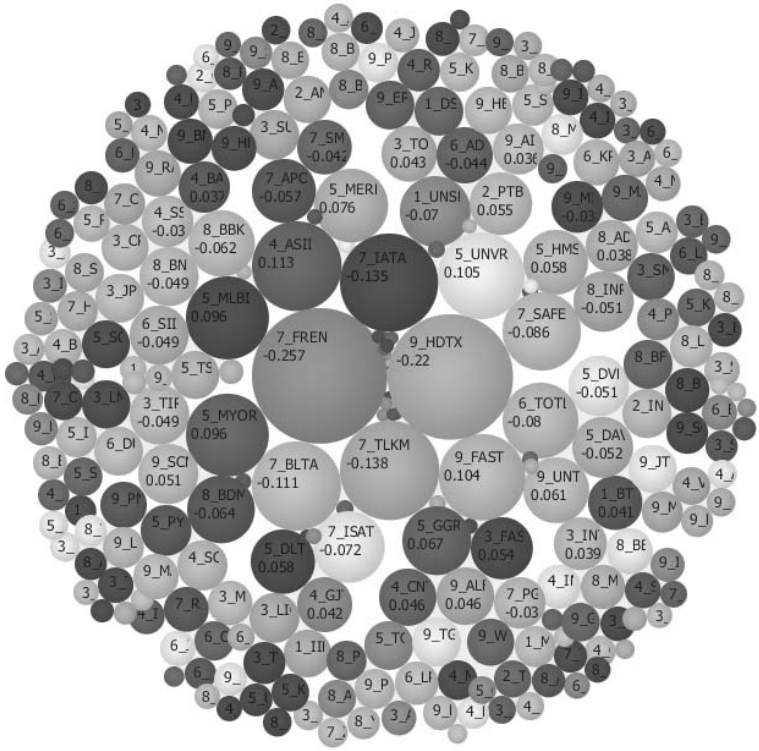
Figure 2 Efficient Frontier Optimal Portfolio with Short selling permitted and not permitted shown by blue and red lines respectively



It can be seen from the Figure 2 that the slope of the tangency portfolio is the efficient portfolio as its slope is greater than any other combination of risky security with riskless asset. Similarly slope of short portfolio is greater than the slope of the long only portfolio therefore it contribute more to the volatility of the market index. Portfolios with highest slope is the one that provide higher return at a specific level of risk. The colorful rounded dots represent the return and risk provided by any particular stock. Figure 2 also shows that stocks in the further southeast are riskier and provide higher returns and vice versa.

Largest proportion of fund that is 11.3 percent allocated to ASII stock from miscellaneous industry followed by UNVR stock from consumer goods industry with 10.5 percent as can be seen in Figure 4. There are negative investments as well due to permission of short selling. More than 25 percent of FREN stock from infrastructure, utilities and transportation are sold short followed by HDTX stock from trade, services and investment sector with 22 percent of its stock sold short. Optimal short portfolio is achieved by allocating investment into all 269 stocks by taking 87 negative positions and and 182 positive positions.

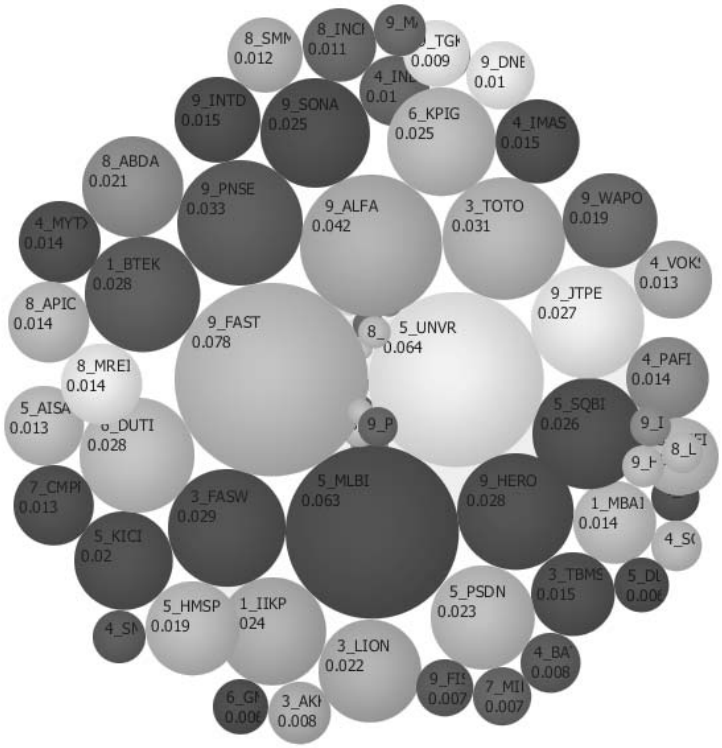
Figure 3 Circular Map of Optimal Portfolio Allocation with Short Selling



When short selling is not permitted then largest proportion of investment is allocated for FAST stock from trade, services and investment sector and UNVR stock from consumer goods industry with 7.8 percent and 6.4 percent respectively as illustrated in Figure 5. Optimal portfolio in this case is achieved by allocating investment into 69 stocks by taking only positive positions while making no in- vestment in remaining 200 stocks.

Table 2 shows that among short portfolios infrastructure, utilities and trans- portation portfolio provide returns 4 times higher than the all stocks portfolio however the risk is 16 times greater than the return for all stock portfolio.

Figure 4 Circular Map of Optimal Portfolio Allocation with no Short Selling



It is also revealed that among long portfolios the agriculture portfolio provide return approximately 2 times higher than the return from all stocks portfolios however with the 5 times greater risk. Allocation of more funds to stocks such as GSMF, ENRG, SULI and any other stock with β greater than 1 (which is market β has increased the volatility of market due to their high β values, for instance β for above stocks are 3.9, 2.4 and 2.1 respectively. From regression analysis it is found that there are stocks with β closer to one than β of the portfo- lio portfolio for instance the β of all stocks portfolio which should have resemble the market β is quite surprisingly close to 0 for short and 0.3 for long portfolio indicating that these portfolios do not contribute much to the volatility of market which is theoretically not correct. Sharpe's Measure reveals that both all stocks short and long portfolios have the highest ratios compare to any sectoral portfolio.

The diversification effect shown by the value of residual standard error of 0.04 for all stocks no short portfolio which is lowest than any individual stock as illus- trated in Figure 5 that residuals are more close with regression line, however the value of of its R^2 is not the highest. Value of R^2 show the portion of systematic risk that can not be diversified away.

Conclusion

Optimal portfolios were computed for short and long portfolios, where slope of all stocks short portfolio is greater than long portfolio. Largest proportions of stocks shorted are from infrastructure, utilities and

transportation sector equaling

17.2 percent. Largest proportion of stocks in long only portfolio are from trade, investment and services sector equaling 23.2 percent.

The more diversified and larger portfolio provide better tangency portfolio. All stocks short and long portfolios performed better than any other individual sector portfolio. Standard error for β and residual standard error are large compare to individual stocks indicating risk was not reduced due to diversification. Low values of R^2 for portfolios shows that most of the market variance not explained by them.

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