Portofolio Optimization Through MPT on any Economic Situation on Indonesian Stock Exchange (2010-2020)

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Abstract. Modern portfolio theory told us that investors are tend to optimize the expected return of investment subject to a target of risk perception. In the real world, risks are depend on may factors, such as systematic risk (market risk and macroeconomics risk which can not be controlled to diversification) and non-systematic risk (specific company risk which can not be controlled through diversification). Applying Security Market Line Approach, constrained maximization and considering changes in economic situation between 2010-2020, we found that Modern Portfolio Theory can improve portfolio performance when limited impact is spotted on minimizing systematic risk of portfolio.

1. Introduction
Investment is an activity conducted by economic agent to maintain the asset value against dropping value of money (inflation) and as a form of wealth accumulation. Maximizing investment return is the sole target of any investment activity. As economic agent delay their today’s consumption and keep the money in the other form (investment), improving wealth is the main target of this activity.

In relations to investment activity, economic agent invest their money in Portfolio, which defined as pool of funds which invest in wide range of investment product, which in this paper will be specifically doing analysis in stock market. Currently Indonesia Stock Exchange (IDX) have more than 500 listed companies which will be an option for the investment activity. Everyday, professional investment manager and retail investor face many possibilities of market movement and investment choice.

During the investment process, investor could pick one of so many available investment approach. In general, we have two analysis of stock market. The first is fundamental analysis which dig deeper the underlying situation of the company. The second method, we have technical analysis who analyze price pattern and momentum of the stock price.

In practice, Investment Manager performance is measured in the return of the investment and the risk. Good performance is associated with appropriate return for every risk added to the portfolio. High return investment but followed by high risk may not be considered as a good investment, while smaller return investment with low risk could be considered as good investment is the ratio is oke. In this research, we will analyze one of the option to optimized the portfolio value, through Modern Portfolio Theory, Capital Asset Pricing Model and Security Market Line.

Modern Portfolio Theory tell us about maximizing optimum investment result subject to specific desired risk level (portfolio return mean-variance). In this theory, investor should not invest only in one instrument, but spread out the portfolio in several instrument to lower the risk profile of portfolio.
In this theory, every investment instrument has their own properties and specific correlation with market and between the instrument. MPT assume that investors are tend to have risk aversion in nature, which means when investor faced several investment set who have similar profile of expected return, investor will put their money into investment set who has lower overall risk profile.

Effort made by investors to minimized the risk are called diversification. By definition, Diversification is a risk management strategy that mixed a variety of investments within a portfolio. A diversified portfolio contains a mix of distinct asset types and investment in an attempt at limiting exposure to any single asset or risk. The rationale behind this is that a portfolio constructed of different kinds of assets will, on average, yield higher long-term returns and lower the risk of overall portfolio. Diversification should be considered good and necessary if correlation between instrument is less than one (<1).

In mathematical equation, we could specify the formula below:

$$E(R_p) = \sum_{i} w_i E(R_i)$$  \hspace{1cm} (1)

which

$R_p$: Overall Portfolio Return

$R_i$: Instrument Return.

On the optimization process, investor will face this kind of constrain:

$$\sigma_p^2 = \sum_{i} w_i^2 \sigma_i^2 + \sum_{i \neq j} w_i w_j \sigma_i \sigma_j \rho_{ij}$$  \hspace{1cm} (2)

which $\sigma_p$: Portfolio Covariance.

In theoretical perspective, we we could explain that the optimum portfolio could be achieved through optimizing expected return subject to specific mean-variance target.

Talking about portfolio optimization, we need a measurement to calculate appropriate expected return. One of the useful theory called Capital Asset Pricing Model (CAPM). This is a method that are being used in investment world to define an expected return of the portfolio. This method define risk in two concept: systematic risk and non-systematic risk.

Systematic risk is a general risk which are related with overall business and macroeconomics environment (market risk). This kind of risk can not be lowered through diversification, since it is the overall risk of financial market.

In the otherside, we also have non-systematic risk, which is risk inherit from specific factors (idiosyncratic) of the company where we invest the money. In this case, non-systematic risk specifically is coming from company financial situation, expected corporate action, industry condition and other specific factors. This kind of risk could be lowered through diversification, by investing to company or sector which has low correlation between them.

Mathematically, we could write CAPM mode as:

$$\frac{E(R_f) - R_f}{\beta_i} = E(R_m) - R_f$$  \hspace{1cm} (3)

which

$E(R_f)$: Expected return of instrument

$R_f$: Risk free rate (central bank or government bonds yield)

$E(R_m)$: Overall stock market return

$\beta_i$: Beta, which could be defined as sensitivity of instrument investment return and stock market return.

Mathematically, we could re-write beta as:
Practically, expected return of investment is related with beta. The higher the beta, the higher volatility of instrument, relative to overall market situation. The lower the beta, the lower the expected return of the investment. Explanation on this situation will be discussed on Security Market Line topic, which is application of CAPM.

Security Market Line (SML), is a graphic which explain the equation in Capital Asset Pricing Model and explaining risk and return of instrument relative to systematic risk (Market Risk). The application of graphical explanation on CAPM through SML could be explained below:

\[ SML: E(R_i) = R_f + \beta_i [E(R_m) - R_f] \]

In the graphical explanation of the SML, Y axis is the expected return (Ri), while the X axis is the systematic risk of the instrument, while the intercept (Rf) is the risk free rate (central bank interest rate or government bond yield). Example of Security Market Line is explained below:

The higher Beta of the instrument, the higher expected return required, vice versa. For stock market picking criteria, the return of the stock should be higher than security market line to be considered undervalued and worth investing. In the other hand, if the instrument return is below Security Market Line, the investment is not to be considered as worthy as the return is not paying its expected volatility.

2. Methods
In building the portfolio, we should define the target that aimed on the research. In this paper, we divide the methods in four parts: 1. Defining the characteristic of every instrument, both in Beta, Expected Return and Real Return for every year, 2. Defining the market expected return (Rm), 3. Creating Security Market Line every year to define stock that are included on the portfolio, 4. Doing optimization technique to create investment weighting. Here is the details of the methods: mathematics anxiety questionnaire. The questionnaire was arranged by using the Likert Scale. We use the Pearson correlation formula, SPSS, and Microsoft excel to analyze the data.

1. Defining the instrument characteristic. In this phase, we calculate Beta, expected return and real return of each individual stock.
2. Defining market expected return. In this phase, we define market expected return by using growth of stock market Index (IHSG) that year.
3. Creating Security Market Line. In this phase, we calculate the security market line for every year and pick the stock based on the security market line, based on equation (5).
Stock will be categorized as worth investing (to be included on portfolio) or not worth investing (not to be included on portfolio).

4. Portfolio Optimization. In this phase, based on the worth investing phase we found in 3rd phase, we create optimization model based on the Modern Portfolio Theory (maximizing expected return subject to constraint). In this case, we use market β as a constraint.

In this research, we optimize portfolio assuming β = 1 to create a portfolio which perfectly have similar volatility level with stock market but with optimized return.

3. Results and Discussions
In this research, we pick the optimum portfolio out of 100 largest stock in Jakarta Composite Index (IHSG). 100 largest stock is a category used by major fund manager on defining ready to invest stock as largest stock tend to have better liquidity profile. Here is the list of 100 largest stock by market capitalization in Jakarta Composite Index.

| No. | Code | No. | Code | No.  | Code | No.  | Code | No.  | Code |
|-----|------|-----|------|------|------|------|------|------|------|
| 1   | BBCA | 21  | MEGA | 41   | BDMN | 61   | NISP | 81   | SLIS |
| 2   | BBRI | 22  | INKP | 42   | EXCL | 62   | BBTN | 82   | APIC |
| 3   | UNVR | 23  | DNET | 43   | PTBA | 63   | KAEM | 83   | MEDC |
| 4   | TLKM | 24  | MAYA | 44   | RMBA | 64   | BSDE | 84   | POWR |
| 5   | BMR | 25  | INTP | 45   | TCPI | 65   | DSSA | 85   | ASMI |
| 6   | ASII | 26  | BYAN | 46   | AALI | 66   | MKPI | 86   | ITMG |
| 7   | HMSP | 27  | EMTK | 47   | CASA | 67   | JPFA | 87   | GOOD |
| 8   | TPIA | 28  | INCO | 48   | SDO  | 68   | CTIA | 88   | STTP |
| 9   | ICBP | 29  | ADRO | 49   | TKIM | 69   | ISAT | 89   | INAF |
| 10  | SMMA | 30  | MDKA | 50   | BNGA | 70   | MNCN | 90   | HEAL |
| 11  | CPIN | 31  | BNLI | 51   | ULTI | 71   | LIFE | 91   | BRIS |
| 12  | BBNI | 32  | MIKA | 52   | FREN | 72   | CARE | 92   | SMRA |
| 13  | GGRM | 33  | PGAS | 53   | ANTM | 73   | IPTV | 93   | BBKP |
| 14  | UNTR | 34  | POLL | 54   | MLBI | 74   | AKRA | 94   | SMAR |
| 15  | BRPT | 35  | ARTO | 55   | PWON | 75   | MAPI | 95   | PLIN |
| 16  | KLBF | 36  | BTPS | 56   | PBPN | 76   | WIKA | 96   | BTM |
| 17  | INDF | 37  | AMRT | 57   | BTPN | 77   | DMAS | 97   | DMND |
| 18  | SMGR | 38  | TBIG | 58   | BNII | 78   | IBST | 98   | BSIM |
| 19  | MYOR | 39  | JSMR | 59   | SCMA | 79   | LPKR | 99   | WSKT |
| 20  | TOWR | 40  | ACES | 60   | FASW | 80   | BJBR | 100  | KPIG |

**Figure 2.** 100 Largest Stock in Indonesia Stock Exchange

In the stock picking for optimum portfolio, we have to include also change in yearly economic variable such as risk free rate and market return during period of the research (2010-2019). On this case, we mention the details of those variable value below:
|                | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|----------------|------|------|------|------|------|------|------|------|------|------|
| Em (Market Return), % | 43.8 | -0.4 | 11.9 | -1.0 | 24.4 | -20.3 | 16.2 | 24.3 | 0.2  | 1.9  |
| Rf (Risk Free Rate), % | 7.6  | 6.0  | 5.2  | 8.5  | 7.8  | 9.0  | 7.7  | 6.3  | 8.0  | 7.1  |
| GDP Growth, %     | 6.1  | 6.2  | 6.0  | 5.6  | 5.0  | 4.9  | 5.0  | 5.1  | 5.2  | 5.0  |
| Inflation, %      | 6.7  | 3.8  | 3.7  | 8.1  | 8.4  | 3.4  | 3.0  | 3.6  | 3.1  | 2.7  |
| Real Interest Rate | 0.9  | 2.2  | 1.5  | 0.4  | -0.6 | 5.6  | 4.6  | 2.7  | 4.9  | 4.3  |

Figure 3. Stock Market Return and Economic Indicator, 2010-2019

From the data, we could see that market return move in volatile manner. The general tendency is, when GDP growth higher and Real Interest Rate lower, stock market return tend to be higher, vice versa. It indicates the overall trend on systematic risk in the system which relate to Capital Asset Pricing Model, but do not explain the stock picking, as we need to define expected return of each instrument.

As an early part of the research, we conduct calculation of expected return of each stock using Capital Asset Pricing model. The first phase is by calculating the value of the stock beta. We get Beta by doing linear regression between daily stock market return as independent variable and specific stock return as dependent variable, as formulated below:

$$\beta_i = \frac{\text{Cov}(R_i, R_m)}{\text{Var}(R_m)}$$

Based on the calculation, we find the yearly Beta of each stock as follows:
Post Beta calculation, by knowing the market return, risk free rate and beta, we could calculate the expected return of each instrument. The result as follows:

![Figure 4. Stock Beta, 2010-2019](image_url)
After that, we calculate position for each stock at Security Market Line, by calculating difference between the return and expected return (Real Return – Ri). Stock with real return higher than the expected is qualified to be included on the portfolio. The details is below, with negative value means the stock is not qualified for the portfolio at the specific years.
After getting the qualified stock, we start to conduct optimization function as below:

$$\max E(R_w) \quad \text{s.t.} \quad \beta = 1$$

Stock picking conducted by assuming portfolio beta should be equal to market (β = 1). From the optimization, we get the weighting of investment for each year as below:
| Year | Weighting | 2010 | Weighting | 2011 | Weighting | 2012 | Weighting | 2013 | Weighting | 2014 | Weighting |
|------|-----------|------|-----------|------|-----------|------|-----------|------|-----------|------|-----------|
|      |           | UNVR | 0.00%     | BBCA | 1.90%     | BBCA | 1.86%     | BBCA | 1.85%     | BBCA | 1.85%     |
|      |           | ASI  | 2.57%     | BBRI | 48.23%    | TLMK | 10.70%    | BBRI | 57.51%    | BBRI | 43.30%    |
|      |           | HMPA | 0.29%     | UNVR | 1.03%     | BMRI | 1.03%     | UNVR | 0.00%     | UNVR | 0.00%     |
|      |           | TPMA | 0.21%     | BMRI | 8.28%     | TLMK | 6.51%     | BMRI | 0.00%     | BMRI | 0.05%     |
|      |           | SMMI | 0.00%     | ASI  | 2.86%     | HMPA | 2.46%     | BMRI | 0.01%     | HMPA | 39.28%    |
|      |           | CPIN | 5.43%     | HMPA | 0.00%     | TPMA | 2.64%     | BMRI | 0.15%     | HMPA | 39.28%    |
|      |           | BBNI | 1.08%     | CPIN | 3.83%     | SMMA | 0.87%     | CPIN | 0.01%     | CPIN | 0.15%     |
|      |           | GGRM | 0.00%     | BBNI | 1.98%     | GGRM | 1.74%     | BBNI | 0.01%     | BBNI | 0.09%     |
|      |           | UNTR | 4.52%     | GGRM | 1.74%     | UNTR | 1.81%     | GGRM | 0.86%     | GGRM | 0.07%     |
|      |           | KLIB | 0.88%     | UNTR | 1.81%     | KLBF | 2.01%     | UNTR | 3.61%     | KLBF | 0.02%     |
|      |           | MYOR | 0.24%     | KLBF | 2.01%     | SMGR | 0.85%     | KLBF | 0.86%     | SMGR | 0.07%     |
|      |           | MEGA | 0.29%     | SMGR | 0.85%     | MYOR | 1.34%     | SMGR | 0.86%     | MYOR | 0.09%     |
|      |           | BYAN | 0.00%     | MYOR | 1.34%     | MEGA | 0.11%     | MYOR | 1.74%     | MEGA | 0.07%     |
|      |           | BNLN | 0.24%     | MEGA | 0.11%     | BNLN | 0.24%     | MEGA | 1.98%     | BNLN | 0.00%     |
|      |           | AMRT | 0.54%     | BNLN | 0.24%     | AMRT | 0.76%     | AMRT | 1.28%     | AMRT | 0.00%     |
|      |           | JSMR | 0.15%     | AMRT | 0.76%     | JSMR | 0.00%     | JSMR | 0.11%     | JSMR | 0.11%     |
|      |           | ACES | 0.00%     | JSMR | 0.00%     | ACES | 1.03%     | ACES | 0.11%     | ACES | 0.11%     |
|      |           | EXCL | 0.16%     | ACES | 1.03%     | MLBI | 0.00%     | ACES | 0.11%     | MLBI | 0.00%     |
|      |           | TIKM | 0.17%     | MLBI | 0.00%     | BTPN | 0.11%     | MLBI | 0.00%     | BTPN | 0.11%     |
|      |           | BNGA | 0.72%     | BTPN | 0.11%     | SCMA | 0.69%     | BTPN | 0.11%     | SCMA | 0.69%     |
|      |           | ULLT | 0.18%     | SCMA | 0.69%     | FASW | 0.13%     | SCMA | 0.69%     | FASW | 0.00%     |
|      |           | MLBI | 0.00%     | FASW | 0.13%     | KAEF | 1.62%     | FASW | 0.13%     | KAEF | 1.62%     |
|      |           | PWON | 0.31%     | KAEF | 1.62%     | BSDE | 0.00%     | KAEF | 1.62%     | BSDE | 0.00%     |
|      |           | PBNN | 0.76%     | BSDE | 0.00%     | JPFK | 5.22%     | BSDE | 0.00%     | JPFK | 5.22%     |
|      |           | BTTP | 0.35%     | JPFK | 5.22%     | CTIA | 2.99%     | JPFK | 5.22%     | CTIA | 2.99%     |
|      |           | BNII | 1.96%     | CTIA | 2.99%     | ISAT | 0.14%     | CTIA | 2.99%     | ISAT | 0.14%     |
|      |           | SCMA | 0.16%     | ISAT | 0.14%     | MNCN | 0.74%     | ISAT | 0.14%     | MNCN | 0.74%     |
|      |           | FASW | 0.00%     | MNCN | 0.74%     | AKRA | 2.44%     | MNCN | 0.74%     | AKRA | 2.44%     |
|      |           | NISP | 0.28%     | AKRA | 2.44%     | MAPI | 1.12%     | AKRA | 2.44%     | MAPI | 1.12%     |
|      |           | BBTN | 41.98%    | MAPI | 1.12%     | STTP | 0.00%     | MAPI | 1.12%     | STTP | 0.00%     |
|      |           | DSSA | 0.13%     | STTP | 0.00%     | INAF | 1.02%     | STTP | 0.00%     | INAF | 1.02%     |
|      |           | JPFK | 0.38%     | INAF | 1.02%     | SMRA | 1.07%     | INAF | 1.02%     | SMRA | 1.07%     |
|      |           | MNCN | 5.58%     | SMRA | 1.07%     | SMAR | 0.72%     | SMRA | 1.07%     | SMAR | 0.72%     |
|      |           | AKRA | 0.37%     | SMAR | 0.72%     | KPIG | 2.51%     | SMAR | 0.72%     | KPIG | 2.51%     |
|      |           | MAPI | 0.33%     | KPIG | 2.51%     | Total | 100.00% | KPIG | 2.51%     | Total | 100.00% |
|      |           | WIKA | 6.35%     |        |           |       |       |        |       |       |
|      |           | LPKR | 0.26%     |        |           |       |       |        |       |       |
|      |           | APIC | 0.00%     |        |           |       |       |        |       |       |
|      |           | ITMG | 1.23%     |        |           |       |       |        |       |       |
|      |           | STTP | 0.00%     |        |           |       |       |        |       |       |
|      |           | SMRA | 1.36%     |        |           |       |       |        |       |       |
|      |           | BBKP | 3.48%     |        |           |       |       |        |       |       |
|      |           | SMAR | 6.07%     |        |           |       |       |        |       |       |
|      |           | KPIG | 0.00%     |        |           |       |       |        |       |       |
|      |           | Total | 100.00% |        |           |       |       |        |       |       |
Based on the calculation above, we get the portfolio return in 2010-2019 reflected in table below.

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 |
|------|------|------|------|------|------|------|------|------|------|------|
| Market Return | 43.80 | -0.39 | 11.89 | -0.98 | 24.36 | -20.30 | 16.21 | 24.34 | 0.18 | 1.91 |
| Portfolio Return | 301.25 | 36.87 | 57.40 | 21.01 | 42.22 | 5.82 | 90.52 | 45.31 | 35.97 | 19.16 |
| Excess Return | 257.45 | 37.26 | 45.51 | 22.01 | 17.86 | 26.12 | 74.11 | 20.97 | 35.79 | 17.25 |

**Figure 7. Weighting of Selected Stock, 2010-2019**

**Figure 8. Comparison between portfolio return and market return, 2010-2019**

4. **Conclusion**

From the results above, we can conclude that:

1. Applying the modern portfolio theory and CPAM CPAM could reduce the risk profile of portfolio and add return enhancement as overall return is above market benchmark
2. The portfolio could reduce the unsystematic risk as return edged higher at lower volatility.
3. Systematic risk in term of Beta could be lower, but the overall correlation between return of portfolio and overall market remain high, providing indication that we can not fight agains some economic downturn, such us downturn during current market volatility
4. We need to recalibrate and upgrade the Portfolio Model periodically to sustain long-term superior return.
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