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Applying Monte Carlo Concept and Linear Programming in Modern Portfolio Theory to Obtain Best Weighting Structure

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The world is entering the era of recession when the trend is bearish and market is not so favorable. The capital markets in every major country were experiencing great amount of loss and people suffered in their investment. The Jakarta Composite Index (JCI) has shown a great downturn for the past one year but the trend bearish year of the JCI. Therefore, rational investors should consider restructuring their portfolio to set bigger proportion in bonds and cash instead of stocks. Investors can apply modern portfolio theory by Harry Markowitz to find the optimum asset allocation for their portfolio. Higher return is always associated with higher risk. This study shows investors how to find out the lowest risk of a portfolio investment by providing them with several structures of portfolio weighting. By this way, investor can compare and make the decision based on risk-return consideration and opportunity cost as well.

Keywords: *Modern portfolio theory, Monte Carlo, linear programming*

Introduction

The crisis was first triggered by the sub-prime mortgage issues in the US financial market. At that time (over and about year 2006-2007), some people and organizations might actually have already been aware regarding the latent problems of sub-prime mortgage prior to the current crisis that the world is now facing. US investment banking industry has failed and collapsed. The financial crisis has become one of the most radical reshaping of the global banking sector. Meanwhile, governments and the private sector battle to shore up the financial system, following the disappearance of Lehman and Merrill as independent entities and the billions of dollars government rescue of AIG.

The housing market in US is related to the mortgage industry in significant term. And at that time, investment bankings were mainly invest the fund into the mortgage-backed securities, issued by some institutions which securitize the mortgage into MBS. This is one of the investment vehicle that eventually has hurt the investors. There are lots of varieties of instruments available in the market. Allocating all the funds into single instrument is significantly vulnerable to risk (Bodie, Kane, and Marcus, 2008). Otherwise, putting funds partially into more than one instrument may distribute the risk of investing as well as the return itself. Return is the proceeds gained from the willingness to take the risk (Damodaran, 2002). The higher the risk, the higher the potential gain in return.

The way in allocating the funds into some available instruments of investment is the basis of effective diversification in portfolio management. Diversification is a powerful method to manage investment risk. While diversification is good, certain types of diversifications are bet-

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ter. This was the premise of Harry Markowitz's Nobel Prize winning theory. He showed that when the assets in a portfolio do not move in concert with each other, their individual risks can be effectively diversified away (Gibson, 1996). Diversification among assets that move together is ineffective diversification. Effective diversification reduces portfolio volatility and smoothes out the returns. In general, anything that reduces volatility eventually increases the compound rate of returns.

Effective diversification can be done through an effective asset allocation. Asset allocation is an investment method that pools or combines various asset classes such as stocks, bonds, and cash in a single portfolio of investment. It has to wise in terms of risk and return on portfolio investment in order to have an effective diversification. Back to the above example, conducting such allocation may move the investor away from the effective assets allocation and possibly even expose the investor to more risk if the pool of assets was not well-diversified since the first time. If that is the case, then it is the time the conservative investors should step in and bring the portfolio into the effective diversification. They should change the allocation, in other words consider the asset rebalancing. There are some methods on portfolio rebalancing (Fischer and Jordan, 1991), such as:

- Buy-and-hold. It is a do-nothing strategy after buying some assets. This strategy comprises of initial weights allocation and followed by no action forever.
- Constant-mix. It is a strategy to dynamically rebalance the current weightings by trading whenever market conditions have changed from the first balance. It implies a constant proportion of the portfolio invested in shares.
- Constant proportion portfolio insurance. This strategy involves buying shares as they rise and selling them as they fall. When implementing the strategy, investors select a floor below which the portfolio value is not allowed to fall to certain level.
- Active tactical. The goal is to outperform the constant-mix strategy by overweighting asset classes that are expected to be outperformed whereas underweight sectors that are expected to be underperformed. This strategy allows investors to flexibly follow elements of the constant-mix and constant proportion strategies based on market context.
- Black-Litterman. In this model, investor inputs any number of views or statements about the expected returns of arbitrary portfolios, and the model combines the views with equilibrium, producing both the set of expected returns of assets as well as the optimal portfolio weights. The investor should invest in portfolio first, and then rebalance from current weighting by adding some weights on portfolios representing investor's views (Vince, 1990).

As time goes by, many strategies or approaches have been improved lately by using advanced knowledge and know-how related to the portfolio risk in terms of investment and finance area (Bodie, Kane, and Marcus, 2008). There are some approaches that have been known as tools to better the investor's decision when dealing with the uncertain future events or market volatility, they are:

- Altman Z-Score. This model was created by Edward Altman. It combines some financial ratios to determine the possibility of bankruptcy of a company in certain industry. The lower the score, the higher the probability of bankruptcy.
- Black Scholes. It was developed at 1973 by Fisher Black, Robert Merton and Myron Scholes, and is still applied today as one alternative way of determining fair prices of options. This model assumes that market is efficient, European exercise terms apply, and that interest rates should remain constant and known.
- Binomial model. It is an equation or an open-form that generates a tree of possible future price movements. The performance of a portfolio is measured by the result of investor's strategy compared to a certain benchmark selected. Any relationship between investors' trading strategies and its expectations concerning asset prices movement will prove that different portfolios can be interpreted as the result of differing expectations for asset price movements.

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There are three main issues in this research as listed below :

- What kinds of asset should be preferred or selected from some asset classes available in the onshore capital market of Indonesia considering recent market situation?
- How should all the funds be allocated amongst the structured weightings into those selected assets in order to have the possible lowest risk in the future without significantly jeopardizing the portfolio rate of return?
- What portfolio weight structure should be selected in order to satisfy the investor's objectives and constraints or requirements based on the historical and recent market situation?

Literature Review

Portfolio management

Portfolios are combinations of assets, they consist of set of securities or asset classes (Fischer and Jordan, 1991). Conventional portfolio planning called for the selection of those assets that best fit the investor needs and desires. Otherwise, modern portfolio theory suggests that the traditional approach to portfolio analysis, selection and management may well yield less than optimum result. Portfolio management is the process of maintaining and allocating set of assets to meet the investment objectives of investor.

Monte Carlo in Finance

The Monte Carlo approach can be utilized to obtain solutions to quantitative problems which need forecast and simulation. Monte Carlo approach can provide an optimal solution to an optimization problem by directly simulating the process and then calculating the statistics results. Monte Carlo simulation is a method for evaluating a model using sets of random numbers as inputs. Monte Carlo approach is often utilized when the model is complex and involves massive uncertain parameters. A simulation can be done and evaluate in a massive number of runs by using computer's processor. Monte Carlo simulation generates random numbers from certain type of distributions, generates those numbers and stores the model outcomes. This process is then being repeated many times before the results are displayed as a new combined distribution. The general approach of Monte Carlo Simulation can be described in Figure 1.

This process can be actually be done in more descriptive, mathematical, or algorithmic way, but the principle of conducting Monte Carlo simulation is just similar to the flowchart in Figure 1. Defining a domain of possible inputs is one of the input parts which are determined by the investor. In this case, it may come to decision of investor regarding the portfolio weight selection in order to have effective diversification. The next step will deal with generating random number with certain predetermined type of distribution. In this research the large number of expected returns will be generated in the basis of uniform distribution.

Research Method

Basic framework

Managing investment portfolios is a dynamic and an ongoing process. It consists of many steps such as specifying the investor's investment objectives and constraints, developing investment strategies, evaluation of portfolio composition and performance, monitoring investor and market conditions, and finally implementing any necessary rebalancing (Fischer and Jordan, 1991). In general, the very basis of those steps can be described by Figure 2.

Model requirement

In an optimization model, there should be input and constraints definition in purpose to meet the model objective. The input can be defined by the investor together with the empirical data prior to the model execution.

Historical data

Historical data is the empirical data of some asset classes as part of the input to the model.

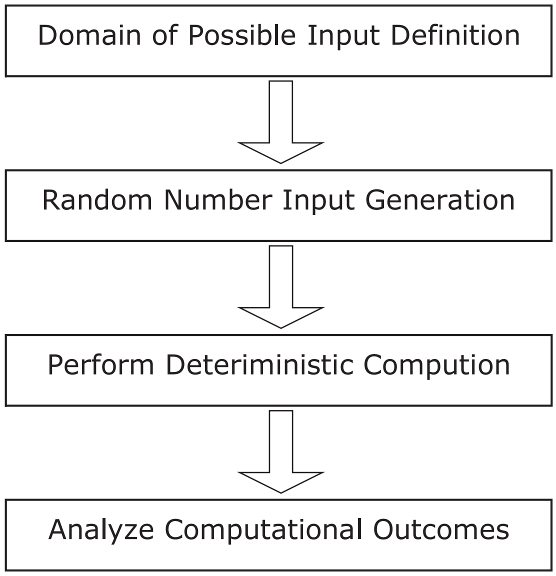

Figure 1. General flow of Monte Carlo simulation

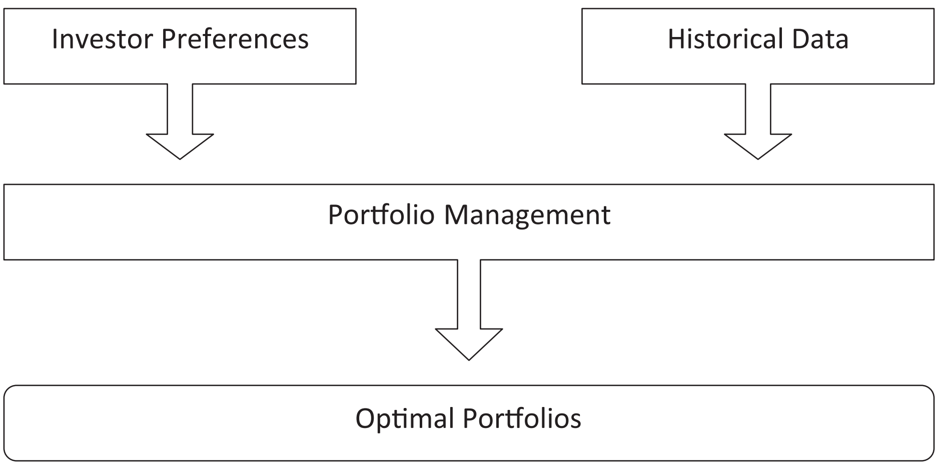

Figure 2. Basic framework of model

This can be done if the assets have been defined and the timeframe as well, to mention also the importance of the availability of empirical data of each asset in the market. Therefore, even in the input stage, the constraints have already been applied to the model. Figure 3 is the input side of the graph-based model representation:

In the historical data definition, there will 12 assets (nine stocks, two bonds, one cash) with 36 month of historical net earnings data for each asset.

Data preparation

Data preparation is part of the historical data definition. But rather than merely taken from the certain sources, those are data which have already been statistically calculated prior to the model execution. There are two tasks needed to be done in this part. The first task is to have the three years historical monthly net earnings of each asset selected. The second task is to have the statistically-related data based on the results obtained from the first task.

Maximum and minimum data are needed in purpose to generate the random data based on uniform distribution. The reason for this is to have the same probability of the value which may exist in the future from the large number of runs simulated later (Levin and Rubin, 1998). The mean average and standard deviation are actually generated in order to compare to the figures obtained from the outcomes of optimization and simulation in the next phase of this

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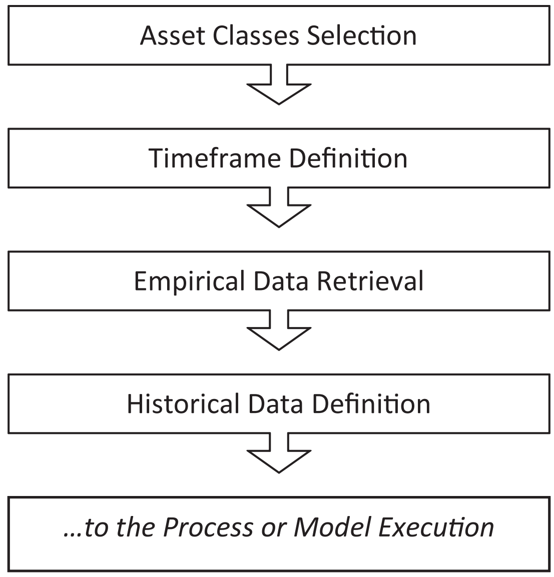

Figure 3. Historical data filtering

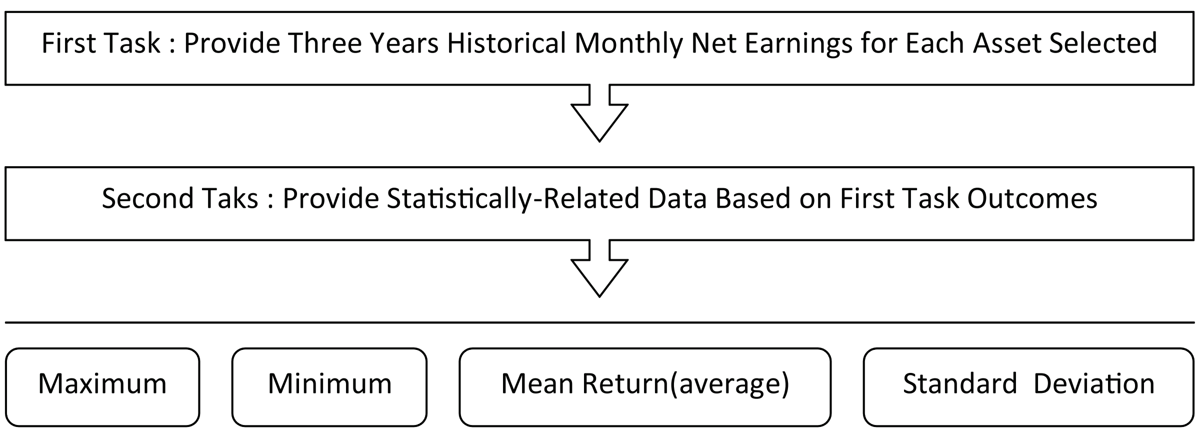

Figure 4. Tasks in historical data definition

research. The mean return used is the arithmetic average for the sake of simplicity in the calculation and the relevance as well. The standard deviation for each asset is calculated by using the standard routine function in the Excel-based tool as a representation of volatility of each asset in the past.

Model objective

Generally there are two types of objectives in the optimization model, they are maximization and minimization. The first one needed to be maximized is usually the expected return of the portfolio whereas the portfolio risk is to be minimized. Therefore, the investors need to aware and also ought to select which of both main objectives fit preference of investor. Usually the investor will fall to the final portfolio which has the highest return with the lowest risk possibly constructed. This is the challenge of the portfolio management actually.

Lowest portfolio risk

Lowest portfolio risk is the possible minimum of volatility or standard deviation that can be reached from certain diversification or portfolio weight structure. The portfolio weight structures are going to be defined in the constraints part of the model.

The calculation of portfolio risk needs only two sets of data, they are the portfolio weight structures and the portfolio variance. The portfolio expected returns data is nothing to do with the process of calculating the portfolio risk.

Since it only deals with the portfolio risk, then at this part the minimization is the only task needed to be done. The model aims at finding the lowest portfolio risk possible from adjusting the weight structure. This is the part of the process in the portfolios selection.

Since no investor will know what will happen in the future, then the most rational thing to do is trying to obtain the weight structure that will have the lowest portfolio risk that can be reached.

Highest portfolio expected return

The portfolio expected return is simply calculated by the multiplication of weighting to the expected return of each asset selected. The expected returns of each asset are a function of random in uniform distribution. Since there will be many weighting structures involved in the model as well as the random expected returns of portfolio, then there will be many portfolio expected returns that will be populated from the process.

Objective selection

The main part of the first phase of this model is the process minimizing the portfolio risk for every weighting structure defined in the constraints part of the model definition. It is the risk that is needed to be minimized prior to the simulation of the random expected returns possibly constructed in the uniform distribution. The principle objective of this model is actually to have a single weighting structure which is statistically able to provide investors with the maximum portfolio rate of return on investment with the lowest risk based on the forecasted expected returns of each asset.

Model constraint

There are boundaries in the process of optimization that the model should be subjected to. Those are set to limit the process in order to have the single solution at the final stage of the model.

Basic constraint

The basic constraint is applied to certain parameter in the model. In this research were applied to the weighting of portfolio constructed. In mathematical expression, the basic constraints are defined as below:

$$\sum_{i=1}^{n} w_i = 100\% \qquad 1)$$

where,
$w_i \geq 0$ where $i = 1,2,3,4,\ldots n$ and i is integer;
w_i = the series of weight structure;
n = number of assets.

Total constraints

The basic and conditional constraints are combined together prior to the execution of the model. These are the whole constraints applied as the boundaries the model is subjected to:

- Maximum and minimum value of expected return;
- Uniform distribution of random number generation;
- Total random series generated = 10,000;
- Total shares of in portfolio weight = 100%;
- Each of shares of weight is at minimum 0% and maximum 100%;
- The 17 weighting structures as conditional constraints;
- Minimum target return, in this research is set about 18% p.a. or 1.5% p.m.

All the constraints above should be applied in AND method instead of OR. It means the solution should satisfy each of the constraints and not even single constraint is violated.

Model format

This is how the model is shown in a descriptive way to reach the objective of investor. The objective is to find the optimal or best weighting structure with the lowest risk possible in order to deal with the uncertainty of future event by utilizing the defined historical data and powerful statistical parameter of measurement. The constraints are to build such boundaries where

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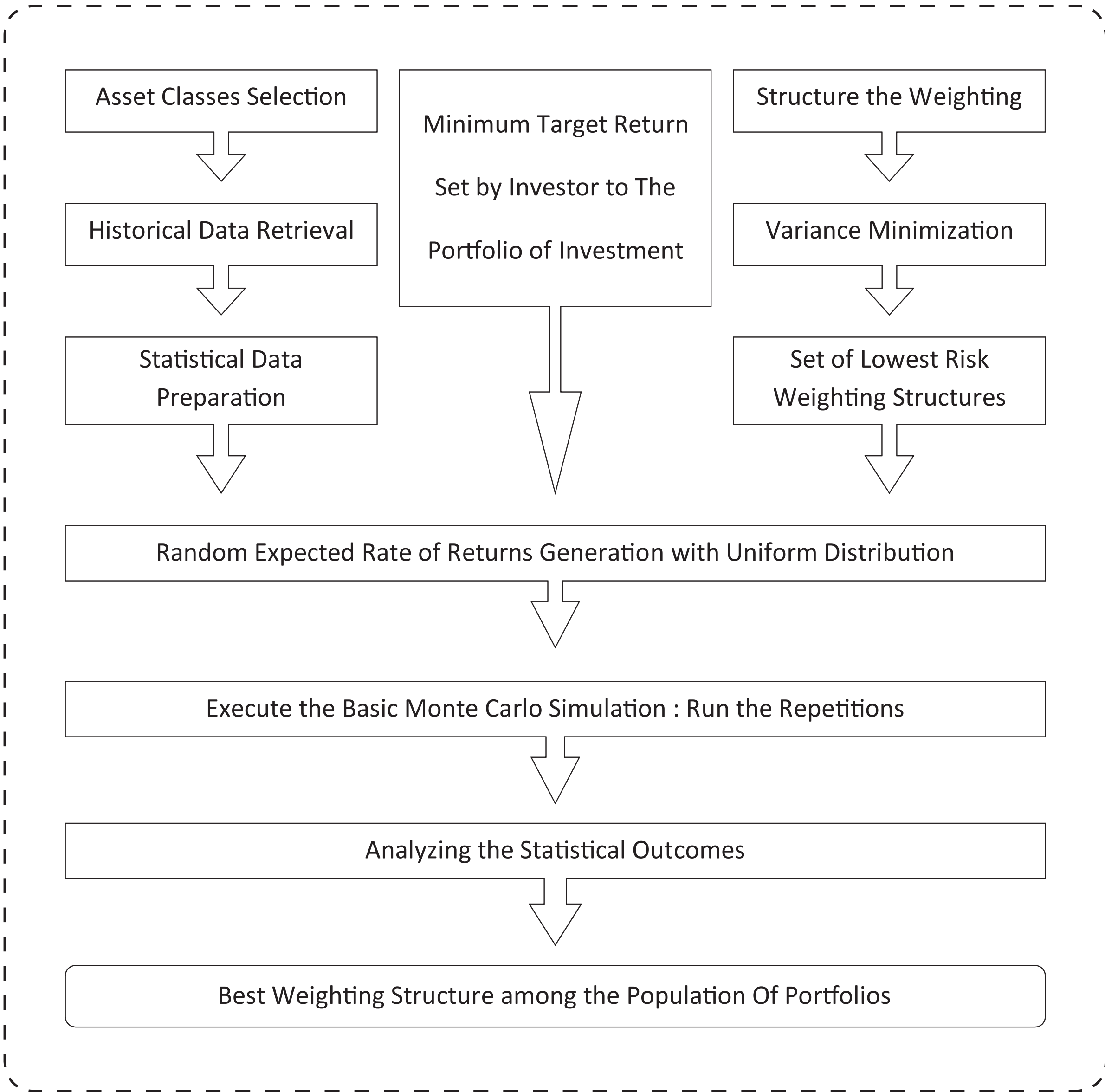

Figure 5. Model in flowchart*
* subject to total constraints

the model is going to be executed. The basic and conditional constraints are applied into the historical input and investors preference (in this case the 17 weighting structures of portfolio as results of optimization). The next stage of the model is to simulate the outcomes by using the defined weighting structures and random expected returns and statistically analyzed the result. Each result will have different characteristic and proximity to the solution needed. The selected portfolio should be the one with the lowest portfolio risk but with the expected return that is equal or greater than target return defined by the investor since the first time.

Result and Discussion

Data input

There are two types of relevant data for this research, first is the historical data which comprises the empirical data of asset's net earnings from the past three years in monthly period, and the second is the statistical-based data which comprises parameters such as mean or average, standard deviation, covariance, coefficient of correlation, and else.

Table 1. List of selected stocks out of LQ-45

#	Code	Company	Sector	Sub-sector	Value (V)	Frequency (F)
1	BUMI	Bumi Resources Tbk	Mining	Coal Mining	250,800,000,000,000	1,131,839
2	TLKM	Telekomunikasi Indonesia Tbk	Infrastructure	Telecommunication	59,500,000,000,000	289,625
3	ASII	Astra International Tbk	Misc Industry	Automotive & Components	37,600,000,000,000	252,915
4	BMRI	Bank Mandiri (Persero) Tbk	Finance	Bank	26,900,000,000,000	258,069
5	UNSP	Bakrie Sumatra Plantations Tbk	Agriculture	Plantation	21,700,000,000,000	386,253
6	UNTR	United Tractors Tbk	Trade & Services	Wholesale(durable)	21,500,000,000,000	219,880
7	ELTY	Bakrieland Development Tbk	Construction	Property & Real Estate	17,500,000,000,000	211,370
8	INDF	Indofood Sukses Makmur Tbk	Consumer Goods	Food & Beverages	13,900,000,000,000	212,540
9	INKP	Indah Kiat Pulp & Paper Tbk	Basic Industry	Pulp & Paper	12,500,000,000,000	220,943
			Total		461,900,000,000,000	3,183,434

Asset picking

The analytical components that most commonly utilized by equity investors to select good investment prospects might include some or many categories (Fischer and Jordan, 1991). Industrial or sector analysis may involve identification and analysis of various variables in the economy that are likely to gain superior performance. Scholars indicate that the health of an asset in particular sector or industry is as important as the performance of the individual asset itself. In other words, even the best asset located in a weak sector will probably may perform poorly because that sector is out of favor or some assets looked like bullish but eventually bearish instead. Each sector or industry is unique in terms of its customer base, market share among firms, industry growth, competition, regulation, and business cycles (Baumohl, 2008).

There are three types of empirical data involved in the research, they are from equity market (represented by selected stocks), fixed income market (represented by selected government and corporate bonds), and money market (single instrument of cash). The list is taken from LQ-45 population list. Those stocks are considerably leading the industries in terms of liquidity and volume of trading. All the stocks in the population were categorized into nine sectors. Therefore, there should be nine representing top stocks taken from LQ-45 list of stocks.

Based on the volume and frequency together (which was stated as V x F in terms of mathematic as stated in the header part of last column), the nine top representing stocks should be BUMI, TLKM, ASII, BMRI, UNSP, UNTR, ELTY, INDF, and INKP. Those stocks respresents stocks of the industry of mining, infrastructure, miscellaneous, finance and banking, agriculture, trade and services, construction, consumer goods, and basic industry, respectively.

Bonds are another instruments included in the portfolio investment. There are two types of bonds included in this research, government bond and corporate bond. FR00002 represents the government bond and HMSP03 (HM Sampoerna corporate bond) represents corporate bonds.

There are some reasons behind the selection of both bonds in this research. First is the liquidity. The maturity of FR00002 is near, which will be matured in year 2009. It made this bond easy to transact and liquid in fixed-income market. The second is coupon-bearing bond type. FR00002 is one of the bonds with highest coupon available in current Indonesia fixed-income market. It has 14% gross coupon rate per year, and it is the top government bond instrument in the fixed-income market in terms of coupon rate with length of tenure less than one year. The third is the data availability. FR00002 has already traded in the market for more than three years. Therefore, the historical data are available to be retrieved and analyzed together with other instruments involved in this research. The corporate bond is represented by HMSP03, stands for HM Sampoerna Corporate Bond. Rating-wise, bond is considered to be in the level of investment grade.

For money market instrument, this research only uses the government-issued money market, it is called SBI (Bank of Indonesia Certificate).

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Table 2. Auction result of SBI dan SBIS at 31st December 2008

Parameters of instruments		SBI		SBIS
Tenor	24	87	178	28
Overall indicative target		57.5		
Received offer	44.3	4.45	6.1	0.92
Range of bid rate	9.25% - 11.25%	11.00% – 11.20%	11.70% - 12.00%	-
Absorbed amount	29.48	3.59	5.46	0.92
Stop of rate	10.90% (FA)	11.15% (FA)	11.90% (FA)	-
Weighted average SBI's auction	10.83	11.08474	11.82	-
Return of SBIS	-	-	-	10.83381
Settlement date	5-Jan-09	5-Jan-09	5-Jan-09	31-Dec-08
Due date	29-Jan-09	2-Apr-09	2-Jul-09	28-Jan-09
Frequency of auction	184	27	26	16

Description:

- tenor in days amount
- overall indicative target, received offer and absorbed amount in billion rupiah
- range of bid range, weighted average SBI's auction, and SBIS rate of return in % (percent)
- frequency of auction in transaction unit

Source: Bank Indonesia

The terms of the SBI used in this research was one month, therefore the name is SBI 1-month. The reason behind this was purely based on the total market demand for this SBI 1-month which considered as the biggest amongst all SBIs available in the money market. This can be seen at Table 2 that mentioned SBI 1-month as the cash instrument with the highest absorbed amount at year-end 2008.

Historical timeframe

It needs three years of monthly historical data of asset's net earnings for the research to complete the analysis and evaluation prior to obtaining the best and expected result. Three years backward can exhibit roughly three kind of world economic conditions which was totally different. By analyzing the world economic data (especially for total GDP or world output), it is obvious that the Y2006 was an uptrend year, Y2007 was a bullish year, Y2008 was the top of the peak and also the beginning of recession era, as shown by Table 3.

National Bureau of Economic Research (NBER) of US has declared that United States had been in recession in year 2008 and several economists expressed that recovery may not appear until as late as 2011 (Foldvary, 2007). It means that the year 2008 is the starting point of the recession cycle as explained above. That completes the recovery-bullish-recession cycles of the economy, thus completes the three economic condition of the world. That is the reason behind the three years historical data retrieval that will be utilized as the main input of the model. If the world is definitely in recession, the question remains whether Indonesia has already been in recession also. While this research is being conceived, the government of Republic of Indonesia has not yet clearly declared that Indonesia already in recession although the world had has. Nevertheless, regardless Indonesia has already entered the recession cycle or not, one thing should be considered is the pattern of capital market cycle in Indonesia. JCI (Jakarta Composite Index) represents the price movement of total equity in Indonesia capital market. This JCI movement is closely related to the movement of GDP in certain way since it comprises hundreds of vital companies within it.

JCI vehicle comprises more than 300 companies and have strong relationship with the Indonesia Gross Domestic Product (GDP). At a glance, it can be analyzed that from the year

Table 3. GDP growth Y2005-2008

Selected areas	Y2005	Y2006	Y2007	Y2008
United States	12,397,900,000,000	13,163,900,000,000	13,811,200,000,000	14,334,034,000,000
United Kingdom	2,231,900,000,000	2,376,990,000,000	2,727,810,000,000	2,787,371,000,000
Euro Area	10,083,550,000,000	10,637,310,000,000	12,179,250,000,000	19,195,080,000,000
China	2,243,850,000,000	2,657,880,000,000	3,280,050,000,000	4,222,423,000,000
Japan	4,549,110,000,000	4,368,440,000,000	4,376,710,000,000	4,844,362,000,000
India	808,710,000,000	916,250,000,000	1,170,970,000,000	1,232,946,000,000
Indonesia	286,970,000,000	364,460,000,000	432,820,000,000	488,149,000,000
Total selected areas	32,601,990,000,000	34,485,230,000,000	37,978,810,000,000	47,104,365,000,000
Total world	44,433,002,000,000	48,244,879,000,000	54,584,918,000,000	60,109,392,000,000
World cycle phase	Recovery	Uptrend	Bullish	End of peak

Source: tradingeconomics.com

Source: www.tradingeconomics.com

Figure 6. JCI historical prices Y2005-Y2008

2005 up to year 2007, the market trend of Indonesia capital market was in bullish. Commencing year 2008, the market drop significantly. As a logical consequence, it can be concluded that the year of 2006 was in a bullish year, the peak of market was in year 2007, and the drop commenced at year 2008. This might enough for the research to retrieve the last three years of historical data as a representation of three different types of capital market cycle, they are bullish, peak, bearish.

Additional data requirement

Investors are rational (Gibson, 1996) and they expect the certain rate of return on their investment portfolio for sure. Therefore they have their own target return for their investment portfolio. The target return should be different amongst investors, and it depends on investor's risk appetite and preferences. In this research, the target return should be defined and the rate is about 18% net per annum, equal to 1.5% per annum. Reason behind this is because at the time this research is commenced, the yield to maturity of some government bonds were about 14-16% at that time. The figure 18% is a slightly taken above the average YTM of Indonesia government bond.

The other additional data needs to be considered is the risk-free rate. At year 2008, HSBC applied the rate of time deposit at level 9.25% per annum for Rupiah currency. Thus is simply assumed to be the risk-free rate for the whole parts of the research. The currency is set to Rupiah since all assets defined in the portfolio will

Table 4. Statistical parameters

Parameters	BUMI	TLKM	ASII	BMRI	UNSP	UNTR	ELTY	INDF	INKP	FR0002	HMSP03	SBI-1
Minimum	-53.56%	-24.48%	-45.32%	-41.13%	-61.97%	-66.67%	-67.23%	-44.39%	-48.43%	0.62%	1.05%	0.66%
Maximum	40.20%	17.95%	33.79%	35.91%	58.33%	33.54%	122.22%	26.97%	139.32%	1.39%	1.38%	1.06%
Mean	2.24%	0.43%	1.05%	0.90%	2.76%	1.79%	3.76%	1.06%	2.83%	0.82%	1.17%	0.82%
Std. Deviation	20.10%	9.30%	13.90%	13.22%	22.27%	16.07%	29.03%	14.10%	28.33%	0.17%	0.10%	0.14%

Table 5. Coefficient of correlations

Assets	BUMI	TLKM	ASII	BMRI	UNSP	UNTR	ELTY	INDF	INKP	FR0002	HMSP03	SBI-1
BUMI	1.000000	0.090074	0.411605	0.226659	0.500697	0.336622	0.356743	0.615977	0.289736	-0.686909	-0.500880	-0.403033
TLKM	0.090074	1.000000	0.615837	0.747954	0.170317	0.503846	0.102783	0.352198	-0.028306	-0.238225	-0.387428	0.137386
ASII	0.411605	0.615837	1.000000	0.716694	0.392185	0.696529	0.340343	0.617895	0.281944	-0.467562	-0.347023	-0.064465
BMRI	0.226659	0.747954	0.716694	1.000000	0.263234	0.584444	0.212763	0.478866	0.211777	-0.384160	-0.487087	0.015605
UNSP	0.500697	0.170317	0.392185	0.263234	1.000000	0.536381	0.749788	0.511952	0.451631	-0.236570	-0.255489	0.217558
UNTR	0.336622	0.503846	0.696529	0.584444	0.536381	1.000000	0.248696	0.698606	0.370941	-0.425010	-0.375439	-0.035726
ELTY	0.356743	0.102783	0.340343	0.212763	0.749788	0.248696	1.000000	0.297063	0.384324	-0.256742	-0.143943	0.095333
INDF	0.615977	0.352198	0.617895	0.478866	0.511952	0.698606	0.297063	1.000000	0.433811	-0.491270	-0.477787	-0.079515
INKP	0.289736	-0.028306	0.281944	0.211777	0.451631	0.370941	0.384324	0.433811	1.000000	-0.123398	0.010462	-0.126499
FR0002	-0.686909	-0.238225	-0.467562	-0.384160	-0.236570	-0.425010	-0.256742	-0.491270	-0.123398	1.000000	0.480114	0.724363
HMSP03	-0.500880	-0.387428	-0.347023	-0.487087	-0.255489	-0.375439	-0.143943	-0.477787	0.010462	0.480114	1.000000	-0.002844
SBI-1	-0.403033	0.137386	-0.064465	0.015605	0.217558	-0.035726	0.095333	-0.079515	-0.126499	0.724363	-0.002844	1.000000

be an onshore type of investment, it means that all funds to be allocated to the portfolio are in Rupiah currency also.

Data collection

After retrieval process of data from certain resources has been completed, now all the data are set and ready to be calculated. The last three years (2005-2008) historical net earnings data is displayed in monthly basis per asset. All the data shown in the table were net earnings. It means that for stock, the figures were derived from percentage of prices changes between two consecutive months. As for the bonds, the figures were derived from the prices of bond changes between two consecutive months. It was slightly different from the SBI 1-month, the percentages are calculated by simply dividing the SBI 1-month by twelve since one year comprises 12 months.

Statistical data calculation

The historical data, investor's target return, and risk-free rate have been defined and the model is now moving to the next stage. Some parameters need to be calculated statistically prior to the optimization and simulation of the model.

Statistical parameters

The model needs the statistical parameters calculated from the defined historical data such as maximum value, minimum value, mean or average, and standard deviation. By using formulas and expressions as defined in previous chapter, it can be managed to provide the numbers as shown in Table 4.

Coefficient of correlation and covariance

After the standard deviation of the historical data for each asset is defined, the twelve assets can be displayed in terms of their correlation and covariance in one table respectively. As previously described in formula expressions, the covariance, coefficient of correlation and standard deviation are all parameters in single formula. Covariance is actually the multiplication of standard deviations with its coefficient of correlation of the pair variables. It means, if the standard deviation of each assets are already known, the coefficient of correlation can be calculated, then covariance can be derived by using those both parameters.

Scenarios of weighting

There are about 17 possible weighting structures which investors need to select. Each of

Table 6. Covariance

Assets	BUMI	TLKM	ASII	BMRI	UNSP	UNTR	ELTY	INDF	INKP	FR0002	HMSP03	SBI-1
BUMI	0.040389	0.001684	0.011499	0.006024	0.022413	0.010873	0.020810	0.017459	0.016494	-0.000239	-0.000102	-0.000116
TLKM	0.001684	0.008655	0.007964	0.009202	0.003529	0.007534	0.002776	0.004621	-0.000746	-0.000038	-0.000036	0.000018
ASII	0.011499	0.007964	0.019324	0.013175	0.012143	0.015562	0.013733	0.012114	0.011102	-0.000112	-0.000049	-0.000013
BMRI	0.006024	0.009202	0.013175	0.017489	0.007754	0.012423	0.008167	0.008932	0.007933	-0.000088	-0.000065	0.000003
UNSP	0.022413	0.003529	0.012143	0.007754	0.049611	0.019202	0.048475	0.016082	0.028495	-0.000091	-0.000058	0.000069
UNTR	0.010873	0.007534	0.015562	0.012423	0.019202	0.025833	0.011602	0.015836	0.016888	-0.000118	-0.000061	-0.000008
ELTY	0.020810	0.002776	0.013733	0.008167	0.048475	0.011602	0.084253	0.012161	0.031600	-0.000129	-0.000042	0.000040
INDF	0.017459	0.004621	0.012114	0.008932	0.016082	0.015836	0.012161	0.019891	0.017331	-0.000120	-0.000068	-0.000016
INKP	0.016494	-0.000746	0.011102	0.007933	0.028495	0.016888	0.031600	0.017331	0.080240	-0.000060	0.000003	-0.000051
FR0002	-0.000239	-0.000038	-0.000112	-0.000088	-0.000091	-0.000118	-0.000129	-0.000120	-0.000060	0.000003	0.000001	0.000002
HMSP03	-0.000102	-0.000036	-0.000049	-0.000065	-0.000058	-0.000061	-0.000042	-0.000068	0.000003	0.000001	0.000001	0.000000
SBI-1	-0.000116	0.000018	-0.000013	0.000003	0.000069	-0.000008	0.000040	-0.000016	-0.000051	0.000002	0.000000	0.000002

Table 7. The possible 17 weighting structures

Weighting structure #	Condition constraints and boundaries		
1	Portfolio comprises with merely stocks		
2	Portfolio comprises with merely bonds		
3	Portfolio comprises with merely cash		
4	Share of stock ≥ (bond + cash)	AND	share of bond ≥ cash
5	Share of stock ≥ (bond + cash)	AND	share of bond ≤ cash
6	Share of bond ≥ (stock + cash)	AND	share of stock ≥ cash
7	Share of bond ≥ (stock + cash)	AND	share of stock ≤ cash
8	Share of cash ≥ (stock + bond)	AND	share of stock ≥ bond
9	Share of cash ≥ (stock + bond)	AND	share of stock ≤ bond
10	Share of stock = share of bond	AND	share of bond = share of cash
11	Share of stock ≤ (bond + cash)	AND	share of bond ≥ cash
12	Share of stock ≤ (bond + cash)	AND	share of bond ≤ cash
13	Share of bond ≤ (stock + cash)	AND	share of tock ≥ cash
14	Share of bond ≤ (stock + cash)	AND	share of stock ≤ cash
15	Share of cash ≤ (stock + bond)	AND	share of stock ≥ bond
16	Share of cash ≤ (stock + bond)	AND	share of stock ≤ bond
17	Free-style (has no specific rule, but the target is the weighting with the lowest risk)		

those weighting structures yet still in verbal description of the investor. They need to be quantified in terms of value respectively. By using Excel-based tool called Solver, the figures can be provided even to each asset as defined previously. This is the part where the risk minimization takes place for each of the weighting structure.

Risks minimization

Stocks comprise nine selected assets, bonds comprise two (government and corporate bond), and SBI 1-month represents cash. Each of the weighting structure (17 possible structures) will have different share or portion for each 12 asset. Solver found the weightings by conducting risk minimization to all weighting structures. Table 8 is the result of risk minimization process done by solver with 32,767 times of trials (repetitions).

It can be seen that each weighting structure has its own lowest risk in particular. That is because each of them has its own variance and standard deviation of portfolio as already defined. All those figures have yet nothing to do with the rate of expected return since it will be done in separate process prior to the simulation. Table 8 can be displayed together with the verbal explanation of each weighting structure as Table 9 shows. The structure number 16 has the lowest risk weighting amongst all. The method of obtaining the lowest risk is by utilizing solver of Excel add-ins.

Random number generation

Random numbers are generated to forecast the possible value occurred in the future for each asset in the portfolio. They are defined by using uniform distribution for about 10,000 figures, represents the large number of repetitions

https://scholarhub.ui.ac.id/icmr/vol5/iss1/4
DOI: 10.21002/icmr.v5i1.1582

Table 8. The lowest risks for each weighting structures

Weight	BUMI	TLKM	ASII	BMRI	UNSP	UNTR	ELTY	INDF	INKP	FR0002	HMSP03	SBI-1	Stock	Bond	Cash	Risk
1	10.58%	80.28%	0.00%	0.00%	0.00%	0.00%	0.38%	1.79%	6.97%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	8.47%
2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	7.80%	92.20%	0.00%	0.00%	100.00%	0.00%	0.10%
3	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	100.00%	0.00%	0.00%	100.00%	0.14%
4	5.53%	39.92%	0.00%	0.00%	0.00%	0.00%	0.19%	0.93%	3.43%	50.00%	0.00%	0.00%	50.00%	50.00%	0.00%	4.20%
5	5.53%	40.02%	0.00%	0.00%	0.00%	0.00%	0.15%	0.82%	3.48%	25.00%	0.00%	25.00%	50.00%	25.00%	25.00%	4.21%
6	0.30%	0.10%	0.00%	0.23%	0.00%	0.03%	0.00%	0.00%	0.00%	27.85%	70.83%	0.66%	0.66%	98.68%	0.66%	0.07%
7	0.24%	0.00%	0.00%	0.17%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	67.84%	31.76%	0.41%	67.84%	31.76%	0.06%
8	0.29%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.01%	0.00%	0.30%	99.40%	0.30%	0.30%	99.40%	0.13%
9	0.26%	0.00%	0.00%	0.09%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	49.65%	50.00%	0.35%	49.65%	50.00%	0.07%
10	3.83%	26.58%	0.00%	0.00%	0.00%	0.00%	0.08%	0.53%	2.31%	33.33%	0.00%	33.33%	33.33%	33.33%	33.33%	2.80%
11	0.24%	0.00%	0.00%	0.17%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	69.38%	30.21%	0.41%	69.38%	30.21%	0.06%
12	0.26%	0.00%	0.00%	0.09%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	49.83%	49.83%	0.35%	49.83%	49.83%	0.07%
13	2.99%	19.82%	0.00%	0.00%	0.00%	0.00%	0.06%	0.42%	1.70%	50.00%	0.00%	25.00%	25.00%	50.00%	25.00%	2.08%
14	0.26%	0.00%	0.00%	0.09%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	50.00%	49.65%	0.35%	50.00%	49.65%	0.07%
15	2.88%	19.89%	0.00%	0.00%	0.00%	0.00%	0.00%	0.48%	1.75%	0.00%	25.00%	50.00%	25.00%	25.00%	50.00%	2.10%
16	0.24%	0.00%	0.00%	0.17%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	69.19%	30.40%	0.41%	69.19%	30.40%	0.06%
17	0.24%	0.00%	0.00%	0.17%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	69.08%	30.51%	0.41%	69.08%	30.51%	0.06%

Table 9. Conditional constraints and lowest risk WS

Weighting structure	Conditional constraints and boundaries			Stock	Bond	Cash	Lowest risk
1	Portfolio comprises with merely stocks			100.00%	0.00%	0.00%	8.47%
2	Portfolio comprises with merely bonds			0.00%	100.00%	0.00%	0.10%
3	Portfolio comprises with merely cash			0.00%	0.00%	100.00%	0.14%
4	Share of stock ≥ (bond + cash)	AND	share of bond ≥ cash	50.00%	50.00%	0.00%	4.20%
5	Share of stock ≥ (bond + cash)	AND	share of bond ≤ cash	50.00%	25.00%	25.00%	4.21%
6	Share of bond ≥ (stock + cash)	AND	share of stock ≥ cash	0.66%	98.68%	0.66%	0.07%
7	Share of bond ≥ (stock + cash)	AND	share of stock ≤ cash	0.41%	67.84%	31.76%	0.06%
8	Share of cash ≥ (stock + bond)	AND	share of stock ≥ bond	0.30%	0.30%	99.40%	0.13%
9	Share of cash ≥ (stock + bond)	AND	share of stock ≤ bond	0.35%	49.65%	50.00%	0.07%
10	Share of stock = share of bond	AND	share of bond = share of cash	33.33%	33.33%	33.33%	2.80%
11	Share of stock ≤ (bond + cash)	AND	share of bond ≥ cash	0.41%	69.38%	30.21%	0.06%
12	Share of stock ≤ (bond + cash)	AND	share of bond ≤ cash	0.35%	49.83%	49.83%	0.07%
13	Share of bond ≤ (stock + cash)	AND	share of stock ≥ cash	25.00%	50.00%	25.00%	2.08%
14	Share of bond ≤ (stock + cash)	AND	share of stock ≤ cash	0.35%	50.00%	49.65%	0.07%
15	Share of cash ≤ (stock + bond)	AND	share of stock ≥ bond	25.00%	25.00%	50.00%	2.10%
16	Share of cash ≤ (stock + bond)	AND	share of stock ≤ bond	0.41%	69.19%	30.40%	0.06%
17	Free-style (has no specific rule, but the target is the weighting with the lowest risk)			0.41%	69.08%	30.51%	0.06%

in order to have the high level of confidence or low level of error in terms of statistics.

Expected return of portfolio

The expected return of portfolio can be derived from the multiplication of the weighting structure and the expected return of each asset. The weighting structures have already been defined through risk minimization process and the expected returns of each asset have already been generated by random number generation in previous part. So the data has already completed in order to move on to the process of simulation.

Monte Carlo basic simulation

The basic simulation of Monte Carlo is actually done through 10,000 times of repetitions according to the large numbers generated by random function within uniform distribution. These massive repetitions are done respectively to each weighting structures as previously defined. The results of the repetitions should provide the model with all the statistical figures of each weighting structures, in this case the mean, standard deviation, minimum and maximum returns possible calculated and simulated.

As can be seen from Table 10, the 10,000 massive iterations which represent the possible expected returns on portfolio can be displayed

Table 10. Simulation result: Weighting structure 1

Iteration	Return	Risk	#	Bins	Counts	Scale	Total
1	-11.70%	8.47%	1	-28.41%	1	0.02	0.00
2	21.16%	8.47%	2	-27.85%	0	0.00	0.00
3	-19.73%	8.47%	3	-27.29%	2	0.04	0.00
4	-15.15%	8.47%	4	-26.73%	2	0.04	0.00
5	11.90%	8.47%	5	-26.17%	5	0.09	0.00
6	-9.55%	8.47%	6	-25.61%	5	0.09	0.00
7	19.81%	8.47%	7	-25.06%	4	0.07	0.00
8	6.66%	8.47%	8	-24.50%	16	0.29	0.00
9	7.87%	8.47%	9	-23.94%	19	0.34	0.01
10	12.42%	8.47%	10	-23.38%	16	0.29	0.01
11	-5.83%	8.47%	11	-22.82%	23	0.41	0.01
12	-4.67%	8.47%	12	-22.26%	27	0.48	0.01
13	12.23%	8.47%	13	-21.70%	20	0.36	0.01
14	-8.23%	8.47%	14	-21.14%	24	0.43	0.02
15	3.16%	8.47%	15	-20.58%	38	0.68	0.02
16	-15.35%	8.47%	16	-20.02%	37	0.66	0.02
17	-4.69%	8.47%	17	-19.46%	59	1.06	0.03
18	-9.18%	8.47%	18	-18.91%	58	1.04	0.04
19	0.92%	8.47%	19	-18.35%	64	1.14	0.04
20	9.26%	8.47%	20	-17.79%	76	1.36	0.05
21	21.17%	8.47%	21	-17.23%	76	1.36	0.06
22	-0.54%	8.47%	22	-16.67%	83	1.48	0.07
23	8.95%	8.47%	23	-16.11%	97	1.73	0.08
24	4.03%	8.47%	24	-15.55%	96	1.72	0.08
25	-7.86%	8.47%	25	-14.99%	110	1.97	0.10
…	…	…	…	…	…	…	…
9977	7.75%	8.47%	77	14.08%	106	1.90	0.89
9978	-6.32%	8.47%	78	14.64%	106	1.90	0.90
9979	17.46%	8.47%	79	15.20%	100	1.79	0.91
9980	18.13%	8.47%	80	15.76%	111	1.99	0.92
9981	-7.22%	8.47%	81	16.32%	84	1.50	0.93
9982	-15.79%	8.47%	82	16.88%	76	1.36	0.94
9983	18.76%	8.47%	83	17.44%	84	1.50	0.05
9984	-8.84%	8.47%	84	18.00%	64	1.36	0.95
9985	-18.12%	8.47%	85	18.56%	71	1.27	0.96
9986	12.04%	8.47%	86	19.12%	68	1.22	0.97
9987	-3.46%	8.47%	87	19.68%	59	1.06	0.97
9988	2.15%	8.47%	88	20.23%	40	0.72	0.98
9989	-14.18%	8.47%	89	20.79%	38	0.68	0.99
9990	15.10%	8.47%	90	21.35%	44	0.79	0.99
9991	-7.34%	8.47%	91	21.91%	35	0.63	0.99
9992	0.60%	8.47%	92	22.47%	27	0.48	0.99
9993	14.77%	8.47%	93	23.03%	21	0.38	0.99
9994	0.74%	8.47%	94	23.59%	21	0.38	1.00
9995	21.53%	8.47%	95	24.15%	11	0.20	1.00
9996	1.57%	8.47%	96	24.71%	9	0.16	1.00
9997	-12.49%	8.47%	97	25.27%	5	0.09	1.00
9998	9.83%	8.47%	98	25.83%	6	0.11	1.00
9999	11.82%	8.47%	99	26.39%	5	0.09	1.00
10000	-9.55%	8.47%	100	26.94%	1	0.02	1.00

Statistical summary

Minimum	Maximum	Median	Mean	Std. deviation	Probability	UCL	LCL
-28.41%	26.94%	-0.26%	-0.18%	11.01%	45.10%	-0.61%	0.24%

https://scholarhub.ui.ac.id/icmr/vol5/iss1/4
DOI: 10.21002/icmr.v5i1.1582

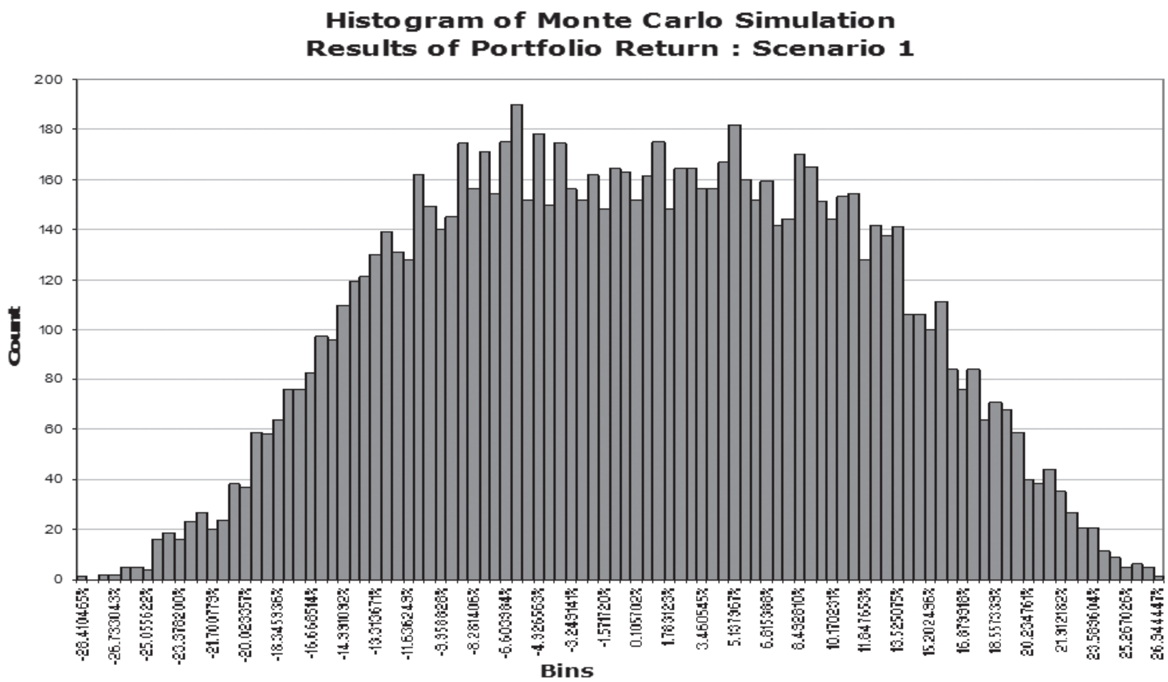

Figure 7. Result of portfolio returns: Weighting structure 1

in a simple statistical view. That view will show the investor regarding the probability of the expected rate of return of the portfolio may fall with such weighting structure. The view of the statistical result can be seen as Figure 7. The absis represents the bins, which is the range distribution of expected rate of returns of weighting structure 1 portfolio. The minimum return is around -28% and the maximum return is around 27%. The ordinate represents the count or frequency of certain bin occurred. At glance see, the pattern is kind of normal distribution, which has some level of skewness and kurtosis. Below are the WS1 statistical measurement which also will be presented by other weighting structures (the other 16 weighting structures).

- Maximum = 26.94%
- Minimum = -28.41%
- Mean = -0.18%
- Standard deviation = 11.01%

By using the statistical routine function of the Excel (percentrank), the probability of some level of target return can be calculated with this weighting structure. It was stated that the target return of the investor is about 1.5% per month net. Therefore, the calculation of the probability has come to the level of 45% chance to get the level of that target return.

Optimal result determination

After the simulations are done to the rest of the weighting structures, then there should be about 17 outcomes of simulation which are going to be selected, regarding the one that will be the best options of all weighting structures. The complete process of optimization and simulations may provide investor with this table summary as shown in the next table.

The lowest risk of portfolio has already been determined, it is the weighting structure 16. But that was historical. In terms of forecasting by using the simulation, the lowest volatility of portfolio return is actually derived by the weighting structure 2 eventually. This will be emphasized more in the efficient frontier plotting part later.

As can be seen, that the first weighting structure resulted with the highest return possible but also with the highest risk although the probability of gaining the target return is still there, about 45% chance to achieve 1.5% target return per month. For rational investor, especially for risk-averse kind of investor, this can be very risky. The lowest risk resulted by the second weighting structure with bond-dominated portfolio. Although the probability of earning

Table 11. Weighting structures simulation result

Wgt	Portfolio Weight Structures	Min	Max	Mean	Stdev	Pr(Return ≥ 1.5%)	Remarks
1	All stocks	-28.41 %	26.94 %	-0.18 %	11.01 %	45.10 %	Highest probability, highest return and risk
2	All bonds	1.02 %	1.38 %	1.20 %	0.09 %	out of range	Highest possible return, the lowest risk
3	All cash	0.66 %	1.06 %	0.86 %	0.12 %	out of range	
4	Stock ≥ bond + cash and bond ≥ cash	-13.66 %	13.97 %	0.38 %	0.34 %	43.40 %	
5	Stock ≥ bond + cash and bond ≤ cash	-13.81 %	14.11 %	0.36 %	0.31 %	43.40 %	
6	Bond ≥ stock + cash and stock ≥ cash	0.69 %	1.51 %	1.12 %	1.12 %	0.10 %	
7	Bond ≥ stock + cash and stock ≤ cash	0.77 %	1.41 %	1.08 %	1.08 %	out of range	
8	Cash ≥ stock + bond and stock ≥ bond	0.51 %	1.19 %	0.85 %	0.85 %	out of range	
9	Cash ≥ stock + bond and stock ≤ bond	0.71 %	1.33 %	1.02 %	1.02 %	out of range	
10	Stock = bond = cash	-8.93 %	9.79 %	0.54 %	0.51 %	41.60 %	
11	Stock ≤ bond + cash and bond ≥ cash	0.77 %	1.42 %	1.09 %	1.09 %	out of range	the highest Sharpe prior to simulation
12	Stock ≤ bond + cash and bond ≤ cash	0.71 %	1.33 %	1.02 %	1.02 %	out of range	
13	Bond ≤ stock + cash and stock ≥ cash	-6.43 %	7.58 %	0.63 %	0.63 %	39.80 %	
14	Bond ≤ stock + cash and stock ≤ cash	0.71 %	1.33 %	1.02 %	1.02 %	out of range	
15	Cash ≤ stock + bond and stock ≥ bond	-6.62 %	7.61 %	0.65 %	0.65 %	40.10 %	
16	Cash ≤ stock + bond and stock ≤ bond	0.77 %	1.42 %	1.09 %	1.09 %	out of range	the lowest risk prior to simulation
17	Free-style	0.77 %	1.42 %	1.09 %	1.09 %	out of range	

Table 12. Risk, return, and Sharpe ratios of each WS

WEIGHTING STRUCTURES	CONDITIONAL CONSTRAINTS	RISK	RETURN	SHARPE
1	Portfolio comprises all stocks	8.47 %	0.81 %	0.0049
2	Portfolio comprises all bonds	0.10 %	1.14 %	3.7128
3	Portfolio comprises all cash	0.14 %	0.82 %	0.3618
4	Share of stock ≥ (bond+cash) AND share of bond ≥ cash	4.20 %	0.82 %	0.0117
5	Share of stock ≥ (bond+cash) AND share of bond ≤ cash	4.21 %	0.82 %	0.0115
6	Share of bond ≥ (stock+cash) AND share of stock ≥ cash	0.07 %	1.07 %	4.5195
7	Share of bond ≥ (stock+cash) AND share of stock ≤ cash	0.06 %	1.06 %	4.9088
8	Share of cash ≥ (stock+bond) AND share of stock ≥ bond	0.13 %	0.83 %	0.4390
9	Share of cash ≥ (stock+bond) AND share of stock ≤ bond	0.07 %	1.00 %	3.3720
10	Share of stock = bond = cash	2.80 %	0.82 %	0.0182
11	Share of stock ≤ (bond+cash) AND share of bond ≥ cash	0.06 %	1.07 %	5.0023
12	Share of stock ≤ (bond+cash) AND share of bond ≤ cash	0.07 %	1.00 %	3.3879
13	Share of bond ≤ (stock+cash) AND share of stock ≥ cash	2.08 %	0.82 %	0.0251
14	Share of bond ≤ (stock+cash) AND share of stock ≤ cash	0.07 %	1.00 %	3.4039
15	Share of cash ≤ (stock+bond) AND share of stock ≥ bond	2.10 %	0.91 %	0.0655
16	Share of cash ≤ (stock+bond) AND share of stock ≤ bond	0.06 %	1.07 %	4.9914
17	Free-style	0.06 %	1.07 %	4.9851

1.5% target return were out of range (since the minimum is only about 1.02% and maximum is about 1.38%), but with mean average of return about 1.25%, particularly for risk-averse type of investor, this is a kind of best portfolio that investor can earn.

Therefore, the selection of portfolio will fall to the second weighting structure where the proportion is 0% in stocks, 0% in cash, but 7.8% in FR00002 and 92.20% in HMSP03. Based on the last three years of historical asset's data, then its better to allocate the entire fund in second weighting structure. In terms of probability and statistics, this weighting structure will provide investor with lowest standard deviation of portfolio return.

Efficient frontier plotting

Once expected returns, standard deviation and correlation coefficients have been determined, then the list of "optimal" portfolios can be created. These portfolios lie on a graph line called the "efficient frontier," which represents the asset mix with the highest expected returns for each given level of risk. By plotting every portfolio representing a given level of risk and expected return, it can be able to trace a line connecting all the efficient portfolios, all these dots usually known as locus. This line forms the efficient frontier. Rational investors limit the selection in the efficient frontier and to the specific portfolio that represents their own risk

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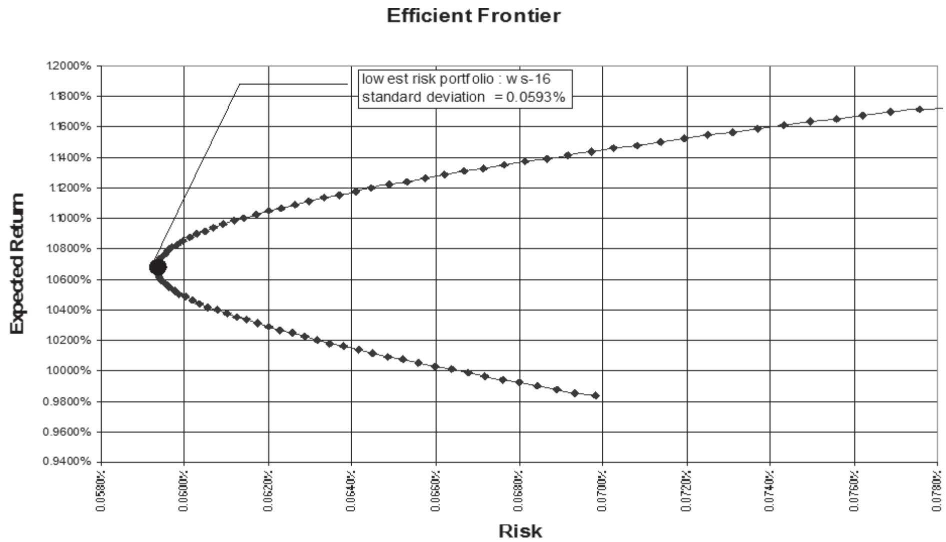

Figure 8. JCI historical prices Y2005-Y2008

tolerance level. Therefore, the other way to find out the optimal portfolios is by utilizing efficient frontier using parameters of the portfolio selected. As shown by the table before, the lowest risk amongst the structures is about 0.0593% and this figure can be plotted in the area of efficient frontier in the investment quadrant. Figure 8 represents the efficient frontier of the optimal portfolios.

As shown in Figure 8, the efficient frontier can be used to find out the lowest risk portfolio and the best one amongst all of then (tangency portfolio should be located in right side). Referring to the graph in Figure 8, the rational investor can pinpoint a single portfolio weighting (within the area of efficient frontier) which is actually better than other optimal portfolios from some point of view (return, risk, or Sharpe ratio).

Anyway, this is the current view by using historical data of the portfolio. The objective as initially defined in this research is to find out the single weighting structure amongst all structured weightings with lowest volatility of its portfolio return or mean. By combining the modern portfolio theory with solver and basic Monte Carlo for simulating the future event, the weighting structure with the lowest standard deviation of portfolio mean can be possibly obtained.

By only depending on historical view, the investor may finally misled selecting the portfolio with the highest Sharpe ratio weighting structure or the lowest risk one, or even the highest return. By fully utilize the simulation of random data which will be probably occured in the future events (in terms of probability using uniform distribution), the decision might end up differently for the investors. As shown by Table 12, the weighting structure with highest Sharpe ratio is located in the tangency portfolio (WS-11 at Table 12), but the structure with the lowest risk is shown by WS-16.

(WS-11 at Table 12), but the structure with the lowest risk is shown by WS-16. From historical point of view, choice of portfolios may fall to the WS-11 and WS-16. Nevertheless, using the simulation to forecast the future events, the weighting structure with lowest standard deviation of its portfolio mean is eventually the WS-2.

Conclusion

The research has come to a certain conclusions based on the three issues which mentioned in the very beginning part of this article. As the result has shown, stocks can be allocated much in a portfolio of investment but it should be done in a way that do not harm or jeopardize the portfolio as whole in terms of its risk or volatility. After assessing the high volatility of some asset classes which had been pooled together within an investment portfolio, it surely does not very wise for investors to keep the portfolio weighting in dominant stock instead of dominant bond or cash. By making the decision to switch the portfolio into much more in bond or cash, the risk of portfolio can be significantly reduced but also in the same time limiting the potential return of portfolio that can be earned. As for the risk-averse type of investor, the dominant bond and cash may be more preferred.

As the portfolio should be dominated by the fixed income instrument, then the next issue will be the share figure for each one of them. Based on the calculation done in this research, the best structured weighting should be the number two (WS-2) since it can provide investors with lowest risk of its forecasted mean return. The choice of portfolio comprises 0% in stocks, 0% in cash, but 7.8% in FR00002 and 92.20% in HMSP03.

The world market is now in recession and people are currently living in it. Prior to the recession, investors are all enjoying the great earnings they have got from trading stocks and other high risk instruments when market is in bullish trend. Therefore, if it merely based on the historical figure or nothing to do with the forecasting figures of the returns, then investors should have different choices of best portfolio. Based on the risk minimization process, the investor should be selecting the one with the greatest Sharpe ratio of all structured weightings, that is the 11th WS. It comprises 0.41% stocks, 69.38% bonds and 30.21% cash. The portfolio risk of this choice of portfolio is the lowest among them all but with the highest level of Sharpe ratio.

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