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Optimalization Stock Portfolio LQ45, With Linear Programming Method Period 2003 – 2009

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There many factors that should be considered when someone want to invest their money into stock market. The market analysis consists of fundamental analysis and technical analysis. The research combine those analysis into quantitative analysis, to select stock, optimizing portfolio, and evaluate the optimum portfolio by using a back-testing simulation of last 60 days of the reseach data. This paper used LQ45 as the first criteria for stock selection. The Linear programming is used to optimize portfolio allocation with several constraints. The objective function is to minimize CV. Data from Indonesian Stock Exchange, period 2003 – 2009. The result shows that the minimum CV at portfolio consists of 63% SMCB, 18.31% INDF, and 18.69% AAL. The back-testing simulation shows that the portfolio grew from Rp 57 millions to Rp 71 millions in 60 days. The statistic test results that even the portfolio return is 4 times than its market return, its not significantly, but the portfolio risk is significantly greater than its market risk (α = 5%).

Field of Research: Finance

1. Introduction

Indonesia has about 230 millions peoples (Indonesian Statistic Bureau Center, 2009), became a nation with the largest population in South-East Asia. It has only about 310.000 investor (Indonesian Stock Exchange, 2009). Compare to Malaysia that has about 1/10 of Indonesia population, Malaysia has 25% active investors. The Indonesian people prefers to invest their money into banking sector, such as time deposits. In the last 5 years, Indonesian government and capital market instutions actively encourages many new investors to invest their money into capital market. At the end, this money flows to real sector to support economic growth.

In the 2007, Indonesian capital market has booming situation. Many mutual funds can earn gain of 50 to 70% a year. Since 2007, the Indonesian composite index (IHSG), is dramatically increase from 1,300 to 2,800. Even the first quarter of 2008, the Indonesian Composite Index has its record of 3,000, but the next

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quarter the market is crash, back to 1,300 because of global crisis. The crisis began because of default of supreme mortgage in US, and it spreads widely to other sectors.

Today, there are more than 400 stocks listed in the Indonesian Stock Exchange. Besides the Composite Index, there is LQ45 index consists of 45 most liquid stocks in the market to guide the investors (Indonesian Stock Exchange, 2008). But investor can not select all of those stocks because they only have a very limited fund. They need some additional guidance, so they can focus to several stocks to maintain their portfolio. And, they need some tools to optimize their portfolio.

The LQ45 capitalization is about 70 – 80% of total Indonesian Stock Exchange (Indonesian Stock Exchange, 2008), it means that the 45 stocks became market mover. This index is often used as criteria of stock selection to optimize portfolio performance. Elton & Gruber (1995) used single index model to optimize portfolio. First, all of stock was ranked by excess return to beta ratio. Then, stock was selected if it included before or at the Cut-off.

Sudaryanto (2001) applied this concept to optimize portfolio in Jakarta Stock Exchange. Soemapradja (1998) was also applied this concept with different method, the tableau model, to optimize portfolio consists of commodities futures in Tokyo Grain Exchange – the tableau model (Elton & Gruber, 1995) was used because there is no market index in commodity futures exchange.

This paper intends to use LQ45 as the stock selection criteria and to determine the optimum portfolio using linear programing.

2. Literature Review

The Indonesia Stock Exchange (Indonesian Stock Exchange Guidance, 2008) now has 8 type of index as investor guidance when trading to the market :

1. Composite Index (IHSG), based from all of listed stocks
2. Sectoral Index, based from industry / sector / sub sector
3. LQ45 Index, 45 selected stocks, based on stock liquidity, market capitalization, and certain criterias
4. Jakarta Islamic Index (JII), 30 stocks which based on shariah, high liquidity, market capitalization
5. Kompas 100, 100 stocks selected, based on certain criterias
6. Main Board Index, big market capitalization stocks
7. Development Board Index, based on certain development criterias
8. Individual Index, stock individual index

LQ45 established on February 1997, consists of 45 highly liquidity stocks and market capitalization, with selection criterias (Indonesian Stock Exchange Guidance, 2008) :

1. At least already listed 3 months
2. Included to 60 selected stocks in requlat market
3. The best 30 selected stocks in regular market is automatically listed to LQ45 stock list.
4. The other 15 stocks was selected with certain criterias, such as day trading in regular market, transaction frequency in regular market, and market capitalization

The LQ45 stock list was evaluated every 3 months, and revised every February and Augustus of current year. The market capitalization of 45 stocks in LQ45 stock list represent about 70-80% of of market capitalization (Indonesian Stock Exchange, and Limas Stockhomindo, 2008). The Sectoral Index is the sub sector of Indonesian Composite Index. All of listed stocks were classified into 9 sectors based on Jakarta Industrial Classification (Jasica), they are : Agriculture, Mining, Basic industri and Chemical, Miscelaneous Industry. Consumer Goods, Property and Real Estate, Transportation and Infrastructure, Finance, and Trades, Service and Investment.

Diversification is used to reduce total risk of portfolio (Elton & Gruber, 1995). Portfolio optimization is related to minimize portfolio risk and maximize portfolio return, therefore, the Coefficient of Variation (CV) became a risk measure more complete. The optimum portfolio problem can be formulated into linear programming and can be solved using linear programming solver (Wurtz, 2009).

Linear programming is a model that consists of linear relationships representing a firm's decisions, given an objective and constraints (Taylor, 2006). This model can be used to solve business problems, such as maximize profit, and minimize costs. The model must be solved by using mathematical techniques. Ms Excel can be used to solve linear programming problem, solver must be installed first with some activation procedures (Arifin, 2007).

3. Methodology and Research Design

Types of data used in this study are secondary data, derived from the Indonesian Stock Exchange site as the manager of the stock market in Indonesia. Sampling is based on research objectives, namely to do the selection, portfolio optimization and evaluation of simulation, then including purposive sampling. Some of the methods used to analyze the data and calculations are :

1. Adjusted Risk Ranking to rank stocks based on historical performance that led to the selection of stocks that make up the optimum portfolio.
2. Linear Programing to determine the portfolio optimization based on objective function (minimization of risk-adjusted or CV). To facilitate the calculation iteration, the study uses the help function on Ms Excel Solver.
3. Two-sample test methods Analysis of Variance (ANOVA) to determine whether two samples come from the same population, to test the research hypothesis

Research will be conduct into 5 stages, there are :
1. Selecting stock that always listed on LQ45 index during 2003-2009
2. Selecting stock based on stock performance during the last 60 days of research data
3. Selecting stock based on stock rationalization
4. Optimizing stock allocation with linear programming approach
5. Back-testing simulation and statistical test (Anova)

4. Discussion of Findings

Stage 1 : Selecting Stock from LQ45 Stock List

The first stage of the selection of shares, refer to the list of stocks selected in the list of stocks that make up the index LQ.45. Index LQ.45 launched since February 1997. Shares that are always selected on the basis of LQ45 data for the last 7 years is as follows :

Table 1. List of 10 Stocks That Always Listed in LQ45 During 2003-2009

Code	Company	Sector	Market Cap.
AALI	Astra Agro Lestari	Agriculture	MB
ANTM	Aneka Tambang	Mining	MB
ASII	Astra Internasional	Automotive	MB
BBCA	Bank Central Asia	Finance / Bank	MB
INDF	Indofood	Consumer goods	MB
ISAT	Indosat	Telecomunication	MB
MEDC	Medco Energi Int'l	Energy	MB
SMCB	Semen Cibinong / Holcim	Basic Industry	DB
TLKM	Telkom Indonesia	Telecomunication	MB
UNTR	United Tractors	Heavy equipment	MB

Source : Indonesian Stock Exchange - Nov 2009, MB = Main Board DB = Development Board

Handbook Based Stock Price Index Indonesia Stock Exchange (2008), the stocks selected in the list with the criteria LQ.45 index level of liquidity and market capitalization. List of the 45 stocks reevaluated every 6 months, every February and August. LQ45 index.

Stage 2 : Selecting stock from CV Rank

The last date of data is 24 November 2009, this research will use the last 60 days of data only. Stock as financial instrument, is catagorized to high fluctuation price movement, the maximum length of data must not exceed than 60 days of trading (Hull, 1996). Therefore, 27 Augustus 2009 will be the first date for the next analysis, simulation and evaluation.

Table 2. Stock Risk and Return During The Last 60 Days of Data

Code	Avg. Return	Std.Deviation	Sector
AALI	0.13%	1.53%	Agriculture
ANTM	-0.02%	2.80%	Mining
ASII	0.20%	2.59%	Automotive
BBCA	0.12%	2.16%	Finance / Bank
INDF	0.32%	2.77%	Consumer goods
ISAT	-0.05%	1.58%	Telecommunication
MEDC	-0.18%	2.52%	Energy
SMCB	0.42%	2.50%	Basic Industry
TLKM	0.08%	1.27%	Telecommunication
UNTR	0.19%	2.39%	Heavy equipt.

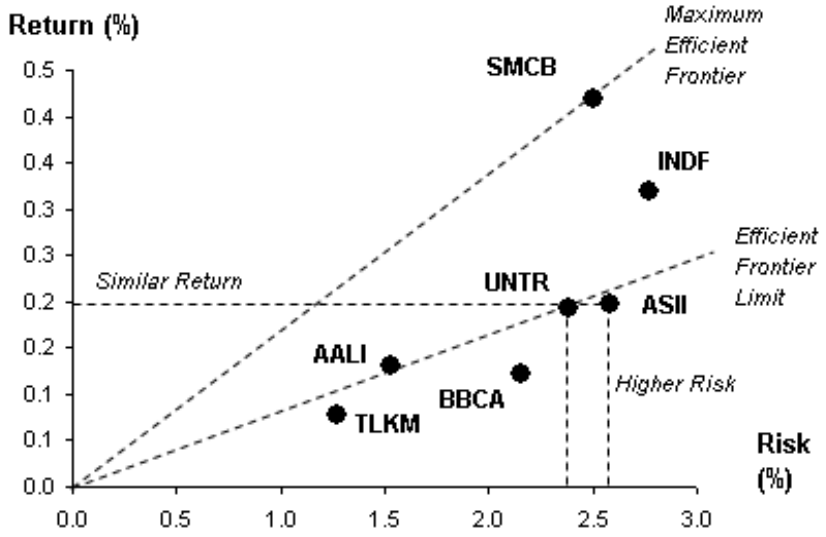
Source : Indonesian Stock Exchange - Nov 2009

ISAT, MEDC, and ANTM are not selected to the next step because they have negatively return. The other 7 stocks are ranked based on Coefficient of Variation (CV), with ascending order as follows :

Table 3. Stock Rank Based on CV

Stock Code	Avg. Return ($\overline{R}_i$)	Risk (σ_i)	CV	Rank	Sector
SMCB	0.42%	2.50%	5.96	1	Basic industry
INDF	0.32%	2.77%	8.67	2	Consumer goods
AALI	0.13%	1.53%	11.59	3	Agriculture
UNTR	0.19%	2.39%	12.43	4	Heavy equipment
ASII	0.20%	2.59%	13.17	5	Automotive
TLKM	0.08%	1.27%	16.45	6	Telecommunication
BBCA	0.12%	2.16%	17.59	7	Finance / Bank

Picture 1. Efficient Frontier and Stock Selection



Based on Markowitz (1956) and Elton & Gruber (1995), the investor prefer to select stock with lower risk and higher return. Therefore, the efficient frontier will

be move from right-bottom to left-top, that is meaning, the tangency of efficient frontier on the left-top will greater than right-bottom.

Some adjustment ; The stock return of ASII is quite similar with UNTR, but ASII had higher risk than UNTR. This made ASII will not be selected. The consequences, the other 2 stocks that position below of UNTR efficient line will not be selected also (TLKM and BBCA). The investor prefers stock with similar return and lower risk (Alexander, Sharpe, Bailey, 2000). At this point, we have only 4 stocks to optimize in the next stage.

Stage 4 : Determine Available Fund

According to some stock trading company, we classified the minimum opening balance into this classifications :

Table 4. Minimum Opening Balance

Min. Openning Balance	Recommended to
Less than Rp 5 milllions	Beginner investor
Rp 5 - 25 millions	Beginners and novice investor
More than Rp 25 millons	Novice investor

This opening balance will be needed as a constraint when we use linear programming to determine the optimum stock allocations. Some others stock trading company request for higher minimum opening balance, such as Rp 100 billlions even more. This research will be made into 2 versions; first, the opening balance will not be used to determine the optimum stock allocations in percentages. The second version, the opening balance will be used, and the final answer of optimum stock allocation will be provided in number of Lot (1 Lot = 500 shares).

We determine the opening balance as maximum available fund. The second version of optimum portfolio is Rp 100 billions, because the linear programming calculations, using Solver (Ms Excel Add-ins), will automatically adjust the required fund to meet the constraints and achieve the objective. The additional benefit, we will know that the optimum portfolio should be recommended to beginner investor or novice investor, based on Table 3.

Stage 5 : Declare Variables and Equations

There are some variables and equations that should be declared before continue to the linear programming calculation :

S_1 = Number of Lot SMCB (int)* w_1 = SMCB allocation (%)
S_2 = Number of Lot INDF (int) w_2 = INDF allocation (%)
S_3 = Number of Lot UNTR (int) w_3 = UNTR allocation (%)
S_4 = Number of Lot AALI (int) w_4 = AALI allocation (%)

$\rho_{12} = 0{,}48$	$\rho_{23} = 0{,}21$	$\overline{R}_1 = 0{,}42\%$	$\sigma_1 = 2{,}50\%$
$\rho_{13} = 0{,}37$	$\rho_{24} = 0{,}46$	$\overline{R}_2 = 0{,}32\%$	$\sigma_2 = 2{,}77\%$
$\rho_{14} = 0{,}47$	$\rho_{34} = 0{,}43$	$\overline{R}_3 = 0{,}19\%$	$\sigma_3 = 2{,}39\%$
		$\overline{R}_4 = 0{,}13\%$	$\sigma_4 = 1{,}53\%$

*int = integer number in lot (1 lot = 500 shares)

Portfolio return equation :

$$R_{Port} = \sum_{n}^{1} w_i R_i = w_1 R_1 + w_2 R_2 + w_3 R3 + w_4 R_4$$

Portfolio risk equation :

$$\sigma_{Port} = \sqrt{\begin{matrix} w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + w_3^2\sigma_3^2 + w_4^2\sigma_4^2 + 2w_1w_2\sigma_1\sigma_2\rho_{12} + 2w_1w_3\sigma_1\sigma_3\rho_{13} \\ + 2w_1w_4\sigma_1\sigma_4\rho_{14} + 2w_2w_3\sigma_2\sigma_3\rho_{23} + 2w_3w_4\sigma_3\sigma_4\rho_{34} \end{matrix}}$$

Proportion of each stock :

$$w_1 = \frac{1280.S_1}{(1280.S_1 + 2650.S_2 + 13750.S_3 + 21650.S_4)}$$

$$w_2 = \frac{2650.S_2}{(1280.S_1 + 2650.S_2 + 13750.S_3 + 21650.S_4)}$$

$$w_3 = \frac{13750.S_3}{(1280.S_1 + 2650.S_2 + 13750.S_3 + 21650.S_4)}$$

$$w_4 = \frac{21650.S_4}{(1280.S_1 + 2650.S_2 + 13750.S_3 + 21650.S_4)}$$

Note : The number of 1280 is SMCB's price at the first day of calculation, so do 2650 for INDF, 13750 for UNTR, and 21650 for AALI.

Total allocation of all stocks must equal to 100% :

$$w_1 + w_2 + w_3 + w_4 = 1$$

Total stock value must not exceed to available fund of Rp 100 millions :

$$(1280.S_1 + 2650.S_2 + 13750.S_3 + 21650.S_4).500 \le 100 \ billions$$

Note : We must multiply all stock's lot with 500, because 1 lot consist of 500 shares.

The optimizing portfolio will be proceed into 2 versions :

1. Let the linear programming determine the optimum allocation for each stock in percentage, there for the maximum available fund wil not be used (version 1).

2. The maximum available fund is Rp 100 billions, the linear programming will adjust the required fund automatically, and the final result provides in number of lot for each stock (version 2).

Optimizing Portfolio Version 1

Objective Function : Minimize $CV = \frac{\sigma_{Port}}{R_{Port}}$

Constraint Funtions :

$w_1 + w_2 + w_3 + w_4 = 1$ $\quad 0 \le w_3 \le 1$

$0 \le w_1 \le 1$ $\quad 0 \le w_4 \le 1$

$0 \le w_2 \le 1$

Picture 2. Portfolio Version 1 on Ms Excel

Stock	W_i	R_i	σ_i	W_iR_i	$(W_iT_i)^2$		$2W_iW_jT_iT_jR_{ij}$
SMCB	1.00%	0.42%	2.50%	0.00%	6.25E-08	SMCB-INDF	6.65E-08
INDF	1.00%	0.32%	2.77%	0.00%	7.67E-08	SMCB-AALI	2.83E-08
AALI	1.00%	0.13%	1.53%	0.00%	2.34E-08	SMCB-UNTR	5.62E-08
UNTR	1.00%	0.19%	2.39%	0.00%	5.71E-08	INDF-AALI	1.75E-08
						INDF-UNTR	6.09E-08
						AALI-UNTR	3.14E-08
Total	**4.00%**			0.01%	**2.20E-07**		**2.61E-07**

Port Risk =	0.07%
Port Return =	0.01%
CV =	6.54

Note : Each stock allocation was 1% temporary

Picture 3. Final Result Optimizing Version 1

Stock	W_i	R_i	σ_i	W_iR_i	$(W_iT_i)^2$		$2W_iW_jT_iT_jR_{ij}$
SMCB	62.97%	0.42%	2.50%	0.26%	2.48E-04	SMCB-INDF	7.68E-05
INDF	18.36%	0.32%	2.77%	0.06%	2.59E-05	SMCB-AALI	3.33E-05
AALI	18.67%	0.13%	1.53%	0.02%	8.16E-06	SMCB-UNTR	0.00E+00
UNTR	0.00%	0.19%	2.39%	0.00%	0.00E+00	INDF-AALI	5.99E-06
						INDF-UNTR	0.00E+00
						AALI-UNTR	0.00E+00
Total	**100.00%**			0.35%	**2.82E-04**		**1.16E-04**

Port Risk =	1.99%
Port Return =	0.35%
CV =	5.69

Linear Programing conclude that the optimum portfolio consists of (rounded in 2 decimals) : 62.97% of SMCB, 18.36% of INDF, and 18.67% of AALI. UNTR is excluded, with minimum CV of 5.69.

Optimizing Portfolio Version 2

Objective Function : Minimize $CV = \frac{\sigma_{Port}}{R_{Port}}$

Constraint Funtions :

$w_1 + w_2 + w_3 + w_4 = 1$ $\quad 0 \le w_3 \le 1$

$0 \le w_1 \le 1$ $\quad 0 \le w_4 \le 1$

$0 \le w_2 \le 1$ $\quad (1280.S_1 + 2650.S_2 + 13750.S_3 + 21650.S_4).500 \le 100{,}000{,}000$

Linear Programing conclude that the optimum portfolio consists of (rounded in 2 decimals) : SMCB 57 lots (63.00%), INDF 8 lots (18.31%), and AALI 1 lot (18.69%). UNTR is also excluded, with minimum CV of 5.69. Both version of optimum portfolio have similar allocation and minimum CV, and UNTR was excluded. To find further results, research will make several recalculation with different available fund, from Rp 5 millions to Rp 100 millions, as follows :

Table 5. Portfolio Alternatives in Different Available Fund

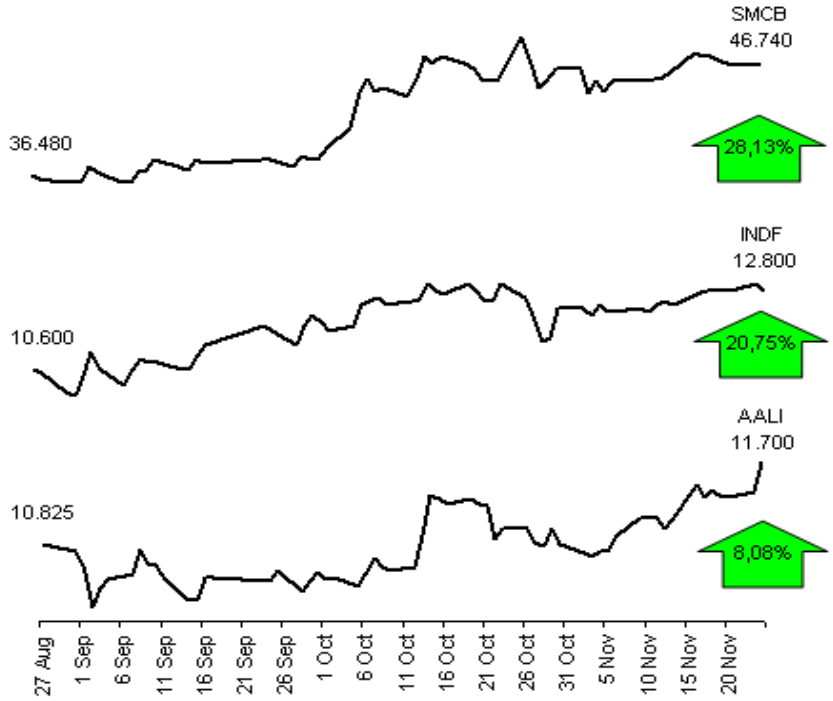
Port Code	Available Fund (millions)	Port Value (millions)	Optimum Allocation (Lot)				Port Risk (%)	Port Return (%)	Port CV
			SMCB	INDF	AALI	UNTR			
1	100	57.9	57	8	1	-	1.99	0.35	5.69
2	50	48.8	47	6	1	-	1.95	0.34	5.74
3	40	39.8	35	5	1	-	1.87	0.32	5.84
4	30	24.5	30	4	-	-	2.31	0.40	5.78
5	20	11.6	14	2	-	-	2.30	0.40	5.75
6	10	8.4	9	2	-	-	2.26	0.39	5.79
7	5	3.9	4	1	-	-	2.26	0.39	5.79

None of those portfolio alternatives select UNTR. The portfolio which value Rp 60 – 100 millions have similar composition; 57 lots of SMCB, 8 lots of INDF, and 1 lot of AALI. The best portfolio is the first portfolio, but it suitable only for investor who has at least Rp 100 billions of fund. The last portfolio is suitable for beginner investor, it only required Rp 3,9 millions

Portfolio Simulation and Evaluation (Stage 5)

The best portfolio (portfolio 1) is selected for further evaluation with back-testing simulation and statistic test – ANOVA (portfolio with CV of 5.66). This simulation was started from 27 Augustus until 24 November 2009 (60 days). At the first day of simulation, the portfolio value was Rp 57.9 billions, consist of Rp 36.5 billions of SCMB, Rp 10,6 billions of INDF, and Rp 10.8 billions of AALI. At the same day, the Indonesian Composite Stock Index was 2,356.

Picture 4. Back-Testing Portfolio in 60 days of data (thousands Rp)



Form Picture 8, the highest contribution came from SMCB, it grew 28.13% from the beginning value. Otherwise, the sum of contribution between INDF and AALI had almost equals to SMCB (20,75% + 8,08% = 28,83% ≈ 28,13%). INDF and SMCB had several different price movement, but at the end the portfolio value was still increasing slowly.

Picture 5. Back-Testing the last 60 days of data (Portfolio in thousands Rp)

Overall, this simulation showed that the portfolio average return (0.37% per day, and 23.03% in 60 days) was 4 times than the market index (0.09% per day and

4.92% in 60 days). The portfolio risk was 2.06% per day, and market index was 1.10% per day. The portfolio risk was twice than its market index. Those data will be tested with ANOVA.

Statistic Test : Portfolio Return

H_0 : The portfolio average return is less or equal to the market average return $(\mu_1 \le \mu_2)$

H_1 : The portfolio average return is greater than the market average return $(\mu_1 > \mu_2)$

$\overline{X}_1 = 0{,}37\%$ $\quad s_1 = 2.06\%$ $\quad n_1 = 59$ $\quad \alpha = 5\%$

$\overline{X}_2 = 0{,}09\%$ $\quad s_2 = 1{,}10\%$ $\quad n_2 = 59$

$$Z_{TEST} = \frac{\overline{X}_1 - \overline{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} = \frac{0{,}37\% - 0{,}09\%}{\sqrt{\frac{(2{,}04\%)^2}{59} + \frac{(1{,}10\%)^2}{59}}} = 0{,}904$$

$$Z_{SIG} = Z_{0.05} = 1.64$$

The statistic conclusion : Do not reject H_0 because $Z_{TEST} < Z_{SIG}$, therefore the portfolio average return is less or equal to the market average return $(\mu_1 \le \mu_2)$.

Statistic Test : Portfolio Risk

H_0 : The portfolio variance is less or equal to the market average variance $(\sigma_{1}^2 \le \sigma_{2}^2)$

H_1 : The portfolio variance is greater than the market variance $(\sigma_{1}^2 > \sigma_{2}^2)$

$s_1 = 2{,}06\%$ $\quad n_1 = 59$

$s_2 = 1{,}10\%$ $\quad n_2 = 59$

$$F_{TEST} = \frac{s_1^2}{s_2^2} = \frac{(2{,}06\%)^2}{(1{,}10\%)^2} = 3.513 \qquad F_{SIG} = 1.53$$

The statistic conclusion : Reject H_0 and do not reject H_1, therefore the portfolio variance is greater than the market variance significantly $(\sigma_{1}^2 > \sigma_{2}^2)$

5. Conclusion

1. During January 2003 - November 2009 there were 10 stocks which always selected into LQ45. Based on Coefficient of variation (CV) ranking, only 4 stocks are reselected for portfolio optimization. They are SMCB, INDF (Indofood), AALI, and UNTR.
2. By using Linear Programming method to find the minimum CV as objective function, the optimum portfolio should be allocated to 63% of SMCB, 18.31% of INDF, and 18.69% of AALI with CV of 5.66, while UNTR is excluded. The optimum portfolio value is Rp 57,9 millions. This portfolio composition is not suitable for beginner investor. The optimum portfolio value that suitable for beginner investor is between Rp 3.8 to 11,6 millions, is consist of only SMCB and INDF, with ratio 4 -7 lots of SMCB for every lot of INDF. The commissions fee has been considered for all allocations.
3. A back-testing simulation using last 60 days the research data shows that the portfolio return is 0.37% per day, or about 4 times of its market return which is only reach 0.09% per day. The largest contribution of portfolio return came from SMCB. This simulation also shows that portfolio risk is 2.06%, or about 2 twice of its market risk of 1.10%. The statistic test results (α = 5%) that the portfolio return is significantly lower than or equal to market return, whereas the portfolio risk (variance) is significantly greater than market risk.

Suggestions

1. The linear programming recommends that we should not take UNTR, because this stock allocation is too minimum, makes higher target return, and needs same fundamental analysis as other stocks.
2. Once the investors choose a higher stock price with limited fund, they should target to higher price to earn gain. This strategy is more speculative because the probability to achieve higher target price is low. SMCB and INDF are recommended because either they have relatively lower price than UNTR, we can buy them more lots. So, when their price have small increases, the multiplier effect of more volume can support to get the target gain easily. Besides, SMCB and INDF are defensive stocks.
3. In fact, even this back-testing simulation shows the optimum portfolio return is 4 times of its market return, unfortunately, this portfolio performance is not significantly at α = 5%. This is because the market trend is bullish. We must make further analysis to get better solution, so we do not need to use more speculatively strategy.

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