# APPLYING MONTE CARLO CONCEPT 

AND LINEAR PROGRAMMING IN MODERN PORTFOLIO THEORY TO OBTAIN BEST STRUCTURED WEIGHTING

## THESIS

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UNIVERSITY OF INDONESIA
FACULTY OF ECONOMY
MAGISTER MANAGEMENT STUDY PROGRAM
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# APPLYING MONTE CARLO CONCEPT AND LINEAR PROGRAMMING IN MODERN PORTFOLIO THEORY TO OBTAIN BEST STRUCTURED WEIGHTING 

## THESIS

Completed as one of the requirements to achieve the title Magister Management

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## STATEMENT OF ORIGINALITY

## This final paper represents my own effort,

any idea or excerpt from other writers in this final paper, either in form of publication or in other form of publication, if any, have been acknowledged in this paper in accordance to the academic standard or reference procedures


## PREFACE

Praise to the Lord Christ Jesus who has given His blessings to all of us so that the writer can complete and finish this thesis as one of some requirements to achieve the formal title of magister management (MM).

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Jakarta, March 2009

Tumpal Sihombing

## LETTER OF AGREEMENT TO PUBLISH THE THESIS FOR ACADEMIC PURPOSE ONLY (Individual Assignment)

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|  | ABSTRACT |
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| Name | $: \quad$Tumpal M Sihombing |
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In the capital market, investment is usually utilized as a kind of tool for the investors against the number one enemy, the inflation. By this way, investment is a better alternative than time deposit and cash instrument which offer less return on investment than capital market instrument. Investment can also be a tool for investors in growing their wealth and preserve it. By staying invested, investor can generate earnings and even more from their existing money or fund as long as the market is in expectation and in favour.

Now the world is entering the era of recession when the trend is bearish and market is not so favorable. Many investors are now experiencing great losses and suffer in their investment. The investment has become like an enemy instead of a tool to grow, protect and preserve the wealth of investors. Some investors have stated that the investment did not making them money anymore at this time of recession, some said that better not to invest their money in capital market instead. All of these statements were raised mainly because one thing that investors have usually forgotten, its portfolio risk management. Investment bankings in US were bankrupt and no more. The capital markets in every major country were experiencing great amount of loss and people suffered in their investment. That was because one term that has been abandoned all this time, portfolio risk management.

In bullish trend, that was fine to structure the portfolio of investment in stocks and less in bonds as long as the return and risk of the portfolio were also fine with the investors. But when the market changes, the structure should be different in terms of portfolio contents. The investor should reduce the portion or share of stocks (since these relatively have high volatility) and increase the share of bonds and cash in their portfolio. That is the thing the investor should do.

Capital market of Indonesia has also suffered because of this world recession. The JCI as the main index price of BEI (Indonesia Stock Exchange) has shown a great downturn for the past one year. Now is the bearish year of the JCI. Therefore, it is also wise for the rational investors to also consider restructuring their portfolio to become mainly in bonds and cash instead of stocks. The way the investors doing this should be by applying the best method ever conceived called modern portfolio theory which was founded by Nobel Winner Henry Markowitz.

Risk and Return are just like two sides of one coin. The greater the return, the greater the potential risk may embodied within the investment. The research in this thesis will show investor on 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

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## CHAPTER 1

## PRELIMINARY

### 1.1. Background

"Change is inevitable. Change is constant." (Quoted by Benjamin Disraeli, 1804-1881). Change does happen, and change is the very fundamental basis of life. Life lies upon an ongoing and dynamically changing world and so does every single thing within it. Anything that does not follow, will be eroded as time goes by before eventually vanished. World is now facing financial crisis and entering the era of recession (Savage, 2009). Change or dounturn and bearish trend in the financial market are the major events that attract significant attention of the worldwide economies.

Historically speaking, 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. In US banking industry, investment banking is no more and no longer exist. 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. Some investment banks in US have already been converted into holding banking by regulation of US government (Financial Times, 11/12/2008 8:07 AM).

Default, restructuring and bankruptcy in major banks are events that happening as the logical consequences of current world financial market crisis. Some banks are bailed out and others just been let gone into the bankruptcy as the case of Lehman Brothers.

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 the some institutional which securitize the mortgage into MBS. This is one of the investment vehicle that eventually has made suffer 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, 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.

It is difficult to define favorable level of return without mentioning the risk involved within the definition and investor's preference. This consideration tends to be subjective and could be differ amongst investors as well as organizations. There are some level of judgment may be included in this concern. Hedge funds define the risk differently from mutual funds. Mutual funds define risk also differently compared to the banking industry.

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 better. 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.

As for example, let's say an investor has decided to put its funds into several asset classes consist of stocks $60 \%$ IDR $120,000,000$, Bonds $35 \%$ IDR $70,000,000$, Cash $5 \%$ IDR $10,000,000$. Total worth $100 \%$ IDR $200,000,000$. Let's say it was the initial investment and as time goes by, the market turns. There were some hiking in the return of stock. Let's say that at the certain point of time the portfolio of investment has changed into stocks IDR $160,000,000$, bonds IDR $70,000,000$, cash IDR $10,000,000$ and worth total IDR $240,000,000$. This result is good since it has earned favorable return on investment, about $40 \%$ above initial capital. But the question remains whether this was a good portfolio investment or not all. The answer will lie upon how much is the portfolio

Effective diversification can be done through an effective asset allocation. Asset allocation is an investment methodology 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 exposed the investor to more risk if did not well-diversified since the first time. It 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 buy some assets. It sets the initial allocation weights and then does nothing 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 be invested in shares.
- Constant proportion portfolio insurance. It is a strategy that buys shares as they rise and sells 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).

### 1.2. Main Issues

There is an old saying, "Do not put all your eggs in one basket". Putting the funds partially in more than one instrument is a very wise and rational act of investing. Rational investors try to achieve certain asset allocation at higher probability of return on investment with the lowest risk possible had. All kinds of strategy in portfolio investment as mentioned above were trying to achieve their objectives with some level of risk-return involved within it.

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, 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 investor trading strategies and its expectations concerning asset prices


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movement will prove that different portfolios can be interpreted as the result of differing expectations for asset price movements.

To the points, the three things or questions below are the main issues in this research:

1. 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?
2. 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?
3. 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?

### 1.3. Research Objectives

The financial crisis has made both individual and institutional investor need to revisit their portfolio balance. That is because the earlier balance has already been such unfavorable in terms of return. The research focuses on resolving issues such as:

1. Selection of maximum 12 assets which represent equity, fixed-income and money market. Those 12 assets comprises stocks, bonds and cash. The stocks will be selected from the LQ-45 population. The bond will be selected from government bonds and corporate bonds. Only one is taken from each of the government bond type. As for the cash, this research selects and assumes SBI-1month as the favorable cash instruments in money market.
2. Constructing 17 possible portfolio weight structures which need to be minimized respectively in their level of risk. After gaining the lowest risk possibly minimized for each of the 17 weight structures, then simulation will take place in order to provide investor with the statistical outcomes.
3. The defined model will provide to the investor about 17 possible weightings with their respective statistical parameters which have already been measured, calculated, simulated and optimized. Those need to be selected according the investor preference.

### 1.4. Scope of Research

There will be some things need to be defined in this research such as:

- The historical data of net returns of all selected assets (stocks, bonds, cash) which are taken from the last three years (2006-2008) respectively is the main input of the model. All the historical data will be provided in monthly basis to simplify the calculation..
- Assumptions are being made in this research, such as the risk-free rate and the target return. Time deposit is considered as the risk-free asset. The rate of time deposit (HSBC counter rate) when this data collection is took place, the rate was $9.25 \%$ net per annum (or $0.77 \%$ net per month). The reason is the investors will not be burdened by any risk by only keep their money in the time deposit with such rate applies. As for the target return, it is assumed and set about $18 \%$ net per annum (or $1.5 \%$ net per month). The reason is at time the data collection took places, the highest yield of the investor could gain from the bond market was about $15-17 \%$. So by increasing slightly the figure into $18 \%$, that was considerably enough for the investors as the target return.
- Some possible construction of portfolio which comprises stocks, bonds and cash. This research builds about 17 weighting structures of the portfolio which need to be simulated and optimized by the model.
- Based on the input (maximum twelve assets), the model will randomly generate about 10,000 numbers prior to the Monte Carlo simulation. This is produced by using the excel routine random function which based on the uniform distribution.


### 1.5. Systematic of Writings

The whole content of writing in this research consists of:

## CHAPTER I PRELIMINARY

This chapter contains everything that is related to reasons behind the investor's need for an applied model. Applying basic concept of Monte Carlo and linear programming are considerably powerful.

## CHAPTER 2 STUDY OF LITERATURES

This chapter explains the fundamental theory and principles which underlie the research. It originates from many sources and materials.

## CHAPTER 3 <br> MODEL CONSTRUCTION

This chapter is about building the model from the very beginning stage into having the final model definition.

## CHAPTER 4 DATA ANALYSIS AND RESULT INTERPRETATION

This chapter is about data analyzing and executing the defined model by conducting the calculation, optimization and simulation.

## CHAPTER 5 CONCLUSION AND ADVICE

This chapter summarizes the research and provides some conclusions to the investors. This chapter also mentions about the limitation of the research that investors should know about.

## CHAPTER 2

## STUDY OF LITERATURES

## 2. 1. The Definition of Investment

An investment is the current commitment of money or other resources in the expectation of reaping future benefits (Bodie \& Kane \& Markus, 2008). In other words, an investment is a kind of decision an individual or organization has to be made by deploying some resources with the hope of gain in the future.

An act of investment is similar with doing business in the market. In business within the market, people are trying to buy something with low price and sell it with higher price and have gains. That is the main idea. The same idea applies to an investment, people do invest today with an expectation of future gain. In the area finance and investment, the term resource and something are meant to be asset. An act of investment is an activity which is deliberated to increase the future value of an asset.

### 2.1.1. Investment Management Process

The investment management process comprises five steps (Fabozzi, 1999):

- Setting investment objectives
- Establishing investment policy
- Selecting a portfolio strategy
- Selecting the assets
- Measuring and evaluating performance

The first step is depending on the institution. It means the investment objective will vary according to the type of institution. For example, fund in a security company can
be invested in the marketable securities. The objective would then be to earn a return on invested funds that is higher than entry fee to the security company.

The second step is a guideline to satisfy the investment objectives. This is related to the asset allocation decision, means the investor should decide how to allocat the funds into several assets available in the market, according to the regulation, preference, and investment strategies.

Figure 2.1 Investment Management Process

> Setting investment objectives

Establishing investment policy

Measure \& evaluate performance

The third step is selecting certain strategy of investment amongst available strategies. Generally it comprises active and passive strategy, the rest are just the enhancement. In an active strategy, it uses available information and forecasting techniques in order to obtain better performance. Otherwise, in a passive investment strategy, it involves minimal expectation of input and really relies on diversification to outperform the performance of some indices in the market.

The fourth step is selection of asset. After the strategy is defined, the next step is to choose to specific assets to be included in the investment. Pooling those assets together usually called as investment portfolio or simply portfolio. This requires a thorough evaluation of assets in portfolio.

The fifth step is measuring and evaluating the performance of assets in portfolio and portfolio itself. It can be done by comparing the result of the portfolio with some kind of benchmark or reference in order to make the comparison. The result of a portfolio investment usually described in term of return that can be obtained and compared with gain an investor can have by supposedly hold the fund in time deposit or other cash equivalent assets.

### 2.1.2. Investment Versus Speculation

Generally, investment is distinguished from speculation by the time horizon of the investor and often by the risk-return characteristics of the investment (Fischer \& Jordan, 1991). As defined, an investment is a commitment of funds made by investors in the hope of some rate of return in the future. If the investment is well performed, the return will worth the risk the investor assumed prior to the decision.

The true investor is interested with the good rate of return, earned on a consistent pattern in a long period of time. Otherwise, the people who do speculation (speculator) seek the opportunities promising very large and fast earning or return. The speculator is less interested in consistent performance and more interested in an abnormal rate of return in such short period of investment. The longer an investor holds an asset, the more important are the return while the investor owns it and the less important is the price when he sells the assets (Williams, 1997).

## 2. 2. Asset Classes

Let every man divide his money into three parts, and invest a third in land, a third in business, and a third let him keep in reserve (Talmud, circa 1200 B.C.-500A.D). Long before the time of stock exchange was born as we know today, historically there had been kind of asset classes existed in the market for the purpose of investment. In general, asset class is defined as a class of assets that have similar characteristics, including risk factors and how returns are created. In current market, there are financial asset and real asset. In this research, the relevant asset involved are the variety in the financial assets such as stocks, bonds, cash (equivalent), mutual funds, etc. The physical material wealth of a society is ultimately driven by the productive capacity of its economy, which is the goods and services its member able to generate. On the contrary, financial assets (such as stock, bond, cash) are no more than sheets or pile of papers or more likely computer entries and do not contribute directly to the economic productivity (Bodie \& Kane \& Markus, 2008).

In this research, there are three financial assets are to be focused, stock, bond and money market securities. They are assumed and considered as the available asset classes in the market an investor can manage to allocate their funds into. Each of assets has some degree of risk embedded. The higher the potential return on an investment, the higher the potential risk and volatility is. Also similar, an investment that offer lower returns are generally lower in risk. It is natural to want to expect the highest possible return on investment, nevertheless it is also important to appreciate the levels of risk associated with the different asset classes. Stock, bond and cash are different asset class from the risk-return characteristics point of view. Stock is commonly the most volatile and risky asset among then all but in the same time also
has the potential highest return as well. Bond and cash are lower in risk and return compared to the stock, but it is cash that is usually generate the lowest return on investment to the investor but not necessarily.

Each asset class has a typical level of risk and return characteristics. Therefore, the step of asset selection will have face the situation where the investor has to make decision whether to chose a specific single asset or a combination of them. Choosing the specific assets can in a form of single asset (stock only or bond only or cash only) or combination with some degree of weighting for each of available asset class such as $60 \%$ stock, $30 \%$ bond, $10 \%$ cash (dominant stock). The fund could also be allocated in a different weighting such as $10 \%$ stock, $20 \%$ bond, $70 \%$ cash. These choices of weighting also provide investor with degree of risk and level of return of the portfolio investment. Generally, the more weighting in stock, the more risky a portfolio will be, but the higher probability to gain the higher risk. The relationship between risk and return for three assets can be shown as below:

Figure 2.2 Asset Class Risk-Return Characteristics


University of Indonesia

### 2.2.1. Stock in Equity Market

Stock is the representation of ownership in a corporation in the form of common stock or preferred stock. This is a kind of asset that signifies ownership in a company and represents a claim on part of the assets and earnings of the company. There are two categories of stock, they are common stock and preferred stock. Common stock provides the owner (investor) to vote at meetings of stockholders and dividend payments. Preferred stock does not have voting rights, but absolutely has higher claim on assets and earnings than the common stock. In other words, owners of preferred stock receive dividends before common shareholders and have priority in the event that a company goes bankrupt, liquidated or default.

In the equity market, stock is a marketable and available asset to the investors. Common stocks are known as securities or equities. These kinds of stock represent ownership shares in a company (Bodie \& Kane \& Marcus, 2008). This is the kind of stock is yet to be focused in this research along with other kind of asset classes (bond and cash). An owner of stock (a shareholder or stockholder or equity holder) has claim to the part of the assets and earnings of a particular company. A stockholder is an owner of a company in a legal and investment point of view. Ownership is determined by the number of shares of an investor owns relative to the number of outstanding shares. Stock is the basis of almost every portfolio of investment. Stock is historically and usually has outperformed other asset classes in the long term time horizon.

It is the capital market where shares are issued and traded either through exchanges or over-the-counter markets. It is one of the most important activity and aspect in an economy as it provides companies with access to capital and investors
with ownership in companies and potential of gains based on the company's future performance. Stocks are listed and traded on stock exchanges which are entities a corporation or mutual organization specialized in the business of bringing buyers and sellers of the organizations to a listing of stocks and securities together. The stock market in the United States includes the trading of all securities listed on the NYSE, NASDAQ, and the Amex. European examples of stock exchanges include the London Stock Exchange, the Deutsche Börse and the Paris Bourse, now part of Euronext. In Indonesia the stocks are marketable and available at BEI (Bursa Efek Indonesia or Indonesia Stock Exchange).

Each of stock exchanges in the world has its own index that reflects the price movement of the market. As the NYSE has its Dow Jones, Japan Stock Exchange has its Nikkei as the price index, and then in Indonesia the price index of BEI is JCI (Jakarta Composite Index). The JCI comprises hundreds of stocks listed in the exchange which are available to the investors to be traded to amongst them. Some of the stocks listed in the BEI within the JCI stocks set were considerably liquid in daily trading. These stocks are pooled into one specific index called LQ-45, because it comprises 45 liquid stocks. In this research, the stock selection will be conducted and used LQ-45 as the stock population which needs to be filtered in to the process of asset and portfolio selection.

### 2.2.2. Bond in Fixed Income Market

Bond is a kind of debt security in which the authorized issuer owes the holders a debt and, depending on the terms of the bond, is obliged to pay interest (the coupon) and/or to repay the principal at a later date, termed maturity. It is a formal contract to repay
borrowed money with interest at fixed intervals (Sullivan, 2003). Bond is issued by a private or government in order to raise the fund for specific reasons. It could be for capital expenditure, business expansion, covering deficit or something else which should be related to the institution's activity and productivity.

Bondholder is a creditor whereas stockholder is company's owner. Bond is usually higher in level of security compared to stock. However the level of returns also usually lower by investing in bond than stock. In common sense, bond is characterized with its stability and security. That is the main reason to recommend the inclusion of bond in the portfolio. By combining bond and stock in a portfolio of investment, the return of portfolio may be reduced slightly but in the same time also reduce the risk of portfolio investment. Share proportion or portfolio weighting can be managed and all of that will depend on investor's risk appetite. The more the risk an investor can burden or fine with, the more the portion of stock in portfolio can be added. On the other hand, a conservative investor may consider adding the portion of into the portfolio since it will provide investor with the less risk of portfolio.

Private and government can issue the bond in the fixed-income securities market. Private or company or corporation issues bond to finance their business activity or other company's initiatives. This kind of security is usually called corporate bond. The length of tenure prior to the maturity of corporate bond is usually less than 40 years. Corporate bond is usually listed on the exchanges and the coupon is also usually taxable (except with the new regulation applied in the Indonesia for at least up to the year of 2011). The other kind of bond security is government bond. It is a bond issued by the government itself (such as FR00002, the second series of fixed rate government bond of Indonesia). These kinds of bonds represent the safest bonds
since the Indonesia government guarantees them all. A government is usually issued and denominated in the country's own currency. Bonds issued by national governments in foreign currencies are normally referred to as sovereign bonds. Republic of Indonesia USD-denominated government bonds are considered as sovereign bond and the MTN (medium term notes) as well. The currency of these sovereign bonds is in USD and they are traded and cleared in the European exchange market.

Investors that invest in fixed-income securities or bond market are typically looking for a regular and stable return on investment. This is the reason for the importance of the bond rating in the market. Since the government bonds are countryissued, the ratings of those kinds of bonds are usually referred to the country's grade, whether it is investment grade or speculative grade. Usually the government bonds are preferred by the investor more than corporate bonds although it is not necessary. Some corporate bonds just showed the good performance and have investment grade rating from international rating companies such as Moody and Fitch. In current fixedincome securities market, there are some available corporate bonds that have investment grade, stable look and relatively secure such as HM Sampoerna Corporate bond, Indosat Corporate Bond, etc.

### 2.2.3. Cash in Money Market

Money market securities are usually referred to cash and others cash equivalent asset. In the simplest definition, cash is a legal tender in notes and coins (Cooper, 2004). Money market security comprises many kind of instruments such as bankers' acceptance (a bank-issued draft that will be accepted for payment, effectively the
same as a cashier's check), certificate of deposit (a time deposit of a bank with a specific date of maturity), repurchase agreements(a kind of short-term loans which normally less than two weeks), commercial paper(an unsecured promissory notes with a fixed maturity of one to 270 days and usually sold at a discount), or other marketable securities with length of tenure less than one year.

### 2.3. Portfolio Theory

Portfolio theory is an enhance investment approach that won a Nobel Prize for its author in 1990. It enables investors to classify, estimate, and control both the type and amount of expected risk and return as measured statistically. This approach usually called as "Modern Portfolio Theory" or "Portfolio Management Theory."

### 2.3.1. History And Background

Portfolio theory originates from conventional security analysis in changing emphasis from analyzing the timing and value of individual investments to determining the statistical movement of price relationships between the individual securities that comprise the overall portfolio. In March, 1952, Harry Markowitz wrote and published an article entitled "Portfolio Selection," (Markowitz, 1952) which explains how to combine assets into efficiently diversified portfolio. In 1990 he entitled to the Nobel Prize in Economics for this theory. This theory explained that investors failed to account correctly for the covariance among security returns. Holding securities that tend to move in concert with each other does not lower one's risk. It means the average risk of a portfolio is not the average of the individual asset of the portfolio if all of their values move in tandem or in concert with each other. Therefore, what was
perceived to be the low risk portfolio could be ended up with a high-risk portfolio. Modern portfolio theory embodies concepts that have been employed succesfully by fund managers for that last few decades in the market (Vince, 1996).

### 2.3.2. Return and Risk

The fact that there is strong relationship between risk and return on the investment is a very significant factor for the decision that investors made. When facing investment decision, there should be an offer of a return that is at least as high as the return on a similarly risky investment on financial markets. It means, for every level of return on the investment made, there should be risk contained within it (Richard and Stewart and Franklin, 2008). Statistically, return on investment usually stated as expected return. It is the weighted average of possible outcomes where the weights represent the outcome probabilities.

On the other side, risk is the possibility of loss in the future as may deviate from the investor's expectation or hope. That is the reason risk and standard deviation terms were used as similar in most literature. There are two major kinds of risk, they are universal (market or systematic or non-diversifiable) risk, and unique (firm or unsystematic or diversifiable) risk. Universal risk is a risk that affects a large number of assets in the whole country or area of an economy. Uncertainties and volatility in the general economy, such as GDP, interest rates, inflation, unemployment could severely affect significantly the universal risk. Market risk cannot be eliminated by holding whatever well-diversified portfolio because this risk is non-diversifiable in nature. On the contrary, unique risk affects only a single or specific firm or a small number of firms. Uncertainties in the certain industries regulation, labor contracts or
suppliers are part of unsystematic risk concern. Unique risk describes specific risk related to the market and can be diversified away. It can be reduced significantly from the investment by constructing a well-diversified portfolio (Fischer and Jordan, 1991). The relationship between the universal risk and unique risk is described below :

Figure 2.3 Relationships between Number of Assets and Standard Deviation


In common sense, it can be stated that the larger the number of assets combined or pooled in a portfolio of investment, the smaller the total portfolio risk can be although the market risk (non-diversifiable risk) is irrelevant. In other words, forming the welldiversified portfolio can eliminate the unsystematic risk.

### 2.3.2.1.Expected Return and Mean

Expected return is the weighted-average most likely outcome in theory of probability. In other words, it is the average of a probability distribution of possible returns (Barron, 1991). It is perceived to mean the statistically obtainable return based on
historical data and future probability assumptions over some period of time. Expected returns are perceived also as theoretical returns. The expected rate of return is the level of return that a realistic investor attempts to maximize at certain accepted level of risk (Damodaran, 2002). This definition can also be explained and formulated mathematically as below:

$$
E\left(r_{p}\right)=w_{1} \bar{r}_{1}+w_{2} \bar{r}_{2}+w_{3} \bar{r}_{3}+\ldots+w_{n} \bar{r}_{n}=\sum_{i=1}^{n} w_{i} \bar{r}_{i} .
$$

Where:
$E\left(r_{p}\right)=$ expected return of the portfolio
$w_{i} \quad=$ weighting or portion (share) of asset $i_{i}$ in the portfolio
$\bar{r}_{i} \quad=$ expected return of asset ${ }_{i}$ in the portfolio
n = number of assets combined in the portfolio

### 2.3.2.2.Coefficient of Correlation \& Covariance

Coefficient of correlation measures the probability of two or more assets whether have movement in the same direction at the same time. The correlation coefficient of +1 implies that the value of assets move in lockstep with each other, although not necessarily by exactly equal increments. A measure of -1 means assets move in opposite directions against each other. By combining asset classes which having low correlation, volatility can be reduced while enhancing risk-adjusted rates of the return on portfolio investment. The negative correlation may give investors a good opportunity in having the effective diversification. A correlation coefficient of zero means that there is no linear relationship between the variables. (Gibson, 1996).

Covariance is measure of the variance of two variables whether move in the same mean time period. Covariance and correlation are related parameters that indicate the extent to which two random variables co-vary. For example there are two stocks in a portfolio. If both stocks are affected by the same industry trends, then their movement will tend to move together. It means both stocks are co-vary and the parameter able to measure such tendency (Levin and Rubin, 1998).

Below is the simple formula that shows relationship between coefficient of correlation and covariance of two different assets:
$\rho_{X, Y}=\frac{\operatorname{cov}(X, Y)}{\sigma_{X} \sigma_{Y}}$.
Where,
$\rho_{X, Y} \quad=$ coefficient of correlation of asset $X$ and asset $Y$
$\operatorname{cov}(X, Y) \quad=$ covariance of asset X and asset Y
$\sigma_{x} \quad=$ standard deviation of asset $\mathbf{X}$
$\sigma_{Y} \quad=$ standard deviation of asset Y

### 2.3.2.3.Variance and Standard Deviation

Risk is the possibility of loss or uncertainty of future gain. Standard deviation as explained previously is the term which is actually the risk itself. It is derived from the fact that future event can not be precisely known prior to happen. Standard deviation and variance are the parameter of measurement for the volatility of portfolio investment movement.

Historical variance or volatility (risk) of an asset or portfolio can be statistically calculated and measured by using standard deviation parameter. The expected rate of return on a portfolio investment can be set according to its perceived risk. If the risk is lower, then the return should be likewise. Harry Markowitz entitled with a Nobel Prize for his theory that showed that to the extent a diversified portfolio has assets that do not move together (in concert) with each other, risk is actually can be diversified away while maintaining and increasing the expected return (Fabozzi, 1999). In finance, the variance and standard deviation of expected returns are common measures of investment risk. Mathematically, standard deviation is square root of the variance itself.
$\sigma_{p}=\sqrt{\operatorname{var}\left(\left[\bar{r}_{p}\right]\right.}=\sqrt{\sigma_{p}^{2}}$
where,
$\sigma_{p} \quad=$ standard deviation of portfolio
$\operatorname{Var}\left[\bar{r}_{p}\right] \quad=$ variance of portfolio

### 2.3.3. Asset Allocation \& Diversification

Asset allocation is the placement of fund among categories of assets in certain weight into the portfolio of investment. Asset allocation affects both risk and return and is a central concept in portfolio investment management.

The extent to which investments chosen for allocation move dissimilarly will determine whether the allocation of assets provides effective diversification (Gibson, 1996). Diversification is a method to manage investment risk of a portfolio.

Nevertheless, not all diversification is necessarily effective. If all assets in the portfolio are tend to be downtrend at the same time, and then diversification would be not effective at all. Diversification among assets that move together is ineffective diversification. Effective diversification should reduce portfolio risk and smoothes out returns. In other words, any type of diversification that reduces portfolio risk or volatility, it increases expected return of portfolio. In order to obtain an effective diversification, investor should select and combine assets that are statistically not moving together along some period of time.

Figure 2.4 Single Asset versus Portfolio Investment


From the figure above, it seems an investor can manage to select whether it is going to be merely in single asset investment (select assetX or asset $Y$ only) or in form of portfolio instead (combine asset $X$ and asset $Y$ in certain proportion). The rational
investor should select the portfolio since the effective diversification is exist in price movement of both assets (coefficient of correlation between asset $=-1$ ). The rest, investor only needs to decide the portion or weighting of both assets in the portfolio in order to have the highest expected return possible to the investment.

### 2.3.4. Portfolio Management

Modern portfolio analysis differs in emphasis from conventional portfolio analysis. The previous one usually gives more focus on risk-and-return estimates whereas the latter emphasizes on the calculation of an intrinsic value. Portfolio management is characterized by an old and new way of portfolio problem solving.

Portfolios are combinations of assets, they are consists of set of security 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.

### 2.3.4.1.Basic Assumptions

Nobel laureate Harry Markowitz had made the assumptions about investor behavior in the investment framework. Those assumptions were:

- Return distributions. Investor looks at each investment chance as a probability distribution of expected rate of return of investment over a given investment horizon.
- Utility maximization. Investor behaves such that they maximize their expected utility over a given investment horizon.
- Risk is variability. Investor measures risk as the variance (standard deviation) of expected returns.
- Risk and Return. Investor makes all the investment decisions by considering only the risk and return of an investment opportunity.
- Risk aversion. Investor prefers the any investment with the lower risk if there were options available to be selected.


### 2.3.4.2.Portfolio Return \& Volatility

The expected return with historical data is simply the average return over $n$ years. Formula 2.1 has shown the mathematical expression for calculating expected return in given time horizon.

In world of finance and investment, the volatility is measured by variance and/or standard deviation. Standard deviation is solely square root of variance. Variance and standard deviation of expected returns are common measures of risk. Both these related measures determine the variability of a distribution of returns about its mean or average. The variance and standard deviation of returns from historical data are calculated as shown by formula expression 2.3 previously. More detail formula can be expressed as below
$\operatorname{variance}=\sigma^{2}=\frac{\sum_{t=1}^{n}\left(R_{t}-\bar{R}\right)^{2}}{n}$

Where,
$R_{t} \quad=$ return in period $t$

```
R}\quad=\mathrm{ average return (expected return)
n = number of data
```

As for the portfolio the expression will have to combined with the weight of each assets allocated in the investment. Below is the formula for portfolio variance expression thus also obtaining the value of standard deviation (square root of variance).
$\sigma_{p}{ }^{2}=\operatorname{var}\left[r_{p}\right]=\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i} w_{j} \sigma_{i j}$
where,
$w_{i} \quad=$ weighting of the-i asset
$w_{j} \quad=$ weighting of the-j asset
$\mathrm{i}, \mathrm{j} \quad=$ integer value commencing 1 to number of assets in the portfolio

This variance portfolio (portfolio standard deviation) becomes the central issue in this research since some weighting structures will be structured and compared in order to have the lowest risk possible conceived to the portfolio of investment.

The theory of Markowitz based on the following concept:
"If two portfolios have the same expected return, the one with the lower volatility will have the greater compound rate of return."

It means, by reducing variance, investors are also reducing risk that comes from volatility. Reduction of portfolio variance reduction can only be obtained through effective diversification. Actively trading or substituting securities within a portfolio
will not only lessen the potential benefits of the variance reduction but will also increase transaction costs (Papp, 1991).

### 2.3.4.3.Efficient Frontier

Modern portfolio theory states that diversification is a tool for the rational investors to optimize their portfolios. Markowitz theory is based on method of diversification which further visualized with the efficient frontier, the locus of all optimal risk-return of the portfolio investment (Gibson, 1996).

The return of portfolio is a random variable and consequently has an expected value and a variance whereas risk is the portfolio standard deviation of portfolio. The model assumes that investors are risk averse. An investor will accept the higher risk if, and only if compensated by higher expected return as logic consequence. In other words, an investor who eager for higher returns should willingly to burden more risk.

Every possible portfolio can be plotted in risk-return quadrant, and set of all such possible portfolios (or locus) defines a region in this space. The boundary line along the upper edge of this region is visualized as the efficient frontier or Markowitz Frontier. The set of portfolios in this Markowitz frontier line represent portfolios where is the lowest risk for a given level of return. Or can be stated as for a certain level of risk, the portfolio exist on Markowitz frontier represents the set of portfolios which offer the best possible return. In dimensions of expected return and standard deviation, the efficient frontier is a locus of efficient portfolios. The rational investors limit their selection of a portfolio to those which appear on the efficient frontier and to the specific portfolio that represents their own risk tolerance level and their target return of the portfolio investment (Kritzman, 1990).

Still related with the Markowitz Theory, there is a specific term called capital allocation line (CAL). Capital allocation line (CAL) is the locus of all possible combinations of the risk-free asset and the risky asset in investment quadrant. This can be drawn only a risk-less asset involved in the portfolio of investment. By plotting the tangency portfolio within the efficient frontier (the one with the best or optimal portfolio) and the risk-free rate (represents the rate an investor would expect from an absolutely risk-free asset over a specified period of time), and then the CAL can be drawn combined with the efficient frontier as below:

Figure 2.5 The Efficient (Markowitz) Frontier


The slope of CAL is the Sharpe ratio of the best portfolio, the tangency portfolio within the efficient frontier.

CALslope $=$ sharpe $\quad$ ratio $=\frac{\text { portfolioreturn }- \text { riskfreerate }}{\text { portfoliorisk }}$.

Sharpe ratio indicates whether returns of portfolio are due to smart investment decisions or merely as a result of additional portfolio risk. This measurement is very useful because although one portfolio can obtain higher portfolio return, it is only as good as long as no more additional risk which burdens significantly the investment. The greater the Sharpe ratio, the better the performance of the portfolio should be. A negative Sharpe ratio indicates that a risk-less asset would perform better than the asset being analyzed.

### 2.4. Monte Carlo Concept and Linear Programming

The term "Monte Carlo" which was suggested by John von Neumann and S. M. Ulam, in the 1940 's, refers to process simulation by using random numbers. The term Monte Carlo (a city known by its gambling casinos) originated from the fact that "numbers of chance" were used in order to solve some of the complex equations involved in the design of the first nuclear bombs.

### 2.4.1.History of Monte Carlo Simulation

The first documented account of Monte Carlo simulation seems to date back to Buffon's needle(1768), at when the technique was used to estimate the value of $\Pi$ by throwing needles on a striped floor and counting the proportion of needles that intersect a line(Dupire, 1998).

Nowadays Monte Carlo simulation is often utilized for risk management. It use utilized to help make decisions given uncertainties in future market trends, fluctuations, and other uncertain factors. In are of finance and investment, Monte Carlo methods are used to valuate and analyze investment portfolios by simulating the
uncertainty of expected return in the future. It is first introduced into the world of finance and investment at year 1964 by David B. Hertz in "Risk Analysis in Capital Investment" (Harvard Business Review).

### 2.4.2.The Flaw of Average

The Flaw of Averages (Savage, 2009) states "Plans based on average assumption are wrong on average." It means, prediction which is based on the historical average value were wrong on average. In other words, using average value in order to forecast the future value of a certain variable is usually wrong in average. In simple explanation, investor can not depend on single average number in order to make investment decision in the future.

This is related to the expected return of portfolio in the future of investment portfolio that investor has. This form of the flaw of averages results from ignoring the effects of diversification and statistical dependence. This is one of the problems addressed by Harry Markowitz and Bill Sharpe in Modern portfolio Theory.

As stated by Roman scholar Pliny the Elder, "The only certainty is that nothing is certain", therefore logically no accurate prediction or forecasting can be made based on single value (in this case the average) in order to make plan and decision regarding investment. What will happen in the future event can only be modeled and simulated by providing a large possible number of certain values which may occur in the future event. By this method, there may be some level of probability some numbers predicted within some range may be occurred in the future event.

### 2.4.3.The Advantage of Simulation

The term simulation refers to any analytical method meant to imitate a real-life system, especially when other ways are too complex or too difficult to generate. Monte Carlo simulation is a form of simulation that randomly generates values for uncertain variables over and over to simulate a model. Simulation is the other way around better than only depend on single average number (Savage, 2009). Investors need the ability to forecast and assess what its future event performance will be for their investments. In most institutions, this is done using a deterministic model, which is a model which does not consider the uncertainty inherent in all the inputs to the model. What the simulation does is to model the relationship between variables, the probability of different weighting amongst the portfolio, and to analyze the portfolio results as a complex whole.

By the advantage of powerful computer nowadays, the simulation can be done by conducting massive repetition in terms of millions of trials within very short of time. Statistically, the larger the number of trials or repetitions conducted in a simulation in order to obtain the outcomes, the smaller the level of error. The relationship between the error and the number of iterations can be seen at this formula:

$$
\varepsilon=\frac{Z \sigma_{p}}{\sqrt{N}}
$$

Where,
$\varepsilon \quad=$ standard error of the mean of the distribution.
$\mathrm{Z} \quad=$ the confidence multiplier of a TWO tailed normal distribution
$\sigma_{p} \quad=$ portfolio standard deviation
$\mathrm{N} \quad=$ number of repetitions (runs)
The larger the number of iterations (runs), the smaller the standard error, thus the higher the confidence level. In this research, the number of runs 10,000 will be conducted to populate the expected rate of return in the future event.

### 2.4.4.Uniform Random Number

The forecast rate of expected returns on the portfolio can be generated according to statistical distribution which defines it. In this research, since the historical values are assumed can not be accurately used to predict the future value by only using average return, then certain statistical approach will have to be applied in order to have the series of massive random number.

In this research, uniform distribution is utilized to generate those random numbers. By knowing the maximum and the minimum figures of the historical value of each asset, the random number (which in term of probability may represent the possible event in the future) can be produced and later calculated. A uniform distribution is one for which the probability of occurrence is the same for all values of population. It is also called a rectangular distribution. For example, if the number of repetition of asset X is about to be 10,000 , then the probability of obtaining any one of the 10,000 possible outcomes is $1 / 10,000$. Since all outcomes are equally probable, the distribution is uniform. If a uniform distribution is divided into equally spaced intervals, there will be an equal number of members of the population in each interval (McLeish, 2004).

### 2.4.5.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 as diagram below:

Figure 2.6 General Flow of Monte Carlo Simulation

> Domain of possible input definition


This process can be actually can be done in more descriptive, mathematical or algorithmic way, but the principle of conducting simulation of Monte Carlo is just
similar with the above flowchart. Defining a domain of possible inputs is one of the input parts which are determine 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.

### 2.4.6.Linear Programming With Solver

A linear programming problem can defined as the problem of maximizing or minimizing a linear function subject to linear constraints. The constraints may be equalities or inequalities (Vince, 1990).

In the area of implementation, linear programming can be applied by utilizing Solver of Excel. Solver is part of a commands sometimes called as what-if analysis tools. By utilizing Solver, optimal value of certain problems of optimization can be found. Solver works with a group of cells that are related, either directly or indirectly to the formula in the target cell. Solver tries to find the values in the adjustable cells in order to generate the result specified in the target cell formula. Some constraints and requirments can be added to restrict or limit the values in the certain boundaries. These constraints can refer to other cells that affect the target cell formula. In this research, Solver will be utilized to determine the maximum return of portfolio as well as minimum risk of a certain structured weighting.

## CHAPTER 3

## MODEL CONSTRUCTION

### 3.1. 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 as below:

Figure 3.1 Basic Framework of Model


This research is based on theory in probability and statistics to better the decision made when dealing with risk and uncertain events in the future by building a model prior to a tool or instruments. This model is simply the derivation of IPO (Input Process Output) model framework.

### 3.2. 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.

### 3.1.1. Historical Data

Historical data is the empirical data of some asset classes as part of the input to the 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. The figure below is the input side of the graph-based model representation:

Figure 3.2 Historical Data Filtering


Historical Data Definition

...to the process or model execution

In the historical data definition, there will 12 assets ( 9 stocks, 2 bonds, 1 cash) with 36 month of historical net earnings data for each asset.

### 3.1.2. 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 need 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.

Figure 3.3 Tasks in Historical Data Definition


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 with the figures obtained from the outcomes of optimization and simulation in the next phase of this research. The mean return uses the arithmetic average for the sake of simple calculation and the relevancy 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.

### 3.3. Model Objective

Generally there two type of objectives in the optimization model, they are maximization and minimization. The first one needs 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.

### 3.2.1. Lowest Portfolio Risk

Lowest risk portfolio 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. As formulated in the expressions 2.3, 2.4 and 2.5 , 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 needs to be done.

Figure 3.4 Deriving Portfolio Risk


At figure 3.4, the goal is to have 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 can be reached.

### 3.2.2. Highest Portfolio Expected Return

The portfolio expected return is simply had from 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.

Figure 3.5 Generating Portfolio Expected Returns


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 will be populated from process described as figure 3.5.

### 3.2.3. 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 needs 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 investor with the maximum portfolio rate of return on investment with the lowest risk based on the forecasted expected returns of each asset.

### 3.4. Model Constraint

There are boundaries in the process of optimization that 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.

### 3.3.1. 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:

$$
\sum_{i=1}^{n} w_{i}=100 \%
$$

Where,
$w_{i} \quad \geq 0$ where $i=1,2,3,4, \ldots n$ and $i$ is integer.
$w_{i} \quad=$ the series of weight structure
n = number of assets

In this expression, the $w_{i}$ should be equal and greater than zero since it was assumed that no minus proportion exist in the portfolio weighting structures.

### 3.3.2. Conditional

The asset classes comprise stocks, bonds and cash within each of portfolio which eventually need to be selected as the best one. Prior to that, investors (both personal or fund managers) may categorize the weighting of the portfolio into several structures. The basis of categorizing the weighting is in the how much fund will be allocated in all asset classes respectively, for example how much fund in stocks, portion in bonds and rest in cash. This is actually the main best practice of fund managers in the current market, dynamic reallocating or changing the weight structures of portfolio dynamically or periodically.

This is actually part of the constraints with conditions set by the investor. In general, there about 17 weighting structures are going to be build as conditional constraints. In simple explanation, some investors are just use the terms 'dominant stocks, less in bonds and cash', or 'dominant bonds and stocks, less and rest in cash', or else. All the list of 17 weighting structures can be seen at attachment (refer to table section). All these weighting structure are going to be optimized in terms of its risk. The respective portfolio risk is going to represent the weighting structure with the lowest risk possible. The weighting structure is placed as part of the constraint in model as described below:

Figure 3.6 Finding the Lowest Risk Weighting Structures

where $\mathrm{j}=1$ to 17 each of them represents the specific weighting structure.

### 3.3.3. 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
- $\quad$ total random series generated $=10,000$
- total shares of in portfolio weight $=100 \%$
- each of shares of weight is at minimum zero $\%$ and maximum $100 \%$
- The 17 weighting structures as conditional constraints
- Minimum target return, in this research is set about $18 \%$ pa or $1.5 \% \mathrm{pm}$.

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.

### 3.5. Model Format

Format of the model can be described in several ways although still explain the same meaning and the same result. In this research, the model definition can be described in
descriptive, flowchart, mathematical, algorithmic and solver depends on the need and simplicity. In this research, linear programming is simply applied by Excel's Solver.

### 3.4.1. Flowchart

In this research, the model is mostly described by using flowchart since it visualizes the model and relatively easier to understand and elaborate.

Figure 3.7 Model in Flowchart


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### 3.4.2. Descriptive

This is how the model is showed in 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 the model is going to be executed. The basic and conditional constrains 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 of 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 is equal or greater than target return defined by the investor since the first time.

## CHAPTER 4

## DATA ANALYSIS AND RESULT INTERPRETATION

### 4.1. 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.

### 4.1.1. Asset Picking

Assets picking can be a very difficult and complex matter to do (Fischer and Jordan, 1991). That is because nobody and no single foolproof method to forecasting assets price movements in the future. Nevertheless, by examining some factors or variables, investors may perceive a better sense of future asset prices or their behavior rather than purely relying on some kind of speculation or advices from some relatives or sources.

The analytical components that most commonly utilized by equity investors to select good investment prospects might include some or many categories (Fischer \& 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 healthiness of an asset's 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 as listed in the table 4.1 as attached. 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 as stated in the table above. 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 $V \times F$ 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, INKP. Those stocks are representing stocks of the industry of mining, infrastructure, miscellaneous, finance and banking, agriculture, trade and services, construction, consumer goods, basic industry, respectively.

Table 4.2 List of Selected Stocks Out of LQ-45

| * | CODE | COMPANY | SECTOR | VALUE(V) | FREQUENCY(F) |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | BUM | Bumi Resources Tbk | Mining | 250,800,000,000,000 | 1,131,839 |
| 2 | TLKM | Telekomunikasi Indonesia Tbk | Infrastructure | 59,500,000,000,000 | 289,625 |
| 3 | ASII | Astra International Tok | Misc Industry | 37,600,000,000,000 | 252,915 |
| 4 | BMRI | Bank Mandiri (Persero) Tbk | Finance | 26,900,000,000,000 | 258.069 |
| 5 | UNSP | Bakrio Sumatra Plantations Tbk | Agriculture | 21,700,000,000,000 | 386,253 |
| 6 | UNTR | United Tractors Tbk | Trade \& Services | 21,500,000,000,000 | 219,880 |
| 7 | ELTY | Bakrieland Devalopment Tbk | Construction | 17.500,000,000,000 | 211,370 |
| 8 | INDF | Indofood Sukses Makmur Tok | Consumer Goods | 13,900,000,000,000 | 212,540 |
| 8 | INKP | Indah Kiat Pulp \& Paper Tok | Basic Industry | 12,500,000,000,000 | 220,943 |
|  | INKP | Indah Kiat Pulp a Papernk | TOTAL | 461,900,000,000,000 | 3,183,434 |

Below are profile summaries of selected nine stocks retrieved from Realtime Investor. BUMI stands for Bumi Resources. The company was established in 1973, and has a primary business in the hotel and tourism industry. There were unfavorable news and rumors regarding this company since it owned by Bakrie. But there were two considerations behind this asset picking, the first was the price has already been discounted significantly, and the second was there were a transition of ownership.

TLKM stands for PT. Telkom. The company represents a continuation of an enterprise owned by the government of the Dutch East Indies. This is the biggest telecommunication state-owned enterprise in Indonesia.

ASII stands for PT Astra International Tbk is now one of the largest conglomeration business group in Indonesia.

BMRI stands for Bank Mandiri. BMRI was able proceed net profit of IDR603.37 billion in 2005 or down sharply by $88.52 \%$ versus IDR5. 26 trillion in 2004.

UNSP stands for United Sumatera Plantations. The history of the company can be tracked to as early as 1911, when NV Hollandsch Amerikaanse Plantage Maatschappij, a rubber plantation company was established. In 1986 Bakrie Group acquired the whole ownership from Uniroyal Sumatera Plantations, which was then owned by Uniroyal and changed the name into United Sumatera Plantations.

UNTR stands for United Tractors. It was founded in 1972 under the name of PT Inter Astra Motor Works, the company has co-operational contracts with Komatsu Forklift, John Deere Internasional and Bomag Koehring Gmbh.

ELTY stands for Elang Realty. As implied by the company's name, the company runs in the property sector. It is founded in mid-1990 under the name PT Purilestari Indah Pratama. Management of this property is in the hands of Aquila International Hotels
and Resorts Management of Singapore. In 1994, occupancy of the hotel reached a satisfactory $\mathbf{6 8 . 3 0 \%}$.

INDF stands for PT Indofood. The company products are marketed under the Indomie,Sarimi,Supermi, Pop Mie dan Top Mie brands and control $90 \%$ of the instant noodle market in Indonesia. In April 1994, Global Mark International Limited, one of the shareholders, floated US $\$ 500$ million worth of 3-year mandatory Exchangeable Bonds (MEB) on the Luxembourg Stock Exchange.

INKP stands for PT Indah Kiat Pulp\&Paper. It was established in 1976 and was listed on both the Jakarta and Surabaya Stock Exchange in the middle of 1990. Indah Kiat is one of Asia Pulp \& Paper Co. Ltd’s indirect subsidiaries and one of the largest pulp and paper producer in Asia.

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 Sampoema 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. As shown in the next table (table 4.4), FR00002 is still 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 whole list of these government bonds is available in the attachment (table 4.3).

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. It can be shown by part of documents as below:

Figure 4.1 HM Sampoerna Corporate Bond Rating Statement


Those were reasons behind the selection of FR00002 and HMSP03. Both bonds are assumed to represent top government and corporate bonds of fixed-income market.

For money market instrument, this research only uses the government-issued money market, it is called SBI (Bank of Indonesia Certificate). The terms of the SBI used in this research was 1 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 below that mentioned SBI 1-month as the cash instrument with the highest absorbed amount at year-end 2008.

Table 4.4 Auction Result of SBI dan SBIS at 31 December 2008

| PARAMETERS of INSTRUMENTS | SBI |  |  | SBIS |
| :---: | :---: | :---: | :---: | :---: |
| Tenor | 24 | 87 | 178 | 28 |
| Overah Indicative Target | 57.5 |  |  |  |
| Recerved Offer | 44.3 | 4.45 | 6.1 | 0.92 |
| Range of Bid Rate | $\begin{aligned} & \hline 9.25 \%- \\ & 11.25 \% \end{aligned}$ | $\begin{gathered} \hline 11.00 \%- \\ 11.20 \% \end{gathered}$ | $\begin{gathered} \hline 11.70 \%- \\ 12.00 \% \\ \hline \end{gathered}$ | - |
| Absorbed Amount | 29.48 | 3.59 | 5.46 | 0.92 |
| Stop Of Rate | 10.90\% (FA) | $\begin{gathered} 11.15 \% \\ \text { (FA) } \end{gathered}$ | $\begin{gathered} 11.90 \% \\ \text { (FA) } \\ \hline \end{gathered}$ | - |
| Wetghted Average SBI's Auction | 10.83 | 11.08474 | 11.82 | - |
| Return of SBIS | - | -- | - | 10.83381 |
| Softlement Date | 5-Jan-09 | 5-Jan-09 | 5-Jan-09 | 31-Dec-08 |
| Due Date | 29-Jan-09 | 2-Apr-09 | 2-Jut-09 | 28-Jan-09 |
| Frequency of Auction | 184 | 27 | 26 | 16 |

## Description:

- tenor in daye amount
- overall indicative target, recelved offer and absorbed amount in billion rupiah
- range of bid range, weighted averege sbi's auction, and sbis rate of retum in \% (percent)
- frequency of auction in transaction unit
eource: Bank of Indonesia (BI)


### 4.1.2. 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 below.

Table 4.5 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 Kingdorn | 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 |  |  |  |  |

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 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.

Figure 4.2 JCI Historical Prices Y2005-Y2008


JCI vehicle comprises more than 300 companies and have strong relationship with the Indonesia Gross Domestic Product (GDP). At a glance see, it can be analyzed that from the year 2005 up to year 2007, the market trend of Indonesia capital market was in bullish. Commencing year 2008, the market drop significantly. 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.

### 4.1.3. 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

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should be defined and the rate is about $18 \%$ net per annum, equal to the $1.5 \%$ 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 be an onshore type of investment, it means that all funds to be allocated to the portfolio are in Rupiah currency also.

### 4.1.4. Data Collection

Retrieval process of data from the 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 as shown by table 4.6 in the attachment. 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 with the SBI-1month, the percentages are calculated by simply divide the SBI-1month with twelve since one year comprises 12 months.

Back to the reason of assets picking as defined previously, one other additional reason to pick these assets together were also regarding the data availability in the current market in terms of timeframe.

### 4.2. 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.

### 4.2.1. 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 below.

Table 4.7 Statistical Parameters

| Parameters | BUM1 | TUKM | ASIII | BMRI | UNSP | UNTR | ELTY | INDF | INKP | FR0002 | HMSP03 | SBL-1 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Mnimum | -53.56\% | -24.48\% | -45.32\% | 41.13\% | -67.97\% | 66.67\% | -67.23\% | -4.39\% | -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\% | 0.80\% | 2.76\% | 1.79\% | 3.76\% | 1.06\% | 2.83\% | 0.82\% | 1.17\% | 0.82\% |
| Sld 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\% |

### 4.2.2. 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.

Table 4.8 Coefficient of Correlations

| ASSETS | BUMI | TKM | ASII | BMRI | UNSP |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BUMI | 1.000000 | 0.090074 | 0.411605 | 0.226659 | 0.500697 | 0.336522 | ELTY | 1 NDF | INKP | FR0002 | HMSP03 | SBL 1 |
| TLKM | 0.090074 | 1.000000 | 0.615837 | 0.747954 | 0.170317 | 0.336622 | 0.356743 | 0.615977 | 0.289736 | -0,686909 | -0.500880 | -0.403033 |
| ASII | 0.411605 | 0.615837 | 1.000000 | 0.716694 | 0.392185 |  | 0.102783 | 0.352198 | -0,028306 | -0.238225 | 0387428 | 0.137386 |
| BMRI | 0.226659 | 0.747954 | 0.716694 | 1.000000 | 0.263234 | 0.698529 | 0.340343 | 0.617895 | 0281944 | -0.467562 | -0.347023 | -0.064465 |
| UNSP | 0.500697 | 0.170317 | 0.392185 | 0.263234 | 1.000000 | 0.536381 | 0.212763 | 0.478866 | 0211777 | -0.384160 | -0.487087 | 0.015605 |
| UNTR | 0.336622 | 0.503846 | 0.698529 | 0.584444 | 0.536381 | 0.53638 | 0.7 | 0.511952 | 0.451631 | -0.236570 | -0.255489 | 0.217558 |
| ELTV | 0.356743 | 0.102783 | 0.340343 | 0.212763 | 0.749788 | $\bigcirc$ | 0.248696 | 0.699606 | 0.370941 | -0.425010 | -0.375439 | -0.035726 |
| WOF | 0.615977 | 0.352198 | 0.617895 | 0.478866 | 0.511952 | 0.698606 | 029 | 0297063 | 0.384324 | -0.256742 | -0.143943 | 0.095333 |
| 1 NKP | 0.289736 | -0.028306 | 0.281944 | 0.21177 | 0.451631 | 0.370941 | 0.297063 | 1.000000 | 0.433811 | -0.491270 | -0.477787 | -0.079515 |
| FRC002 | -0.686909 | -0.238225 | -0.467562 | -0.384160 | -0.236570 | 0.325010 | 0.384324 | 0.433811 | 1.000000 | -0.123398 | 0.010462 | 0.126499 |
| HMSP03 | -0.500880 | -0.387428 | -0.347023 | -0.487087 | 0.255489 | -0.425010 | -0.256742 | -0.491270 | -0.123398 | 1.000000 | 0.480114 | 0.724363 |
| 5B1-1 | $-0.403033$ | 0.137386 | 0.064465 | 0.015605 | 0.217558 | -0.375439 | -0.143943 | -0.477787 | 0.010462 | 0.480114 | 1.000000 | -0.002844 |
|  |  |  |  | 0.0100 | 0.2175 | -0.035726 | 0.095333 | -0.079515 | -0.126499 | 0.724363 | 0.002844 | 1.000000 |

Table 4.9 Covariance

| ASSETS | BUM | TLKM | ASII | BMRI | UNSP | UNTR | ELTY | INDF | INKP |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| BUMI | 0.040389 | 0.001684 | 0.011499 | 0.008024 | 0.022413 | 0.010873 | 0.020810 | 0.017459 | INKP | FR0002 | HMSP03 | $\frac{\text { SBL-1 }}{-0.000116}$ |
| TLKM | 0.001684 | 0.008655 | 0.007964 | 0.009202 | 0.003529 | 0.007534 | 0.002776 | 0.004621 | -0.000746 | -0,000038 | 0000036 | -0,000116 |
| ASII | 0011499 | 0.007964 | 0.019324 | 0.013175 | 0.012143 | 0.015562 | 0.013733 | 0.012114 | 0011102 | -0.000112 | 49 | -0,0000113 |
| BMRI | 0006024 | 0.009202 | 0.013175 | 0.017489 | 0.007754 | 0.012423 | 0.008167 | 0.008932 | 0007933 | -0,000088 | 5 | -0000 |
| UNSP | 0022413 | 0.003529 | 0.012143 | 0.007754 | 0.049611 | 0.019202 | 0.048475 | 0.015082 | 0028495 | -0.00009 | 0000058 | 000 |
| UNTR | 0010873 | 0.007534 | 0.015562 | 0.012423 | 0.019202 | 0.025833 | 0.011602 | 0.015836 | 0016888 | -0,000118 | -000006 1 | 0000 |
| ELTY | 0080810 | 0.002776 | 0.013733 | 0.008167 | 0.048475 | 0.011602 | 0.084253 | 0.012161 | 0031500 | -0,000129 | -0000ca | $03000 \times 1$ |
| NDF | 0.017459 | 0.004621 | 0.012114 | 0.008932 | 0.016082 | 0.015836 | 0.012161 | 0.013891 | 0017331 | -0.000120 | -0,000068 | 0000016 |
| N/P | 0.016494 | -0.000746 | 0.011102 | 0.007933 | 0.028495 | 0.016888 | 0.031600 | 0017331 | 0.080240 | -0,00060 | 0000003 | 0000061 |
| FR0002 | -0,000239 | -0.000038 | -0.000112 | -0,000088 | -0,000091 | -0.000118 | -0.000129 | -0,000120 | -0,000060 | 0,000003 | 000000 | 03000 cz |
| HMSP03 | -0,000102 | -0.000036 | -0.000049 | -0.000065 | -0.000058 | -0.000061 | 0.000042 | -0,000068 | 0000003 | 0.000001 | 0000001 | 0000000 |
| SBL-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 |

### 4.2.3. Scenarios of Weighting

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

Table 4.10 The Possible 17 Weighting Structures

| WEIGHTING STRUCTURES | CONDITIONAL CONSTRAINTS \& BOUNDARIES |  |  |
| :---: | :---: | :---: | :---: |
| 1 | Portfolio comprises with merely stocks |  |  |
| 2 | Portfolio comprises with merely bonds |  |  |
| 3 | Portfolio comprises with merely cash |  |  |
| 4 | Share of stock $\geq$ (bond + cash) | AND | share of bond $\geq$ cash |
| 5 | Share of stock $\geq$ (bond + cash) | AND | share of bond $\leq$ cash |
| 8 | Share of bond $\geq$ (stock + cash) | AND | share of stock 2 cash |
| 7 | Share of bond $\geq$ (stock + cash) | AND | share of stock $\leq$ cash |
| 8 | Share of cash $\geq$ (slock + bond) | AND | share of stock $\geq$ bond |
| 9 | Share of cash $\geq$ (slock + bond) | AND | share of stock $\leq$ bond |
| 10 | Share of slock $=$ share of bond | AND | share of bond $=$ share of cash |
| 11 | Share of slock $\leq$ (bond + cash) | AND | share of bond $\geq$ cash |
| 12 | Share of stock $\leq$ (bond + cash) | AND | share of bond $\leq$ cash |
| 13 | Share of bond $\leq$ (stock + cash) | AND | share of tock 2 cash |
| 14 | Share of bond $\leq$ (stock + cash) | AND | share of stock $\leq$ cash |
| 15 | Share of cash $\leq$ (stock + bond) | AND | share of stock $\geq$ bond |
| 18 | Share of cash $\leq$ (stock + bond) | AND | share of stock $\leq$ bond |
| 17 | free-style (has no specific nule, but the | e we | hting with the lowest risk) |

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Each of 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.

### 4.2.4. Risks Minimization

Stocks comprises nine selected assets, bonds comprises 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. This table below is the result of risk minimization process done by solver with 32,767 times of trials (repetitions).

Table 4.11 The Lowest Risks For Each Weighting Structures

| T1 | SUM1 | TKM | ASII | BMRI | JNSP | UNTR | ELTY | INbF | INKP | FR0002 | HMSPO 3 | S61-1 | STOCK | BOND | CASH | RISK |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 10.58\% | B0.28\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 0.38\% | 1.79\% | 6.97\% | 0.00\% | 0.00\% | 0.00\% | 100.00\% | 00\% | 0.009 | 46640 |
| 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\% | .00\% | 0.1003 |
| 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\% | 00.009 | 0.143359\% |
| 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 | 4.196487\% |
| 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\% | 25.009 | 4.214640\% |
| 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\% | $0.66 \%$ | 0.066869\% |
|  | 0.29\% | 0.00\% | 0.00\% | 0.17\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 67.64\% | 31.76\% | 0.41 | 67.84\% | . 76 | 0.0 |
| - | 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\% | 0.130352\% |
| 9 | 0.26\% | 0.00\% | 0.00\% | 0.09\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 49.65\% | 09 | 0.35\% | 49.65\% | 0.00 | 0.067734\% |
| 10 | 3.83\% | 26.58\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 0.08\% | 0.53\% | 2.31\% | 33.33\% | 0.00\% |  | .33\% | 3.33\% | 33.33\% | 2.797923 |
| 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\% | 49.83\% | 0.067595\% |
| 12 | 0.26\% | 0.00\% | 0.00\% | 0.09\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% |  | 0.00\% | 25.00\% | 25.00\% | 50.00\% | $25.00 \%$ | 2.080900\% |
| 13 | 2.99\% | 19.82\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 0.06\% | 0.42\% | 1.70\% | 0.00\% | 50.00\% | 49.65\% | 0.35\% | 50.00\% | 49.65\% | 0.067456\% |
| 14 | 0.26\% | 0.00\% | 0.00\% | 0.09\% | 0.00\% | 0.00\% | .00\% | 0.00\% | 1.75\% | 0.00\% | 25.00\% | 50.00\% | 25.00\% | 25.00\% | $50.00 \%$ | 2.104564\% |
| 15 | 2.88\% | 19.89\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 0.00\% | 0.48\% | 0.00\% | 0.00\% | 69.19\% | 30.40\% | 0.41\% | 69.19\% | 30.40\% | 0.059337\% |
| 16 | 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 | $0.059338 \%$ |
| l) | 0.24\% | 0.00\% | 0.0 | 0.17\% | 0.00 | 0.00 |  |  |  |  |  |  |  |  |  |  |

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. The table above
can be displayed together with the verbal explanation of each weighting structure as table below. The structure number 16 has the lowest risk weighting amongst all.

Table 4.12 Conditional Constraints and Lowest Risk WS

| wat | CONDTTIONAL CONSTRAINTS \& BOUNDARIES | STOCK | BOND | CASH | LOWEST RISK |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Portolio comprises with merely stocks | 100.00\% | 0.00\% | 0.00\% | 8.466401\% |
| 2 | Portfolio comprises with merely bonds | 0.00\% | 100.00\% | 0.00\% | 0.100365\% |
| 3 | Portiolio comprises with merely cash | 0.00\% | 0.00\% | 100.00\% | 0.143359\% |
| 4 | Share of stock $\geq$ (bond + cash) AND share of bond $z$ cash | 50.00\% | 50.00\% | 0.00\% | 4.196487\% |
| 5 | Share of stock 2 (bond + cash) AND share of bond $\leq$ cash | 50.00\% | 25.00\% | 25.00\% | 4.214640\% |
| 6 | Share of bond $z$ (stock + cash) AND share of slock $z$ cash | 0.66\% | 98.68\% | 0.66\% | 0.066869\% |
| 7 | Share of bond $\geq$ (stock + cash) AND share of stock $\leq$ cash | 0.41\% | 67.84\% | 31.76\% | 0.059381\% |
| 8 | Share of cash $\geq$ (stock + bond) AND share of stock $\geq$ bond | 0.30\% | 0.30\% | 99.40\% | 0.130352\% |
| 9 | Share of cash $\geq$ (stock + bond) AND share of stock $\leq$ bond | 0.35\% | 49.65\% | 50.00\% | 0.067734\% |
| 10 | Shere of stock $=$ shere of bond $\quad$ AND share of bond $=$ share of cash | 33.33\% | 33.33\% | 33.33\% | 2.797923\% |
| 11 | Share of stock $\leq$ (bond + cash) AND share of bond 2 cash | 0.41\% | 69.38\% | 30.21\% | 0.059338\% |
| 12 | Share of stock $\leq$ (bond + cash) ( AND share of bond $\leq$ cash | 0.35\% | 49.83\% | 49.83\% | 0.067595\% |
| 13 | Share of bond $\leq$ (stock + cash) AND share of tock $\geq$ cash | 25.00\% | 50.00\% | 25.00\% | 2080900\% |
| 14 | Share of bond $\leq$ (stock + cash) AND share of stock $\leq$ cash | 0.35\% | 5000\% | 49.65\% | $0067456 \%$ |
| 15 | Shere of cash s (tyoct * Dond) AND share of stock 2 Dond | 25.00\% | 25.00\% | 50,00\% | 2.104564\% |
| 16 | Shers of cash $\leq$ (stock - bond) AND share of stock $\leq$ bond | 0.41\% | 69.19\% | 30.40\% | $0.059337 \%$ |
| 17 | free-atye (has no specific rude, but the target is the weighting with the lowest risk) | 0.41\% | 69 08\% | 30.51\% | $0059338 \%$ |

wis $x$ weighting structure
The method of obtaining the lowest risk is by utilizing solver of excel add-ins. The solver definition can be seen in the table 4.13 at the attachment, which represents the risk minimization of one weighting structure.

### 4.2.5. 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 in order to have the high level of confidence or low level of error in terms of statistics. The partial results of the random number generation can be seen at table 4.14 in the attachment section. The results are shown in partial because the 10,000 numbers are too large to be attached in this research.

### 4.2.6. 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 retums 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.

### 4.2.7. 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.

Each of the simulation to the respective weighting structure is displayed in the attachment section. The results of the simulation will be graphically displayed in terms of its statistics of the end results, for each of the weighting structures. The tables are similar since the processes are all the same for each weighting structures, only the variables are different such as the weighting, and the expected rate of return of each asset in the portfolio of investment. As for sample, the outcome of the first weighting structure is analyzed by constructing about 100 bins in order to see the pattern of portfolio expected returns distribution for this weighting structure.

Table 4.15 Simulation Result : Weighting Structure 1

| ITERATION | RETURN | RISK | \# | BINS | COUNTS | SCALE | TOTAL |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | -11.700503\% | 8.466401\% | 1 | -28.410465\% | 1 | 0.017885 | 0.000100 |
| 2 | 21.158751\% | 8.466401\% | 2 | -27.851324\% | 0 |  |  |
| 3 | -19.173581\% | 8.466401\% | 3 |  | 0 | 0.000000 | 0.000100 |
| 4 | -15.146648\% | 8.466401\% | 4 | -27.292184\% | 2 | 0.035769 | 0.000300 |
| 5 | 11.901303\% | 8.466401\% | 5 | -26.733043\% | 2 | 0.035769 | 0.000500 |
| 6 | -9.549030\% | 8.466401\% | 6 | -26.173903\% | 5 | 0.089423 | 0.001000 |
| 7 | 19.808932\% | 8.466401\% |  | -25.614762\% | 5 | 0.089423 | 0.001500 |
| 8 | $6.657370 \%$ | 8.466401\% | 7 | -25.055622\% | 4 | 0.071538 | 0.001900 |
| 9 | 7.872280\% | 8.466401\% | 8 | -24.496481\% | 16 | 0.286153 | 0.003500 |
| 10 | 12.424001\% | 8.466 | 9 | -23.937341\% | 19 | 0.339807 | 0.005400 |
|  |  | 8.466401\% | 11 | -22.819060\% | 23 | 0.411346 | 0.009300 |
| 12 | -4.673872\% | 8.466401\% | 12 | -22.259919\% | 27 | 0.482884 | 0.012000 |
| 13 | 12.231674\% | 8.466401\% | 13 | -21.700779\% | 20 | 0.357692 | 0.014000 |
| 14 | -8.230862\% | 8.466401\% | 14 | -21.141638\% | 24 | 0.429230 | 0.016400 |
| 15 | 3.163263\% | 8.466401\% | 15 | -20.582498\% | 38 | 0.679614 | 0.020200 |
| 16 | -15.350464\% | 8.466401\% | 16 | -20.023357\% | 37 | 0.661730 | 0.023900 |
| 17 | -4.694606\% | 8.466401\% | 17 | -19.464217\% | 59 | 1.055191 | 0.029800 |
| 18 | -9.183092\% | 8.466401\% | 18 | -18.905076\% | 58 | 1.037306 | 0.035600 |
| 19 | 0.923834\% | 8.466401\% | 19 | -18.345936\% | 64 | 1.144614 | 0.042000 |
| 20 | 9.263678\% | 8.466401\% | 20 | -17.786795\% | 76 | 1.359229 | 0.049600 |
| 21 | 21.165035\% | 8.466401\% | 21 | -17.227654\% | 76 | 1.359229 | 0.057200 |
| 22 | -0.539927\% | 8.466401\% | 22 | -16.668514\% | 83 | 1.484421 | 0.065500 |
| 23 | 8.953261\% | 8.466401\% | 23 | -16.109373\% | 97 | 1.734805 | 0.075200 |
| 24 | 4.031924\% | 8.466401\% | 24 | -15.550233\% | 96 | 1.716921 | 0.084800 |
| 25 | -7.856506\% | 8.466401\% | 25 | -14.991092\% | 110 | 1.967305 | 0.095800 |
| $\ldots$ | ... | $\cdots$ | $\cdots$ | ... | $\cdots$ | ... | ... |
| 9977 | 7.749477\% | 8.466401\% | 77 | 14.084215\% | 106 | 1.895767 | 0.891400 |
| 9978 | -6.320813\% | 8.466401\% | 78 | 14.643356\% | 106 | 1.895767 | 0.902000 |
| 9979 | 17.462346\% | 8.466401\% | 79 | 15.202496\% | 100 | 1.788459 | 0.912000 |
| 9980 | 18.131973\% | 8.466401\% | 80 | 15.761637\% | 111 | 1.985190 | 0.923100 |
| 9981 | -7.224158\% | 8.466401\% | 81 | 16.320777\% | 84 | 1.502306 | 0.931500 |
| 9982 | -15.792929\% | 8.466401\% | 82 | 16.879918\% | 76 | 1.359229 | 0.939100 |
| 9983 | 18.757628\% | 8.466401\% | 83 | 17.439058\% | 84 | 1.502306 | 0.947500 |
| 9984 | -8.835635\% | 8.466401\% | 84 | 17.998199\% | 64 | 1.144614 | 0.953900 |
| 9985 | -18.121087\% | 8.466401\% | 85 | 18.557339\% | 71 | 1.269806 | 0.961000 |
| 9986 | 12.042991\% | 8.466401\% | 86 | 19.116480\% | 68 | 1.216152 | 0.967800 |
| 9987 | -3.456056\% | 8.466401\% | 87 | 19.675620\% | 59 | 1.055191 | 0.973700 |
| 9988 | 2.153330\% | 8.466401\% | 88 | 20.234761\% | 40 | 0.715384 | 0.977700 |
| 9989 | -14.179571\% | 8.466401\% | 89 | 20.793901\% | 38 | 0.679614 | 0.981500 |
| 9990 | 15.101994\% | 8.466401\% | 90 | 21.353042\% | 44 | 0.786922 | 0.985900 |
| 99 | -7.339581\% | 8.466401\% | 91 | 21.912182\% | 35 | 0.625961 | 0.989400 |
|  | 0.595863\% | 8.466401\% | 92 | 22.471323\% | 27 | 0.482884 | 0.992100 |
|  | 14.77192 | 8.466401\% | 93 | 23.030463\% | 21 | 0.375576 | 0.994200 |
| 9993 | 14.77192 | 8.466401\% | 94 | 23.589604\% | 21 | 0.375576 | 0.996300 |
| 9994 | $0.742694 \%$ |  |  | 24.148745\% | 11 | 0.196731 | 0.997400 |
| 9995 | 21.531163\% | 8.466401\% | 95 | 24.707885\% | 9 | 0.160961 | 0.998300 |
| 9996 | 1.568729\% | 8.466401\% | 96 | 24.707885 | 5 | 0.089423 | 0.998800 |
| 9997 | -12.493075\% | 8.466401\% | 97 | $\frac{25.267026 \%}{25.826166 \%}$ | 6 | 0.107308 | 0.999400 |
| 9998 | 9.832246\% | 8.466401\% | 98 | $\frac{25.826166 \%}{26.385307 \%}$ | 5 | 0.089423 | 0.999900 |
| 9999 | 11.821156\% | 8.466401\% | 99 | 26.385307\% | 1 | 0.017885 | 1.000000 |
| 10000 | -9.552992\% | 8.466401\% | 100 | 26.944447\% |  |  |  |

STATISTICAL SUMMARY

| Minimum | Maximum | Median | Mean | Std. Deviation | Probability | UCL |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $-28.41 \%$ | $26.94 \%$ | $-0.26 \%$ | $-0.18 \%$ | $11.01 \%$ | $45.10 \%$ | $-0.61 \%$ |

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As can be seen from the above table, the 10,000 massive iterations which represent the possible expected returns on portfolio can be displayed 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 below.

Figure 4.3 Result of Portfolio Returns: Weighting Structure 1


In above table, 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. These below is the WS1 statistical measurement which also will be presented by other weighting structures (the other 16 weighting structures).

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

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.

### 4.3. 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 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.

Table 4.32 Weighting Structures Simulation Result

| Wgt | Portfolio Weight Structures | Min | Max | Mean | Stdev | r (Retum $\geq 1.5 \%$ |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | All stocks | -28.41\% | 26.94\% | -0.18\% | 11.01\% | $\frac{\mathrm{rat}}{}$ | Heghest probablity harks |
| 2 | All bonds | 1.02\% | 1.38\% | 1.20\% | 0.09\% | 45.10\% | Hlghest probablity, hlohest return \& risic |
| 3 | All cash | 0.66\% | 1.06\% | 0.86\% | 0.12\% | out of range | Mlghest possible return, the lowest |
| 4 | slock $\geq$ bond + cas and bond $\geq$ cash | -13.66\% | 13.97\% | 0.38\% | 0.34\% | 43.40\% |  |
| 5 | slock $\geq$ bond + cas and bond $\leq$ cash | -13.81\% | 14.11\% | 0.36\% | 0.31\% | 43.30\% |  |
| 6 | bond 2 stock + cas and stock 2 cash | 0.69\% | 1.51\% | 1.12\% | 1.12\% | 0.10\% |  |
| 7 | bond $\geq$ stock + cas and stock $\leq$ cash | 0.77\% | 1.41\% | 1.08\% | 1.08\% | out of range |  |
| 8 | cash $\geq$ stock + bon and stock $\geq$ bork | 0.51\% | 1.19\% | 0.85\% | 0.85\% | out of range |  |
| 9. | cash 2 stock + bon and stock $\leq$ bonk | $0.71 \%$ | 1.33\% | 1.02\% | 1.02\% | out of range | 4, |
| 10 | stock = bond a cash | -8.93\% | 9.79\% | 0.54\% | 0.51\% | 41.60\% |  |
| 11 | stock $\leq$ bond + cas and bond 2 cash | 0.77\% | 1.42\% | 1.09\% | 1.09\% | out of range | the highest sharpe prior to simulation |
| 12 | stock $\leq$ bond + cas and bond $\leq$ cash | 0.71\% | 1.33\% | 1.02\% | 1.02\% | out of range |  |
| 13 | bond $\leq$ stock + cas and stock $\geq$ cash | -6.43\% | 7.58\% | 0.63\% | 0.63\% | 39.80\% |  |
| 14 | bond $\leq$ stock + cas and stock $\leq$ cash | $0.71 \%$ | 1.33\% | 1.02\% | 1.02\% | out of range |  |
| 15 | cash $\leq$ stock + bon and stock $\leq$ bonc | -6.62\% | 7.61\% | 0.65\% | 0.64\% | 40.10\% |  |
| 16 | eash s stock + bon and stock $\leq$ bonc | $0.77 \%$ | 1.42\% | 1.09\% | 1.09\% | out of range. | the lowest risk prior to simulation |
| 17 | free-styie | 0.77\% | 1.42\% | 1.09\% | 1.09\% | out of range | . |

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 still there, about $45 \%$ of 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 $1.5 \%$ 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 zero percent in stocks, zero percent 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.

### 4.4. Efficient Frontier Plotting

Once expected returns, standard deviation and correlation coefficients have been delermined, 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 this 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 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. This figure below represents the efficient frontier of the optimal portfolios.

Figure 4.4 Efficient Frontier of The Lowest Risk WS


As shown above, 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 above, 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 was 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 above, the weighting structure with highest sharpe ratio is located in the tangency portfolio (WS-11 at table below), but the structure with the lowest risk is shown by WS-16.

Table 4.33 Risk, Return and Sharpe Ratios of Each WS

| WEIGHTING STRUCTURES | CONDITIONAL CONSTRANTS |  | RISK | RETURN | SHARPE |
| :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | Portolio comprises all stocks |  | 8.47\% | 081\% | 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 $\geq$ (bond + cash) | AND share of bond $\geq$ cash | 4.20\% | 0.82\% | 0.0117 |
| 5 | Share of stock $\geq$ (bond + cash) | AND share of bond $\leq$ cash | 4.21\% | 0.82\% | 0.0115 |
| 6 | Share of bond $\geq$ (stock + cash) | AND share of stock $\geq$ cash | 0.07\% | 1.07\% | 4.5195 |
| 7 | Shareo of bond $\geq$ (stock + cash) | AND share of stock $\leq$ cash | 0.06\% | 1.06\% | 4.9088 |
| 8 | Share of cash $\geq$ (stock + bond) | AND share of stock $\geq$ bond | 0.13\% | 0.83\% | 0.4390 |
| 9 | Share of cash $\geq$ (stock + bond) | AND share of stock $\leq$ bond | 0.07\% | 1.00\% | 3.3720 |
| 10 | Share of stock = bond = cash |  | 2.80\% | 0.82\% | 0.0182 |
| 11 | Sthare of stock $\leq$ (bond + cash) | AND share of bond $\geq$ cash | 0.06\% | 1.07\% | 5.0023 |
| 12 | Share of stock $\leq$ (bond + cash) | AND share of bond $\leq$ cash | 0.07\% | 1.00\% | 3.3879 |
| 13 | Share of bond $\leq$ (stock + cash) | AND share of tock $\geq$ cash | 2.08\% | 0.82\% | 0.0251 |
| 14 | Share of bond s (stock + cash) | AND share of stock $\leq$ cash | 0.07\% | 1.00\% | 3.4039 |
| 15 | Share of cash 5 (stock + bond) | AND share of stock $\geq$ bond | 2.10\% | 0.91\% | 0.0655 |
| 16 | Share of cash $\leq$ (stock + bond) | AND share of stock $\leq$ bond | 0.06\% | 7 1.07\% | 4.9914 |
| 17 | free-style |  | 0.06\% | 1.07\% | 4.9851 |

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 sinucture with lowest standard deviation of its portfolio mean is eventyally the WS-2.

## CHAPTER 5

## CONCLUSION \& ADVICE

### 5.1. Conclusion

The research has come to a certain conclucion based on the three issues which mentioned in the very beginning part of this thesis. These below three points are the concluded solution of all those issues:

1. 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 limited 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.
2. 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 zero percent in stocks, zero percent in cash, but $7.8 \%$ in FR00002 and $92.20 \%$ in HMSP03.
3. 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 $11^{\text {th }} \mathrm{WS}$. 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.

### 5.2. Advice

Modern portfolio theory combined with the optimization-simulation basic concept is a simple but a very useful model that enables investor to find efficient portfolio. Nevertheless, surely yet it still has limitations.

The bigger the number of repetition, the smaller the error in terms of statistics. In this research, the repetitions are done up to 10,000 times. The results will probably different if the repetitions were conducted in the scale of 100,000 , in millions, or even larger number. It means, the mean and standard deviation of the result could be different but at least, in this research, the proximity to the optimal solution can be earned through the selection of best portfolio weighting structure from the optimal portfolios as constructed.

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## ATTACHMENTS - LIST OF TABLES



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Table 4.1 LQ-45 List of Stocks

| 4 | CODE | CompanY | SECTOR | VALUE( ${ }^{\text {) (in bio) }}$ | FREQUENCY(F) | $V \times F$ | Selected |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 2 | AALI | Astra Agio Lestari Tbk | Agriculture | 21,700 | 386,253 | 8.38 | $v$ |
| 2 | LSIP | PP London Sumatera Tbk | Agricullura | 15.800 | 226,545 | 3.58 | $x$ |
| 3 | LSRO | PP London Sumatera Tok | Agricultue | 11,600 | 162,844 | 1.89 | $\times$ |
| 4 | SGRO | Sampoerna Agro Tbk | Agricultura | 7.800 | 159.772 | 1.25 | x |
| 5 | CPRO | Central Proteineprima Tbk | Agrioura | 7,800 | 159,772 | 1.25 | $x$ |
| 6 | BISI | Bisi International Tbk |  | 5,500 | 132,997 | 0.73 | x |
| 7 | INKP | Inden Klat Puip 8 Paper Tbk | Agriculture | 7,700 | 70,839 | 0.55 | $x$ |
|  |  |  | Bance Industry | 12,500 | 220,943 | 2.76 | $v$ |
| 8. | CPN | Charoen Pokphand Mndonesia Tbk | Basic industry | 4.700 | 86.455 | 0.41 | $x$ |
| 10 | SMCB | Hokim indonesia Tbk | Basic Industry | 2,700 | 96.599 | 0.26 | $x$ |
| 9 | SMGR | Semen Gresik (Perseno) Tbk | Basic Industry | 3,800 | 64,014 | 0.24 | x |
| 11 | ELTY | Balkrieland Development Tbk | Construction | 17,500 | 211,370 | 3.70 | $v$ |
| 12 | LPKR | Lippo Karawaci Tbk | Consiruction | 4,500 | 111,391 | 0.50 | x |
| 13 | KLIA | Kawnsan Industri Jabobeka Tbk | Constuction | 1,800 | 126,713 | 0.23 | $x$ |
| 14 | CTRA | Ciputra Developmert Tbk | Construction | 1,600 | 63,699 | 0.10 | $x$ |
| 15 | INDF | Indofood Sukees Makmur Thk | Consumer Goods | 13,900 | 212,540 | 295 | $v$ |
| 16 | TBLA | Tunas Baru Lampung Tok | Corssumer Goods | 5,100 | 165,771 | 0.85 | $x$ |
| 19 | BMRI | Bark Mandiri (Parsero) Tbk | Finance | 26,900 | 258,069 | 6.94 | $x$ |
| 18 | BBRI | Bank Rakyal Indonesia (Persero) Tok | Finance | 27,700 | 219,320 | 6.08 | x |
| 20 | BBCA | Bank Central Aeia Tow | Finance | 17.500 | 141.227 | 2.47 | $x$ |
| 17 | BNI | Aank International Indonesia Thk | Finance | 28.600 | 70.927 | 2.03 | $x$ |
| 22 | BENI | Bank Negara Indonoska Tbu | Finance | 8.800 | 145,569 | 1.28 | $\times$ |
| 21 | Botca | Bunk Case Nagot Tok | Firance | 11.200 | 70.023 | 0.78 | $\times$ |
| 23 | BDNA | Bars Danmon Indonesal Tak | France | 7.100 | 83.925 | 0.60 | $x$ |
| 24 | PNBN | Bank Pan Indonesia Tha | Fmance | 4.800 | 53,656 | 0.26 | $x$ |
| 28. | TKM | Telmorrunimeal indoneala Thk | Intr matuructur | 58,500 | 289,825 | 17.23 | $v$ |
| 26 | PGAS | Penuanaen Gas Negara (Persero) Tbk | infrastructure | 33.700 | 451.921 | 15.23 | $x$ |
| 27 | LSAT | Indoseal Tbk | Infrastructure | 19,500 | 134,793 | 2.63 | $x$ |
| 29 | MIRA | Mitra Rajasa Tok | Infrastructure | 10.100 | 158,096 | 1.60 | x |
| 28 | TRUB | Truba Alam Manungoal Engineering Tbk | infrastructure | 10,200 | 146,005 | 1.49 | $x$ |
| 30 | DEWA | Darma Herwa Tbk | mfrastructure | 4,500 | 122,288 | 0.73 | $x$ |
| 31 | BTEL | Bakria Telecom Tbik | Intrastuctura | 4,200 | 118,263 | 0.50 | $x$ |
| 32 | BLTA | Berlian Leju Tanker Tbk | Infrastnucture | 1,900 | 24,769 | 0.05 | $x$ |
| 33 | BUMI | Burnl Resources Tbly | Mining | 250,800 | 1,131,839 | 283.87 | $\checkmark$ |
| 34 | ANTM | Aneks Tanbang (Persero) Tbik | Mining | 42.000 | 717,271 | 30.13 | $x$ |
| 35. | PTBA | Tembeng Batubera Butit Asmm Tbk | Mining | 29,700 | 296,723 | 8.81 | $x$ |
| 36 | NCO | Ftemational Nickel Indonesia Tok | Mining | 20,800 | 352,996 | 7.38 | x |
| 30 | TNE | Timen Tbk | Mining | 14,000 | 320,120 | 4.89 | $x$ |
| 37 |  | Enerol Mmoa Persada Th | Mining | 16,900 | 161,560 | 2.73 | x |
| 38 | ENRG |  | Mining | 16,200 | 137,556 | 2.23 | $x$ |
| 38. | TME | Indo Tambengrey Mogen Tbi | Mining | 11,300 | 158,847 | 1.79 | $x$ |
| 40 | MEDC | Medco Energi Intemational Tbk | Miac Industry | 37,800 | 252,915 | 4.51 | $v$ |
| 41 | ASM | Antra International Thr | Trado $\frac{\text { a Services }}{}$ | 21,600 | 219,880 | 4.73 | $v$ |
| 4 | UNTR | United Tractore Tbl | Trade a Servicen | 26,300 | 164,021 | 4.31 | $x$ |
| 42 | BNBR | Bakrie a Brothers Tbk | Trade a Services | 3.400 | - 132.165 | 0.45 | $x$ |
| 44 | AKRA | AKR Corporindo Tbk | Trade a Services | 761 | 17,443 | 0.01 | $x$ |
| 45 | MNCN | Media Nusantara Citra Tbk | Trade a Services |  |  |  |  |
| Source |  | Reartime knvestor |  |  |  |  |  |

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Table 4.3 List of Government Bonds

| 1 | SERIES | BON |  |  |
| :---: | :---: | :---: | :---: | :---: |
| 1 | FR0002 | Fixed Rate Governmem Bond | MATURITY | COUPON RATE)X) |
| 2 | VR0016 | Variable Rate Government Bond | 16-Jun-09 | 14.00 |
| 3 | OR1001 | Retail Government Bond | 25-Jul-09 | 11.00 |
| 4 | FR001C | Fixed Rate Government Bond | 9-Aug-09 | 12.05 |
| 5 | OR1002 | Retail Govermmem Bond | 15-Mar-10 | 13.15 |
| 6 | FR0011 | Fixed Rate Government Bond | 28-Mar-10 | 9.28 |
| 7 | FRC012 | Fixed Rate Government Bond | 15-May 10 | 13.55 |
| 8 | FR0013 | Foxed Rate Govemmem Bond | 15-May-10 | 12.63 |
| 9 | FR0024 | Fixed Rata Govamment Bond | 15-Sep-10 | 15.43 |
| 10 | FROO14 | Fbxed Rate Govermment Bond | 15-0at-10 | 12.00 |
| 11 | FR0021 | Fixed Rate Govemment Bond | 15-Nov-10 | 15.58 |
| 12 | FRD015 | Freed Rate Govemment Bond | 15-Dec-10 | 14.50 |
| 13 | VR0032 | Variable Rate Govemment Bond | 15-Feb-11 | 13.40 |
| 14 | VR0017 | Variable Rato Govemmant Bond | 25-Apr-11 | 11.00 |
| 15 | FR001E | Freed Rate Govemment Bond | 15-Aun-11 | 11.24 |
| 18 | OR1003 | Retail Govemment Bond | 12-Sep-11 | 9.40 |
| 17 | FR0022 | Fred Rate Government Bond | 15-Sep-11 | 12.00 |
| 18 | FROO25 | Fred Rate Govemment Bond | 15-0ct-11 | 10.00 |
| 18 | FR0017 | Foxed Rate Govemment Bond | 15-Jan-12 | 13.15 |
| 20 | OR1004 | Retril Govemment Bond | 12-Mar-12 | 9.50 |
| 21 | FRCO18 | Freed Rate Govemment Bond | 15-Jut-12 | 13.18 |
| 22 | VR0016 | Variable Ram Govemenam Bond | 25-Od. 12 | 11.00 |
| 23 | FR0023 | Fraed Rate Governmert Bond | 15-Dec-12 | 11.00 |
| 24 | FR0039 | Fred Rate Govermmert Bond | 15-Mar-13 | 1250 |
| 28 | FRCOIS | Fued Rate Govemment Bond | 15-Jun-13 | 14.25 |
| 26 | OR1008 | Retil Government Bond | 15-Sop-13 | 11.45 |
| 27 | FROOM | Fred Rete Govemment Bond | 15-Sep-13 | 9.00 |
| 28 | FROOCO | Fraed Resto Govermment Bond | 15-Dec-13 | 14.28 |
| 29 | FROO26 | Fixed Reta Govemment Bond | 15-0at-14 | 11.00 |
| 30 | VR001s | Vartable Rate Govemmert Bond | 25-Dec-14 | 11.21 |
| 31 | VROOR | Variable Rate Govermment Bond | 25-ADP-15 | 11.50 |
| 32 | FROO27 | Fixed Rate Government Bond | 15-Jun-15 | 8.50 |
| 30 | VR0021 | Variable Ratu Cowemment Bond | 25-Nov-15 | 11.00 |
| 34 | VR0022 | Varibil Rath covernment Bond | 25-Mar-16 | 11.21 |
| 38 | FROOSC | Frued Reta Governmert Bond | 15-May 16 | 10.75 |
| 36 | FROO26 | Frued Rate Government Bond | 15-Jut-17 | 10.00 |
| 37 | VR0025 | Variable Ram Govemment Bond | 25-Sep-17 | 11.00 |
| 38 | VR0026 | Variable Rato Gowemment Bond | 25-Jan-18 | 11.00 |
| 30 | FR0032 | Fbxed Rata Govermment Aond | 15-Jut 18 | 15.00 |
| 40 | VROCO7 | Varlable Rato Govemmant Bond | 25-Jul-18 | 11.00 |
| 41 | FROOSE | Froed Rute Government Bond | 15-Aug-18 | 11.60 |
| 42 | VROO28 | Variable Ratu Govemment Bond | 25-Aug-18 | 11.50 |
| 43 | FR0046 | Frued Rats Governmert Bond | 15-Sep-18 | 9.00 |
| 4 | VROO2: | Variable Ram Govemmert Bond | 25-Aug-18 | 11.50 |
| 45 | FROO36 | Frued Rate Govemment Bond | 15-Sep-19 | 11.54 |
| 46 | VR003C | Varlablo Raiw Governmera Bond | 25-Doc-19 | 11.00 |
| 47 | VR0031 | Vartable Rale Govemment Bond | 25-Now-20 | 11.00 |
| 48 | FRO031 | Fraed Rate Govemment Bond | 15-Jun-21 | 12.80 |
| 49 | FRO034 | Frxed Rate Govemment Bond | 15-Jun-22 | 12.90 |
| 50 | FROOS | Fixed Rate Govermment Bond | 15-Jut 22 | 10.25 |
| 51 | FR0043 | Fixed Rate Govermment Bond | 15-Jut 23 | 9.50 |
| 52 | FR0046 | Frxed Rate Govemment Bond | 15-Aug-23 | 11.75 |
| 53 | FROOS | Fbxed Rate Govemment Bond | 15-Sep-24 | 10.00 |
| 31 | FROO4 | Fixed Rate Govemment Bond | 15-Sep-25 | 11.00 |
| 55 | FROOUC | Fixed Rata Govermment Bond | 15-Sep-26 | 12.00 |
| 50 | FR0037 | Froed Rate Govermment Bond | 15-Jut27 | 10.25 |
| 57 | FROOM2 | Fixed Rate Govemment Bond | 15-Fab-28 | 10.00 |
| 58 | FR0047 | Fixed Rate Govermment Bond | 15-May 37 | 9.75 |
| 59 | FROOAS | Fixed Rato Govomment Bond | 15-3ut38 | 10.50 |
| 60 | FROOSC | Fixed Rato Govemment Bond |  |  |

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Table 4.6 The Historical Data (2005-2008)

| MONTH | BUM 1 | TKKM | ASII | BMRI |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Jan-06 | -11.16\% | -13.79\% | -8.41\% | -14.82\% | UNSP | UNTR | ELTY | INDF | INKP | FR0002 | HMSP03 | SBI-1 |
| Feb-06 | -1.18\% | -1.59\% | -5.77\% | -8.99\% | 40.48\% | -16.35\% | 122.22\% | -8.66\% | 45.95\% | 1.03\% | 1.32\% | 1.06\% |
| Mar-06 | 5.95\% | 11.29\% | 16.84\% | 7.41\% | 15 $2.48 \%$ | 3.92\% | -3.13\% | - 5.55 | -6.48\% | 1.00\% | 1.32\% | 1.06\% |
| Apr-06 | 2.25\% | 9.42\% | 4.37\% | 10.34\% | 23.25\% | 10.69\% | 3.23\% | 5.95\% | 2.97\% | 0.99\% | 1.33\% | 1.06\% |
| May-06 | -8.79\% | -6.62\% | -17.99\% | -11.98\% | 14.28\% | 23.86\% | 12.50\% | 26.97\% | 9.62\% | 0.96\% | 1.05\% | 1.06\% |
| Jun-06 | -6.07\% | 4.26\% | 3.40\% | 2.76\% | 14.28\% | 214\% | 2.78\% | -16.81\% | -14.04\% | 1.00\% | 1.06\% | 1.04\% |
| JuH06 | 7.79\% | 4.45\% | -1.54\% | 2.33\% | 20.22\% | 2.14\% | -16.22\% | -6.38\% | -10.20\% | 0.99\% | 1.06\% | 1.04\% |
| Aug-06 | -9.64\% | 6.04\% | 15.62\% | 19.32\% | -10.28\% | 3.70\% | 6.45\% | 19.92\% | 1.14\% | 0.95\% | 1.06\% | 1.02\% |
| Sep-06 | -1.33\% | 6.96\% | 12.16\% | 10.71\% | 8.33\% | 22 | 0.00\% | 13.33\% | 3.37\% | 0.93\% | 1.07\% | 0.98\% |
| Oct-06 | 4.05\% | -0.59\% | 8.84\% | 17.20\% | -2.27\% | 8.98 | -9.09\% | 5.04\% | -2.17\% | 0.86\% | 1.07\% | 0.94\% |
| Now-06 | 5.20\% | 17.86\% | 19.03\% | 1.83\% | -2.33\% | 8.9 | 0.00\% | 6.40\% | 4.44\% | 0.80\% | 1.08\% | 0.90\% |
| Dec.06 | 11.11\% | 2.02\% | -1.57\% | 4.50\% | 15.48\% |  | -10.00\% | 5.26\% | 0.00\% | 0.77\% | 1.08\% | 0.85\% |
| Jan-07 | 20.00\% | -6.44\% | -5.41\% | -11.21\% | 4.12\% | .55\% | 44.44\% | 3.57\% | 0.00\% | 0.75\% | 1.08\% | 0.81\% |
| Feb-07 | 12.04\% | -5.82\% | -5.39\% | -9.71\% | 11.88\% |  | 5.13\% | 25.18\% | -7.45\% | 0.66\% | 1.09\% | 0.79\% |
| Mar-07 | 9.92\% | 10.67\% | -6.05\% | 7.53\% | 1.77\% |  |  | -7.69\% | 2.30\% | 0.66\% | 1.09\% | 0.77\% |
| Apr-07 | 3.76\% | 6.60\% | 9.09\% | 23.00\% | 25.22\% |  | -2.13 | -2.56\% | -2.25\% | 0.67\% | 1.10\% | 0.75\% |
| May-07 | 28.81\% | -9.05\% | 13.89\% | 5.69\% | 5.56\% | 4.43\% | 4.35\% | 7.90\% | 22.99\% | 0.65\% | 1.11\% | 0.75\% |
| Jun-07 | 33.11\% | 3.14\% | 4.90\% | -1.73\% | 0.97\% | 10.46 | 3125\% | 5.49\% | 8.54\% | 0.64\% | 1.11\% | 0.73\% |
| Jut07 | 18.68\% | 16.32\% | 10.95\% | 12.80\% | 21.71\% | 4.24\% | 4.76\% | 17.05\% | -0.88\% | 0.62\% | 1.12\% | 0.71\% |
| Aup-07 | -4.22\% | 3.13\% | -4.80\% | -7.80\% | -22.70\% |  | 48.48\% | 1.80\% | 0.00\% | 0.65\% | 1.13\% | 0.69\% |
| Sep-07 | 40.20\% | 1.38\% | 7.84\% | 8.46\% | 7.69\% |  | -19.39\% | -7.00\% | -17.70\% | 0.70\% | 1.13\% | 0.69\% |
| Oct-07 | 34.27\% | -2.27\% | 33.79\% | 7.09\% | 29.22\% | 33 | 34.18\% | 3.76\% | 1.08\% | 0.68\% | 1.14\% | 0.69\% |
| Nov-07 | 17.71\% | -6.14\% | -2.34\% | -5.96\% | 10.55\% | 2.74 | 11.32\% | 13.99\% | -2.13\% | 0.64\% | 1.15\% | 0.69\% |
| Dec-07 | 6.19\% | 0.00\% | 9.20\% | -1.41\% | 3.4 |  | 3.39\% | 14.77\% | -8.70\% | 0.68\% | 1.16\% | 0.693 |
| Jan-08 | 8.67\% | -8.87\% | -0.18\% | -5.00 |  |  | 1.64\% | 1.98\% | $0.00 x$ | $064 \%$ | 1.17\% | 0676 |
|  | 20.31\% |  |  |  |  |  | 0.00\% | 9.71\% | 9.52\% | $0.63 \%$ | 1.18\% | $087{ }^{0}$ |
|  |  |  |  |  |  |  | 606\% | 3.54\% | $000 \%$ | $068 \%$ | 1204 | $056 \%$ |
| Mar-08 | -18.48\% | -1.53\% | -12.93\% | -3.82\% | -30.20\% | -5.28\% | -22.39\% | -2051\% | 1098 | 0767 | 121\% | $056 \%$ |
| Apr-08 | 7.26\% | -8.29\% | -17.53\% | -8.73\% | - 8.55 | -3.98\% | -2404\% | -2.15* | 25814 | 0374 | 1236 | 0677 |
| Mry-08 | 21.05\% | -8.47\% | 5.00\% | 0.87\% | 21.12\% | 19.92\% | 5.06\% | 2308\% | 13932\% | $087 \%$ | 124\% | 0.69 |
| Jun-08 | 1.86\% | -9.88\% | -8.33\% | -10.34\% | 3.59\% | -1592\% | -14.46\% | -1429\% | -982\% | $086 \%$ | $124 \%$ | 0736 |
| Jut08 | -17.88\% | 5.48\% | 17.14\% | 14.42\% | -26.06\% | -6.174 | 7.04\% | 5.21\% | $21.78 \%$ | 0.798 | 1294 | 0.774 |
| Aup-08 | -18.52\% | 3.90\% | -7.76\% | -504\% | -23.74\% | .9.21\% | -7.89\% | -1.10\% | -23.58\% | $0.85 \%$ | 131\% | $0.77 \%$ |
| Sep-08 | -41.82\% | -10.63\% | -17.79\% | -6.19\% | -33.02\% | -8.70\% | -32.86\% | -12.89\% | -32.34\% | 0.94\% | 1.34\% | 0.81\% |
| Oct-08 | -32.03\% | -24.48\% | -45.32\% | -41.13\% | -61.97\% | -66.67\% | -67.23\% | -4.39\% | 48.43\% | 1.39\% | 1.38\% | 0.92\% |
| Nov-09 | -53.56\% | 8.33\% | 9.09\% | -4.49\% | -0.26\% | 26.19\% | -2.60\% | -11.01\% | -2.44\% | 1.13\% | 1.34\% | 0.94\% |
| Dec-08 | -9.50\% | 17.95\% | 3.43\% | 35.91\% | 6.12\% | 10.69\% | -4.00\% | -4.12\% | -7.50\% | 0.86\% | 1.10\% | 0.90\% |

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Table 4.13 Solver Display of Risk Minimization


Table 4.14 Uniform Distribution Random Numbers (partial)


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Table 4.14 Uniform Distribution Random Numbers (partial)


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Table 4.14 Uniform Distribution Random Numbers (partial)

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  |  |  |  |  |  |  |  |  | 292 |  |  |
|  |  |  |  |  |  |  |  | 23,4\% |  |  |  |  |
|  | 22, |  | 26, $22 \times$ |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  | 13. |  |  |  |
|  |  |  | - -31 |  | 52 | 3. |  | 4, 178 |  |  |  |  |
|  |  |  |  |  |  |  |  | 1,17210 |  | 694 |  |  |
|  |  |  |  |  | - 3 |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | 16. |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | \% |  | - 2 | \% |  | 59.74 |  | - 10.20 | $\frac{76}{162}$ | $\frac{0.089}{238}$ |  |
|  |  |  | - 1.14298 |  | S72, | $\frac{5,438}{2,68}$ | 18868 |  | - $\frac{13,59}{359}$ |  |  |  |
|  | \% |  |  |  | 12. | 36.00 | 2 |  | 172 |  |  |  |
|  | 2076 |  | 20.20\% |  |  |  |  | 13, ${ }^{2}$ | 2, 12 |  |  |  |
|  | 12.389 |  | \% | , |  |  |  | ${ }^{1,0}$ | $3{ }^{3,374}$ | -0,759 |  |  |
|  |  | $\frac{6,914}{6,714}$ | - | 0 |  |  | ${ }^{36}$ |  | $2{ }^{2} 2$ |  |  |  |
|  | 9, | 9,555 | 7,7 | 10. | $\frac{-1.228}{4.108}$ | - 5.518188 |  |  |  | \%11 |  |  |
|  |  |  | $\frac{2,358}{738}$ |  | . 672 |  |  | 4.12 | 12.5 |  |  |  |
|  | $\frac{0.394}{5.394}$ | $\frac{.13 .15 x}{1.20 x}$ | 2.35x |  |  |  | 107 |  | 7, |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | -16938 | - 1.12458 |  |  | 24, 2 279\% |  | 1 | 21.0 |  |  |  |
|  |  | 4x | $\frac{6.098}{2.86}$ |  |  | 706 | -108 |  | 16 |  |  |  |
|  | $\frac{3}{243}$ | 2, 278 | $\frac{1288}{-2.35}$ | - $\frac{36}{12,5}$ | -3, 3 | - | 9 |  | $\frac{-16.7}{\frac{18.1}{4.1}}$ |  |  |  |
|  |  | 2\% |  | 212 |  |  |  | $\frac{175}{258}$ |  | - 1210 |  |  |
|  |  |  |  |  |  | $\underline{-1.15}$ | 16 |  |  |  |  |  |
|  | 6.8 | 12.248 | $\frac{15142}{414}$ | $\frac{14}{1713}$ | 3, $1 . .33 \times 8$ |  |  |  |  |  |  |  |
|  |  | 6.96\% | 1, 1.268 | $\frac{20.0}{20}$ | 1763x |  | 20, 0 | ${ }^{-824}$ |  |  |  |  |
| $\frac{201010}{2012}$ | $-38$ | 1.380 | - $-24.85{ }^{\text {a }}$ |  | 5.61 |  |  |  |  |  |  |  |
| $\frac{3,9}{2 \times 2}$ | \% | -03\% | 2098 | $\frac{36.00 \times}{10.998}$ | $\frac{60.50 \times}{52654}$ | $\frac{-39026}{19664}$ |  |  |  | T, |  |  |
|  | ${ }^{3} 8$ |  |  | 10.38 |  | ${ }^{12.2685}$ | $\frac{-1+8}{275}$ | $\frac{3 \pi}{33} \frac{x}{515}$ |  |  |  |  |
| $\mathfrak{P x}$ |  | 12, 2 ax | - $-18,186$ | 3.3 | 51.2 |  |  |  |  |  |  |  |
|  |  |  |  | $\frac{1.318}{10.968}$ | $\frac{16.019}{2304 \%}$ |  |  | . 13 |  |  |  |  |
|  | 24114 | . $13.37 \times$ | 32.31\% |  |  | $\stackrel{-250596}{20,59}$ |  | ${ }^{34.06}$ |  |  |  |  |
|  | $\frac{111}{111}$ | - | 2, 2.845 | $\frac{14,7}{157}$ | 4 | -3, $\frac{3.218}{1626}$ |  |  |  |  |  |  |
| \% | $\frac{11}{1092}$ | 0.85 | 1,2394 | - -16.35 | ${ }^{\text {f } 299}$ | 52.09 |  | 5 |  | 27 |  |  |
| z0 | - | $\frac{9.99 x}{1559}$ | 32098 | 23, 3 | 40,42x |  |  |  |  | ${ }^{65}$ |  |  |
| . | - |  | ${ }^{21819}$ |  |  |  |  |  |  |  |  |  |
| -3, ${ }_{\text {3, }}^{3}$ | - | 18 | $\frac{1.079}{1.13}$ | - |  | 5.92 |  | \% | \% 17.75 |  |  |  |
| Sos | $\rightarrow-31978$ | $\frac{233}{823}$ |  | - |  | ${ }^{1.0006}$ | $\frac{39.219}{29}$ | 9.976 |  | 2, 71 |  |  |
| ${ }_{2}^{293}$ | - Hi.915 |  | 1695 | -16299 |  |  |  | Q 26 | \%, 2. |  |  |  |
| - | - | 1.520 | - 21.03 | - 9.353 |  | ${ }^{36.236}$ |  |  |  | $8{ }^{664}$ |  |  |
|  | - $21 \times 8 \times$ | i. 59. | - -22914 |  | 59.40x | -30.20\% |  |  |  |  |  |  |
|  | -16529 | 4,028 | 29, 2308 | $\xrightarrow{22.949}$ | $\xrightarrow{1.3 .658 \times 8}$ | (10.99 | * $\begin{array}{r}\text { \% } \\ \hline\end{array}$ |  |  | 122 |  |  |
| 3 | $\frac{61415}{1619}$ |  | $\frac{35892}{}$ | $\frac{32,73 \times}{}$ | 36.46x | -1, 2.078 | - $\frac{3,974}{12,508}$ | $\frac{.3505 x}{12009}$ | - $80.313 \times 1$ |  |  |  |
|  | - -i.4.4 | 110988 | - | - ${ }^{25.068}$ |  |  |  |  |  |  |  |  |
|  | , |  | - 0 | 6, 6 | ${ }^{1,20}$ | - $\frac{-24.185}{-1098}$ |  |  |  |  |  |  |
|  |  | - - |  | $\frac{3.25}{5.54}$ |  | 2.3.38 |  | 12.508 | $\frac{3.648}{1.628}$ |  |  |  |
|  |  |  | 32.318 |  | $\frac{9.07 x}{1.148}$ |  | $\frac{90.168}{2305 \times}$ | $\frac{86.96}{3+3145}$ | \% $\frac{18.698}{1.989}$ |  |  |  |
|  |  |  |  |  | 0.0.4x | 6.5474 | + -28.00 |  |  |  |  |  |
| $\frac{-512 \pi}{2021}$ | $-1$ | -1209 | 30.6 | 36.69 | - 26.34 | 26.50\% |  |  |  |  |  |  |
|  | - + - 03 | - $\frac{2117}{-215}$ | -19.938 | \% 4.0 | - | $\frac{12.83 \times}{}$ | 34,20 | 5, 5144 | ${ }^{125}$ |  |  |  |
|  | - 26.585 | 16808 | 5,348 |  | 23.50 |  |  |  |  |  |  |  |
|  | 13 | 12 | 6, 268 | 1.018 | 22.5 | $\frac{32,38}{5018}$ | 2,772 | \% 6 |  |  |  |  |
|  |  | 1 | -0.08 | $\frac{4.98}{3.568}$ | 13.594 |  |  |  |  |  |  |  |
|  | 0, | d | 21.52 |  | 10.20 |  |  | $\frac{1.858}{1.85}$ | 5 |  |  |  |
|  |  |  | $\frac{24}{58}$ | - 5.8 | 2, 2 | 12. |  | $\frac{15}{5}$ | $\frac{2}{12}$ |  |  |  |
|  |  | . 12.808 |  | $\frac{1.394}{1.508}$ | $\frac{32.93}{9,12}$ | ${ }^{22,6}$ |  | $\frac{3,375}{}$ | \% 21 |  |  |  |
|  |  | $\frac{12898}{5.568}$ | 2. | 1.109 | 19.959 |  | $\frac{88725}{5}$ | cose |  |  |  |  |
|  | 12 |  |  |  | $\frac{.29 .69 \times}{29.19}$ |  | $\frac{13.919}{1.508}$ |  |  |  |  |  |
|  |  |  |  |  |  |  | 4.6.65 |  |  |  |  |  |
|  |  |  |  | 6.868 |  |  | $\frac{50,73}{598}$ |  |  |  |  |  |
|  |  |  | 2, | 22.119 |  |  |  | 2,38 |  |  |  |  |
|  |  |  |  |  |  |  |  | 2.085 |  | - 0.95 |  |  |
|  |  |  |  | 11.748 | $\frac{\text { 年, } 7.94}{}$ | $1{ }^{10378}$ |  | $\frac{6018}{2909}$ |  |  |  |  |
|  |  |  | - -24 | . 3.103 |  |  |  | 36.69\% |  |  |  |  |
|  |  |  |  |  |  |  |  |  | -12,98 |  |  |  |
|  | 928 | 12.158 |  |  |  |  |  |  |  |  | 4 - 1.127 |  |
|  | +1,535 | 1.5.59\% | 2,532 |  |  | 2, 2.268 | 3.659 |  |  |  |  | - $\frac{0}{12}$ |
|  |  | Casis | - 5 |  |  |  |  |  |  |  |  |  |

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Table 4.14 Uniform Distribution Random Numbers (partial)

|  |  | $\begin{array}{\|c\|} \hline-21948 \\ \hline 9884 \\ \hline \end{array}$ |  |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | - -3.385 | .988x | $\frac{.8173}{21264}$ |  | $\frac{-45.948}{-35.93 x}$ |  |  |  |  |  |  | , |
|  | $\frac{38604}{}$ | -6004 | 21269 |  |  |  | 21.309 |  |  |  |  |  |
|  | 36068 | $1613 \times$ | 21148 | 2099\% | $3735 x$ | 24159 |  |  | $\frac{19}{69}$ | $\frac{9}{1296}$ |  |  |
|  | -7818 | 9.668 |  | 05 | - |  |  | $\frac{1679}{959}$ |  | 099 |  |  |
|  | 23, 31924 | 13.519 | - 3 -2, 2780 | 1022\% | $\frac{3657}{375 \%}$ |  | 13 | $\frac{.9}{28}$ | $\frac{51689}{12564}$ |  | 1.136 |  |
|  |  |  |  |  | 2629 |  |  |  | $\frac{15.58}{19248}$ | 131 |  |  |
|  | . $3691 \%$ |  | 12.79 | 2 | .62\% | . 27 | 18.52\% | 15.37 |  |  |  | * |
|  |  | . $2,23 \times 15$ | 14.518 | $\frac{1739 \%}{}$ | 10.758 | . 531 | 3529 | $\frac{.25,314}{3774}$ |  |  | $\underline{1280}$ |  |
|  | O288 | $\frac{22.40 \times 1}{1501 \times}$ |  | $\frac{1562 \%}{}$ | $\frac{18.00 \%}{}$ | $\frac{.9218}{6598}$ | 108.94x | 1.172x | $\frac{5814}{8.114}$ | 0.65\% | 1.22\% | $\frac{0.74}{0.815}$ |
|  |  | S | -1.73\% |  | 2.278 | $16.60 \times$ | $\frac{17.57 \times}{26214}$ | $2280 \%$ | $31.11 \%$ | $\frac{1308}{0.829}$ | 1076 | 9.95\% |
|  | $\underline{19948}$ | $17.91 \times$ | , 168 |  | $\frac{8348}{8.96 \%}$ | 24. | 7682\% |  |  |  | $\frac{1316}{1,36}$ |  |
|  | $\frac{.1799 \%}{.3044}$ | 981\% | - 23.685 | $\frac{1538 \%}{589}$ | 2.02\% | 07 |  |  | \%,748 | $\frac{1318}{024}$ | $\frac{1218}{1214}$ | ${ }^{*}$ |
|  | . 20.178 | 2149 | 22334 | 34.05 |  | 1.7 | 6638 |  |  |  | 1 |  |
|  | 0.318 |  | 20.596 | 066\% | $\frac{3}{14.17 \%}$ | 5,359 |  |  | 19.19 |  | 13 | * |
|  | $\frac{.2086 \%}{.2616}$ |  | $\xrightarrow{-74.96 \%}$ | 123 | $\frac{19}{329898}$ | , 3 |  | 173 | $\frac{11.95 \%}{1109}$ | 0.66 |  |  |
|  | 11.5588 | 11.1781 | $30.86 \%$ | 30986 | 35.109 | $\frac{.15 .13 \%}{}$ | \% 8.38 | 41818 | $\frac{16.35 \%}{}$ |  | 168 | \% |
|  | . $1587 \times$ | $\frac{-1.89 \%}{8.964}$ | - 10.939 ¢ | $\frac{128.78 \%}{}$ | $\frac{-3766 \%}{11076}$ | 30.59\% | 0219 | $\frac{19.81 \%}{18.75 \%}$ | $\frac{71.67 \%}{.11950}$ | $\frac{1.226}{0.96}$ | $1.27 \times$ | ${ }_{9}^{7}$ |
|  | 28.628 | . 18.7781 | 21709 | - $100 \%$ | 41268 |  | 2405 | $13.65 \times$ | 65.128 | $\frac{9}{1.26 \%}$ | $\frac{104}{}$ |  |
|  | $\frac{18.19 \%}{19408}$ | 20,17\% | 19.858 | $13.01 \%$ |  |  | ${ }^{\frac{51}{84} 96}$ | - $\frac{1}{819 \%}$ | $\frac{6587}{1521}$ | 1248 | 29 |  |
|  | 17018 | $17.81 \times$ | 6.864 | $4.09 \%$ | $\frac{3618}{104}$ | 289 | 975 | 125 | 1506 |  |  |  |
| , | 6468 | - 11.1296 | . 15.488 | 4748 | 2.238 | 27914 |  |  | I | 0 |  |  |
|  | 10.15\% | $2.25 \times$ | 4118 | $\frac{185 \%}{2187 \%}$ | . 27.108 | . 56518 |  |  |  |  | 1098 | 0755 |
|  | 2.85 | 11.47 | -6900 | . 316228 | 7.168 |  |  | 31.59 | , |  | . 38 | $\frac{0848}{6696}$ |
|  |  | \|6.07x | 15.28* | $\frac{14.748}{21474}$ | -3268 | 6074 |  | $\frac{3}{164}$ | $\frac{81098}{}$ |  |  |  |
|  | 16.878 | 9.314 | 1.739 | - 4.724 | . 23.708 | $\frac{1668}{-10638}$ | $\frac{50.19}{59}$ | $\frac{18659}{21045}$ | 50,0\% | \%859 | 118 |  |
|  | $\frac{-24.518}{15.448}$ | $\frac{.21 .168}{.1 .946}$ | - 39.954 | $\frac{17936}{0.184}$ | -19190 | $\frac{.2450 \%}{28624}$ |  | -22609 | $\frac{12398}{268}$ | $\frac{087 \%}{115 \%}$ | $\frac{1.99}{174}$ |  |
|  | -2882\% | $15.76 \times$ | 41.046 | 0.75 | . 10.195 | -100 |  |  |  |  | 15 | $\frac{0676}{3015}$ |
|  | . 39.4080 | 7,274 | -.319\% | . 2127374 | $\frac{24318}{11.14}$ | 36959 | 104898 | :59 | 9150 |  |  |  |
|  | 3689 | -2989 | . 31059 | . 3172 | 313is | 212\% | $\frac{78}{51}$ | $\frac{10}{36}$ | 93, ${ }^{515}$ |  | 301 |  |
|  |  | - 7.9781 | 10818 | $\frac{.0819}{1024}$ | $\frac{.53518}{2588}$ |  |  |  |  |  |  |  |
| J4 | -5, 058 | 4918 | -2.134 | $\frac{.2147}{2.14}$ | 22: 2 | .196 | ! |  |  |  |  |  |
| 1345 | 35985 | - 78.8 | 10878 | :10695 | 15888 | 50169 |  |  |  |  |  |  |
|  |  | $\frac{11.1629}{}$ | 21) 368 | .27574 | ¢ | 4.178 | 2 | 4.49 |  |  |  |  |
|  |  | 0.019 | 6549 | 79 | 315:9 | . 55978 |  | 8359 |  |  |  |  |
| 104 | 26 | , 6008 | 30288 | 19148 | 198 C | .19268 |  |  | क. |  | 1 |  |
| 10,0 | 199 | + 515 |  |  | ? 375 | 3, 3015 |  |  |  | O0\% | 131 |  |
| 95 | . 26112 | 868 | $\frac{.7098}{.1489}$ | $\frac{.32158}{.16134}$ | $\frac{45926}{-1298}$ | 263809 | 4058 | 21.378 | 13808 | 㗊 |  |  |
|  | 29.146 | - $20 \%$ |  | 36.134 | 12294 | -0,474 |  | 214\% | 744 | 114 |  |  |
| 155 | 30.87\% | -15.64 | -12.30\% | -7.224 | $1170 \%$ | 6098 | $5022 \times$ | -1681* | 4659\% | 1.03* | 1.154 | $0.97 \%$ |
|  | 1254 |  |  | - 342 | 14.09\% | 4. 20 | $984 \times$ | 11048 | 91848 | 299 |  |  |
|  | $\frac{1196}{194}$ | 11.158 | 26.94x | $\frac{-1936}{-7.328}$ | $\frac{35.67}{21.19 \%}$ | $\frac{10.41 \%}{6214}$ | 3688 | $\frac{.11979}{-2962}$ | 131.919 |  | 1.06\% |  |
|  | -31590 | -2.3489 | 2.12\% | - 3 398 | 35.11\% | 56.008 | . 2699 |  | 802\% | $0.61 \%$ |  |  |
|  | $\frac{1075}{1529}$ | -27.5987 | -2836 ${ }^{2}$ | $\frac{.9 .35 \%}{11.374}$ | $\frac{.10 .19 x}{610 \%}$ | $\frac{58.05 \%}{12.82 \%}$ | $\frac{1281 \%}{886}$ | $\xrightarrow{-10.3089}$ | $\frac{-12.68 \%}{87.99 \%}$ | $\frac{1.049}{1.319}$ |  |  |
|  | -1.55 | - $117 \times$ | .14.619 | 9454 | 8.178 | 7469 | 8139\% | $\underline{-1628}$ | $106.71 \times$ | 0.79\% | $\frac{1.17 \%}{112}$ |  |
|  | $\frac{.4997}{10918}$ |  | .30664 | $\frac{-8.60 \%}{12.11 \%}$ | $\frac{33936}{13.736}$ | $\frac{013 \%}{}$ | $\frac{19996}{10589}$ | . 10.3 .99 |  | $\frac{1.06 \%}{0.91 \%}$ | $\frac{1.12 x}{1.20 x}$ | $\frac{0.78 \%}{0.75 \%}$ |
|  | 2981 | -11.70\% | .26.11\% | -19118 |  | 4.618 | 32.94* | $36.50 \%$ | -1.99\% | .06\% | 1208 |  |
|  | 61 | 11399 | 5, 258 | $\frac{20.69 \%}{2706 \%}$ | 23926 | \% 5159 | - 5.598 | $\frac{1527}{494 \%}$ |  |  |  |  |
|  | 150 | 2.13 | $\frac{-1.228}{4.248}$ | $\frac{27.96 \%}{27.36 \%}$ | $\frac{51588}{-1585}$ |  | -0,61\% | $\frac{31}{2438}$ | 18.03 |  | 154 |  |
|  |  | 10.208 | $\frac{43.898}{1228}$ |  | $\frac{30.124}{30}$ | 30, 528 | 10.104 | $\frac{12939}{31949}$ | 27.74 | $\frac{0.668}{1214}$ |  |  |
|  | -18.3) | \% 6.08 | \%. 215 | $20.39 \%$ | $\frac{.2009}{20.115}$ | 12.24 | 73.93\% | 15,394 | 92796 |  | 1.219 |  |
|  | -21.48 | -20.489 | -10.30\% | $\frac{.10 .37 \%}{8134}$ | -1.4.784 | $\frac{-1.74 \times 3}{62829}$ | $\frac{32.11 \%}{60 \%}$ | - 3.359 |  | .914 | $\frac{120 \%}{214}$ |  |
|  | 1 | 6.697 |  |  | - | 1409\% | 81058 | 25.407 | $\frac{-60188}{12108}$ | 1006 |  | $\frac{0.91 \%}{0.77 \%}$ |
|  | , | $\frac{1}{5.09 \%}$ | 30:54\% | 6,756 | $\underline{3,122}$ | $\frac{17.314}{}$ | $\frac{47614}{82698}$ | 17.19 |  |  |  | $\frac{0.74}{0.868}$ |
|  | 4 $47 \times$ |  | -27.543 | $\frac{10,358}{.36178}$ | 68 |  | . 1.75 5\% | 1639 | 24.0 | 0.618 | 1.268 |  |
|  | 29774 | . $15.50 \%$ | 31.084 | $26.37 \%$ | $\frac{-13.2184}{}$ | $\frac{14.63}{5021}$ | $\frac{228888}{5629}$ | -2978 |  | $\frac{.278}{0.708}$ | $\frac{1.315}{1.154}$ |  |
|  |  | . 7.9 .98 | $\frac{.13}{656}$ | $\frac{.14 .17 \%}{-364 \%}$ | $\frac{72.148}{30.048}$ | $\frac{.8 .}{12.614}$ | . $55.86 \%$ | 18.814 | Q, 315 | 0.836 | 1.198 | $\frac{8}{8}$ |
|  |  |  |  | 19, $15 \times$ | $\frac{3180 \%}{}$ | -17.078 | $\frac{88578}{3.514}$ |  |  | 0.987 |  |  |
|  | $\frac{10.48}{}$ | 9.05 \% | $\frac{.31 .63 x}{.264}$ | $\underline{.35 .30 \%}$ | $\frac{12.009}{1250}$ | - 48.0088 | 407\% | , | $\frac{8.2348}{68.544}$ | $\frac{1.156}{102}$ |  | $\frac{0.70 \times}{0.988}$ |
|  |  | 22.398 | $\frac{-1624}{-108}$ |  | 23.508 | 23.49\% | - $08.99 \%$ | 18.7 | $\frac{68.548}{.32 .218}$ |  |  | 0.986 |
|  | - $21.178{ }^{\text {a }}$ | 115 [id\% | $\frac{180}{}+2$ | 2.53\% | $\frac{72.02 x}{212085}$ | 6 |  | $\frac{86879}{147}$ | ${ }^{89} 6$ | $\frac{1.1512 \%}{1.168}$ |  | $\frac{0.668}{0.719}$ |
|  | 91 | $\frac{37}{128}$ | . 0.92 | 25.41\% | $\frac{-13.674}{42526}$ | 34.36\% |  |  | $\frac{13449}{}$ |  |  | 0.876 |
|  |  | 4.54*1 |  | 27.46\% | $\frac{42.52 \%}{5.59 \%}$ | 8.139 | 116.22\% | $\frac{.2 .519}{20.206}$ |  |  |  | * |
|  |  |  |  |  | -1.948 | 21,768 | $\frac{107268}{-18529}$ | 29.758 | $\underline{2.16 \%}$ | $1.07 x$ | $110 \times$ | 8 |
|  | 21.008 | 1). 624 | 1.748 |  | 4.8.80\% | 310 | -26.378 | $\frac{1.978}{16.194}$ | 4.9 |  |  |  |
|  | $1{ }^{1.147}$ | $\frac{10.30 \%}{2078}$ | $\frac{.9 .93}{16.798}$ |  | 37.91* |  | $\frac{65}{11.1}$ | $\frac{18.198}{9.629}$ | 2.2 | 0.86 | 259 |  |
|  | 1232 | 11.12\% | 2.234 | 6.834 | $\frac{30.51 \%}{1509 \%}$ | $\frac{34.027}{8.592}$ | $\frac{58}{58.60}$ | $\frac{6.374}{905}$ |  |  |  | \% |
|  | . 18.5 |  | . 25.668 | 2.914 | 11.768 | . 4.808 | 82.45* | $\frac{.9 .988}{17.948}$ | 113.968 | 135 | 1.38 | $\frac{1.688}{0.738}$ |
|  | 111 | 285 | . 10 \% 78 | . 18.114 | 18.00\% |  | 109.714 | $\frac{13.81}{2374}$ |  |  | 168 |  |
|  |  |  | 0.088 | (1).81\% | $\frac{52.63}{57.32}$ | -77.13\% | 08) | 29.04 | 69.40\% | 235 | .230 | 0.9 |
|  | I. | $\frac{3.38}{0.38}$ | -. $9.20 \%$ | $\frac{35.19}{}$ | 44.316\% | $\frac{.21 .02 \%}{17.85 \%}$ | -5.50\% | 15.09\% | 4.928 | 0.69\% | $9 \times$ | 0.93\% |
|  |  |  | . 2.528 | 272 |  |  |  |  |  |  |  |  |

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Table 4.14 Uniform Distribution Random Numbers (partial)


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Table 4.14 Uniform Distribution Random Numbers (partial)


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Table 4.14 Uniform Distribution Random Numbers (partial)


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Table 4.14 Uniform Distribution Random Numbers (partial)


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Table 4.14 Uniform Distribution Random Numbers (partial)


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Table 4．14 Uniform Distribution Random Numbers（partial）

|  |  | $\frac{\mathrm{T}_{10 \mathrm{SM}}^{.5762}}{.50}$ | $\frac{45111}{246 \pi}$ |  |  |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | － 7 | $\frac{.506}{1019}$ | $\frac{.24674}{.9819}$ |  |  | 2232\％ | ． 60.936 | 7 |  |  |  |  |
|  |  | 5289 | 1.198 |  |  |  |  |  |  | ＊ |  | 0， 0 29 |
| gea | 17.65 | $\frac{16919}{}$ | 18976 | 2 | 083\％ | $\frac{16119}{6}$ | 65199 | $\frac{8}{25198}$ |  | 8 | 1248 | 0.768 |
| 号 | $\frac{14218}{5178}$ | $\frac{.21364}{.2974}$ | $\frac{23628}{21944}$ |  | 2， $17 \times$ | ． 51618 | 87018 |  | －${ }^{35004}$ |  |  |  |
| 9000 | 10014 |  |  | 4015\％ | 56248 | ． 51619 |  | ${ }_{17} 7894$ |  |  |  |  |
| ${ }_{90078}^{9008}$ | 107156 | － 1.80 | 15 |  |  | $\frac{3.918}{51.896}$ |  | 213609 | －27．16\％ |  |  |  |
|  | － 41627 | 10429 | －-10.636 | 272 | ． 538 | 26318 | 9， 6 |  |  | $0.65 \%$ |  |  |
|  |  |  |  |  |  |  |  |  |  | $\underline{1}$ | ．99\％ | 0.988 |
|  | $\underline{1090 \%}$ | 3088 | 2102\％ | 53 |  |  |  | 3232 | 16.98 | 0.8 | $13 \times$ |  |
|  | － 6 22\％ | 24914 | 2．40x |  | \＄5，644 | 1321 |  | $\underline{4.3006}$ | 109674 | 0.689 | ${ }^{1228}$ |  |
|  | 156\％ | $10.19 \%$ | $\frac{21.08}{}$ | $\frac{-16004}{12614}$ | －5．318 |  |  |  |  |  |  |  |
| Ois | Ma | 18.5 | 2．78\％ | $\frac{1205 \%}{12056}$ |  |  |  | $\frac{-2753}{26,54}$ | －17 |  |  |  |
| O）${ }^{6}$ | 1080\％ |  | 16724 | 34．94\％ | 60．364 |  | 1298 | 2.16 | 131.88 | 0.9 |  |  |
| $\times 2$ | 1206\％ | ＋ | $\frac{.0 .848}{1.24 \times 2}$ | $\frac{-2.37}{18}$ | 72．19x | －${ }^{2} 2062$ | ． 58 |  | 10140 | 1.2 | 1 |  |
|  |  |  | 34．15\％ |  | $\frac{34.298}{3.314}$ | 2 |  | $\frac{15}{36,6}$ |  | 02 | Lis4\％ |  |
|  | － |  | $\frac{.2108}{1018}$ | $\frac{5105}{1305}$ | 55.098 | 337 | 1 |  |  |  | ＋349 |  |
| ¢022 | 1） 15004 | －13．818 | $\frac{1}{854}$ | $\frac{1308 \%}{2313}$ | －-7.50868 | －$-2.310 \%$ | 6. |  | $\frac{372}{87}$ | 0.6 |  |  |
| 923 | 4 f | $\frac{6}{6318}$ | 28278 | 13．12＊ | $\frac{18}{56} 719$ |  | $48.10 \%$ | $\underline{10}$ | 9298\％ | 1．36\％ | 1064 | 0.6 |
|  |  |  | 4804 | 20.279 | $8.05 \%$ | 56. | ． 21.5 | ． 7.128 | 20 | $\frac{1329}{139}$ | 278 |  |
| 902 | 34，80\％ | －22．70\％ |  | 20．20\％ | $\frac{.361 \%}{16929}$ | － 31.3558 |  | ．18298 |  |  |  |  |
| \＄0，28 | $\frac{.2098}{10575}$ | $\frac{16498}{5914}$ | ． 19888 | 568 | 29，49\％ | $\frac{.1678}{-1529}$ | $\frac{1064}{1087 \%}$ | －4．55＊ | ． 5 594 | 1．35\％ | 16 |  |
| 028 | 32906 | 18964 |  | 21．60\％ | 569\％ | 2．115 | － 46.284 | －23．50\％ | 80， $97 \%$ | $\frac{1.31 \%}{0.86 \%}$ |  | $\frac{0.87 \%}{0.89 \%}$ |
|  |  |  |  |  | $\frac{1969}{859}$ | 17168 | $\frac{116.10}{22.23}$ | $\frac{.32959}{104}$ | 52．03\％ | 1.204 | 1.286 | 0.934 |
|  | － 4 89＊ |  | $\frac{32934}{0794}$ | ＊ | $40.36 \%$ | ． 34.84 | 6151 | －029\％ | 13168 |  |  |  |
|  | 15494 | 0534 | 7．20\％ | $\frac{16008}{1418}$ | $\frac{1.62 x}{717 \%}$ | $\frac{.115}{1.756}$ | $\frac{6323}{7205}$ | 0.088 | 2897 | 1．32\％ | 1.34 |  |
| काप | 1276 | 959\％ | 39868 | 199 | ． 24.058 | －3231 |  | $\frac{14.004}{21.19}$ |  | 0.766 | 1218 |  |
|  | O88 | $9.76 \%$ | 2965 | 111 | $\frac{.576}{-129014}$ |  | 21．28\％ | 3．150 | 4611 | 1.029 | 1298 |  |
| का |  | ${ }^{7}$ |  | ． 2043 | －1．94x | － 16 | $\frac{62 .}{69994}$ | －5974 | 124．95\％ | O872 | 16\％ |  |
|  | 14 | 13 | －29］：7 | $1{ }^{1} 7$ | 31 540 | －10654 | 110020 | －6917 | 57.40 | 072 | 228 |  |
| 8 |  | 8，7\％ | －13：4\％ | 4 | $\frac{15}{25819}$ |  | P\％ |  |  |  |  |  |
| ＊ |  | $\frac{1}{7}$ | ！ $26 \times$ | ．11889 | 17038 |  | 589 | 2：55\％ | 63. |  | 12］ | 0.818 |
| 641 |  |  | $\cdots$ | ？ | 4， 4 it | 359873 |  | Tit | 128 | ， 54 | 1346 |  |
| ष्ता | 19.8 | 2 mb | $6 \times$ | $1 \%$ | $6{ }^{3} 6$ | 695 | ¢3， | － | \％ 0 | ？ 312 | ${ }^{1254}$ | $0.67 \times$ |
| x |  | 98 |  |  |  |  | 9272 | \％ea | 215 | 0994 | $1!$ | 0980 |
| A | 17103 |  | 12 | 3.0 | ${ }^{8} 87$ | 22， |  |  | ：013 19 |  |  |  |
| （\％） | 21．94 | 11 |  | ¢ | 32224 | $\frac{33}{612}$ | ． 2199 | 9 171 | － | ：259 | ${ }^{2}$ | 0 9ax |
| ＊ 6 | 4.209 |  | 9397 | 2987 | 29368 | －11］164 | 612 | 132：8 | 0702 | 134 | 12 |  |
| त5 | 1） 76 | ． 186 |  |  | ．3989\％ | 2891 |  | 115 |  | 1.064 | 12 |  |
| 973 | 3 109 | － 19 | 1002 |  | 42．139 | $\frac{.370 \%}{11248}$ | － 5107 | $\frac{30598}{904}$ | $\frac{132136}{23164}$ | 0.608 | 1280 | 0848 |
| Whan | $1{ }^{10209}$ | ． 20.02 c | $\frac{18518}{4.519}$ | －4，69 | ．11．714 | $\frac{169 \%}{}$ | $\frac{.58 .580}{}$ | $\frac{9}{599} 9$ | $\frac{23.16 \%}{1347 \%}$ | ${ }^{1.688}$ |  | $\frac{0.759}{0.75}$ |
| 293 | ${ }^{15} 468$ | 468 | $.164] 5$ | －9．738 | 18．89\％ | 37．04\％ | $4{ }^{20.304}$ | 5．384 | 27928 | 1389 | 1．07\％ |  |
|  | ．15．189 | － 0.33 \％ | ． 31238 | ．20．418 | 30．09\％ | 56.154 | －3573 | 21.59 | 10.58 m |  | 1．36\％ |  |
|  |  | 6， $75 \times 4$ | －13．60\％ | $\frac{11,57 \times 7}{9514}$ | $\frac{4097 \times}{1980}$ | $\frac{125 \times 1}{28.97 \%}$ | 10．00\％ | $\frac{16818}{19.678}$ | 132066 | $\frac{0.93 \%}{1.12 \%}$ | 1．26\％ | $\frac{0.92 \%}{100 \%}$ |
| 年穴 | $\frac{13654}{872}$ | $\frac{.24 .159}{-21054}$ | －116\％ | －1695x | $\frac{1.98 \%}{51.585}$ | $\frac{28.87 \%}{-16.97}$ | $\frac{1.565}{}$ | －4．760 | 29， |  |  |  |
| ，${ }^{\text {a }}$ | 11．74 | －10 508 | －43109 | $9.22 \times$ | 24．108\％ | 19.598 | ． 64.868 | 12.288 | ． 31.90 |  |  |  |
| 981 | 25．73\％ | $10.09 \%$ | 19214 | $13 \times 4 \%$ | 6560 | ${ }^{-0.129}$ | 20.678 | 17018 | $4250 \times$ | $0.67 \times$ |  |  |
|  |  | ．1177x | $\frac{3611 \%}{42744}$ | $\frac{30.578}{8068}$ | ． $5.501 \%$ | $\frac{1.159}{-12018}$ | 6.148 | $\frac{26.55 \times}{13.15 \times}$ | 69．20\％ | 1．1990 | $\frac{1.316}{1.16}$ |  |
| ＂． | 419 | 531\％ | 109\％ | $3316 \times$ | ． 5.590 | ． 34.198 | － 89948 | $1034 \%$ | 12.5150 | 0.998 | ${ }^{126 \%}$ |  |
|  | ग1．029 | 1362m | ． 2.2414 | $10.51 \%$ | 23，32\％ | 34．1\％ | $60.69 \times$ | 1.54 | －1） 1.926 |  |  |  |
| 9 | ． 10369 | $\frac{11}{}{ }^{108}$ | 11515 | 10\％\％ | 7．53＊ | ． $5681 \%$ | $11958{ }^{1}$ | 10．99\％ | $27.34 \times$ |  | 125 | 10 |
|  |  | 11.068 | $\frac{.12 .38}{.14 .706}$ | $\frac{5.018}{.9 .318}$ | $\frac{.50 .10 \%}{10.10 \%}$ |  | $\frac{1}{-5.1519}$ | $\frac{9.178}{11.278}$ | 8．01\％ | 1．25\％ | ${ }_{1}^{1.174}$ |  |
| 9 | $\frac{10}{10} 20$ | 2．73\％ | $3 \% \%$ | 15318 | 26．588 | －46．18 | ． $13 \times 4$ | $\frac{37.178}{21.28}$ | 104，92\％ | $\frac{1,18 \times}{0.75}$ | 1.118 |  |
| \％ | －4．58\％ | 1\％ | 160 | 9．544 | 27.398 |  | 1is＊ |  | 0．59\％ |  |  | $1.00 \%$ |
| कौ1 | 13．1\％ | $\frac{10659}{1284}$ | 3， $314 \times$ | $\frac{.2929}{.1196}$ | － 4.276 | $\frac{18,97}{}$ | 101．67\％ | 18.144 | －89 | 1.234 | 32 | 6．8\％\％ |
|  | －12529 | 1387 | ． 26.469 | 29．914 | ． 4.4146 | 29729 | $\underline{1829}$ | $\frac{-5}{6.05}$ | 126 |  |  |  |
|  | ${ }^{3}$ | $3{ }^{3} 5$ |  |  | 25， | $2.01 \%$ | （1）72\％ | －1．314 | 309988 | 1．05\％ | 1.215 |  |
| 978 | 12．248 | 11．269 | 10248 | ．8．518 | $5{ }^{4.80 \%}$ | $\frac{5861 \%}{}$ |  | －78989\％ | 5928 |  | L 136 |  |
|  | $1816 \times$ | 1100 | ． $10.06 \%$ | $\frac{17.118}{15214}$ | ．30\％ |  | 5803 | 18.3 | 00.4 |  | 209 | 0．828 |
| 9 |  | 16．847 |  | $\frac{15218}{22,94 \%}$ | －18．964 | 183 | $\frac{5}{72,718}$ | 60 |  |  | $\frac{1.176}{1.148}$ | $\frac{0.938}{0.928}$ |
| 99 | 5 568 | －19．38 | 18.398 | 23．376 | $\frac{4825}{1228}$ | $\frac{2122}{152}$ | 72．21\％ |  |  | 164 | 1158 |  |
|  | 18.148 |  |  |  | ${ }_{-1.88}$ | 27 | $4.85 \times$ | 363 |  |  |  | 0 |
| 9 | 25974 | －23038 |  | $404 \%$ |  |  | 12 | 14．31\％ | 13．17 | 1.3 | ， |  |
| 9 | 3.6 |  | 6.148 | $\frac{.14 .59 \%}{25248}$ |  | 256\％ | 2972 | 13.15 | ， |  | 1108 |  |
|  | － 4.028 | 4．139 | $17.1{ }^{4}$ | ． 72828 | ． 10.668 | 61．67\％ | 46．729\％ |  | 126.828 | 2．259 | 1.116 | $0.90 \%$ |
|  | －11．68 | －21．518 | $75^{5}$ | ．5．76\％ |  | $\frac{.6 .8964}{}$ | 4.448 | －10．31\％ | 6．40\％ | $1.09 \%$ | 1．21\％ | 0．85\％ |
| 8 | $\frac{15}{10408}$ | $\frac{16.13}{6854}$ | 1 |  | $\frac{2}{7.53 \times}$ | 21889 |  | 34，3 |  |  | 169 | $\frac{0.5}{0.7}$ |
| 8032 | 16698 |  | 10505 | －2．998 | 6．34＊ | 2.8 | 8.35 | 18.0 | 2．528 | 1.0248 | 16 | 0.919 |
|  | 1300\％ | 1）．108 | －1038 | 12.417 | ， 2.185 | 2． 3 | 27．26＊ |  | $\frac{124.18}{1025}$ | $\underline{1.097}$ |  |  |
|  | 41736 | \％${ }^{3} 8$ | $\frac{6.92}{24}$ | －2765\％ | 20．984 | 37．61\％ | $\frac{.5 .278}{-9.478}$ | 12．3489 | $\frac{101.45 \%}{-5.107}$ | $\frac{0.76 \%}{1.145}$ | $\frac{1.109}{1.109}$ | $\frac{6.978}{6.98}$ |
|  | 1719 | 6449 | （3）3 | 190］＊ | 5， 798 | 26．206 | －11．929 | 16819 | 34．73 | 0.7661 | ．08\％ | 0.958 |
|  | －11．${ }^{\text {c／}}$ | －8，599 | 28318 | $1198 x$ |  |  | ， 8.8158 |  | ， 1566 |  | $\frac{34}{27}$ |  |
|  | $2{ }^{2089}$ |  | 0．69 | － 4.637 | $\frac{7}{2} 183$ | $\frac{35638}{17428}$ | 24．51887 | $\frac{20.368}{0.348}$ | $\frac{32.0109}{}$ | 0．708 | ．239 | 0．924 |
| 1000 | －10， | 2） | 0.088 | 12．198 | 2.2689 | V12\％ |  |  |  |  |  |  |

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Table 4.15 Simulation Result : Weighting Structure 1

| TTERATION | RETURN | RISK | \# |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| - 1 | -11.700503\% | 8.466401\% | 1 | BINS | COUNTS | SCALE | TOTAL |
| 2 | 21.158751\% | 8.466401\% | 2 | -28.410465\% | 1 | 0.017885 | 0.000100 |
| 3 | -19.173581\% | 8.466401\% | $\frac{2}{3}$ | -27.851324\% | 0 | 0.000000 | 0.000100 |
| 4 | -15.146648\% | 8.466401\% | 4 | -27.292184\% | 2 | 0.035769 | 0.000300 |
| 5 | 11.901303\% | 8.466401\% | 5 | -26.733043\% | 2 | 0.035769 | 0.000500 |
| 6 | -9.549030\% | 8.466401\% | 6 | \% | 5 | 0.089423 | 0.001000 |
| 7 | 19.808932\% | 8.466401\% | 7 | \% | 5 | 0.089423 | 0.001500 |
| 8 | 6.657370\% | 8.466401\% | 8 | -25.055622\% | 4 | 0.071538 | 0.001900 |
| 9 | 7.872280\% | 8.466401\% | 9 | -24.496481\% | 16 | 0.286153 | 0.003500 |
| 10 | 12.424001\% | 8.466401\% | 10 | 仿 | 19 | 0.339807 | 0.005400 |
| 12 | -5.830677\% | 8.466401\% | 11 | -23.378200\% | 16 | 0.286153 | 0.007000 |
| 12 | -4.673872\% | 8.466401\% | 12 | -22.819060\% | 23 | 0.411346 | 0.009300 |
| 13 | 12.231674\% | 8.466401\% | 13 |  | 27 | 0.482884 | 0.012000 |
| 14 | -8.230862\% | 8.466401\% | 14 |  | 20 | 0.357692 | 0.014000 |
| 15 | 3.163263\% | 8.466401\% | 15 | -20.582498\% |  | 0.429230 | 0.016400 |
| 16 | -15.350464\% | 8.466401\% | 16 | -20.023357 |  | 0.679614 | 0.020200 |
| 17 | -4.694606\% | 8.466401\% | 17 | -19.46 |  | 0.661730 | 0.023900 |
| 19 | 0.923834\% | 8.466401\% | 19 |  | 58 | 1.037306 | 0.035600 |
|  | 263678\% | \% |  |  |  |  |  |
|  |  |  |  |  |  | 1.484421 | 0.065500 |
|  |  |  |  | -16.109373\% | 97 | 1.734805 | 0.075200 |
|  |  |  |  |  |  | 1.716921 | 0.084800 |
| .. | $\ldots$ | ... | $\ldots$ | ... | ... | ... | $\ldots$ |
| 9977 | 7.749477\% | 8.466401\% | 77 | 14.084215\% | 106 | 1.895767 | 0.891400 |
| 9978 | -6.320813\% | 8.466401\% | 78 | 14.643356\% | 106 | 1.895767 | 0.902000 |
| 9979 | 17.462346\% | 8.466401\% | 79 | 15.202496\% | 100 | 1.788459 | 0.912000 |
| 9980 | 18.131973\% | 8.466401\% | 80 | 15.761637\% | 111 | 1.985190 | 0.923100 |
| 9981 | -7.224158\% | 8.466401\% | 81 | 16.320777\% | 84 | 1.502306 | 0.931500 |
| 9982 | -15.792929\% | 8.466401\% | 82 | 16.879918\% | 76 | 1.359229 | 0.939100 |
| 9983 | 18.757628\% | 8.466401\% | 83 | 17.439058\% | 84 | 1.502306 | 0.947500 |
| 9984 | -8.835635\% | 8.466401\% | 84 | 17.998199\% | 64 | 1.144614 | 0.953900 |
| 9985 | -18.121087\% | 8.466401\% | 85 | 18.557339\% | 71 | 1.269806 | 0.961000 |
| 9986 | 12.042991\% | 8.466401\% | 86 | 19.116480\% | 68 | 1.216152 | 0.967800 |
| 9987 | -3.456056\% | 8.466401\% | 87 | 19.675620\% | 59 | 1.055191 | 0.973700 |
| 9988 | 2.153330\% | 8.466401\% | 88 | 20.234761\% | 40 | 0.715384 | 0.977700 |
| 9989 | -14.179571\% | 8.466401\% | 89 | 20.793901\% | 38 | 0.679614 | 0.981500 |
| 9990 | 15.101994\% | 8.466401\% | 90 | 21.353042\% | 44 | 0.786922 | 0.985900 |
| 9991 | -7.339581\% | 8.466401\% | 91 | 21.912182\% | 35 | 0.625961 | 0.989400 |
| 9992 | 0.595863\% | 8.466401\% | 92 | 22.471323\% | 27 | 0.482884 | 0.992100 |
| 9993 | 14.771922\% | 8.466401\% | 93 | 23.030463\% | 21 | 0.375576 | 0.994200 |
| 9994 | 0.742694\% | 8.466401\% | 94 | 23.589604\% | 21 | 0.375576 | 0.996300 |
| 9995 | 21.531163\% | 8.466401\% | 95 | 24.148745\% | 11 | 0.196731 | 0.997400 |
| 9996 | 1.568729\% | 8.466401\% | 96 | 24.707885\% | 9 | 0.160961 | 0.998300 |
| 9997 | -12.493075\% | 8.466401\% | 97 | 25.267026\% | 5 | 0.089423 | 0.999400 |
| 9998 | 9.832246\% | 8.466401\% | 98 | 385307\% | 5 | 0.089423 | 0.999900 |
| 9999 | 11.821156\% | 8.466401\% | 99 | 26.385307\% | 1 | 0.017885 | 1.000000 |
| 10000 | -9.552992\% | 8.466401\% | 100 | 26.944447\% |  |  |  |


| STATISTICAL SUMMARY |
| :--- |
| MinImum Maximum Median Mean Std. Devlation Probability UCL$\|$ LCL |
| $-28.41 \%$ |
| $26.94 \%$ |

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Table 4.16 Simulation Result : Weighting Structure 2

| TTERATION | RETURN | RISK | \# |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1. | 1.114306\% | 0.100365\% | 1 | BINS | COUNTS | SCALE | TOTAL |
| 2 | 1.133220\% | 0.100365\% | 2 | 1.021156\% | 1 | 2.728775 | 0.000100 |
| 3 | 1.030030\% | 0.100365\% | 3 | 1.024820\% | 4 | 10.915101 | 0.000500 |
| 4 | 1.103784\% | 0.100365\% | 4 | 1.028485\% | 14 | 38.202852 | 0.001900 |
| 5 | 1.143857\% | 0.100365\% | 5 | 2149\% | 26 | 70.948154 | 0.004500 |
| 6 | 1.196988\% | 0.100365\% | 6 | 1.0358 | 31 | 84.592030 | 0.007600 |
| 7 | 1.104429\% | 0.100365\% | 7 | 1.0394 | 42 | 114.608557 | 0.011800 |
| 8 | 1.172718\% | 0.100365\% | 8 | 1.043143\% | 40 | 109.151006 | 0.015800 |
| 9 | 1.162632\% | 0.100365\% | 9 | 1.046808\% | 60 | 163.726510 | 0.021800 |
| 10 | 1.084093\% | 0.100365\% | 10 | 1.050473\% | 41 | 111.879782 | 0.025900 |
| 11 | 1.275302\% | 0.100365\% | 11 | 1.054137\% | 62 | 169.184060 | 0.032100 |
| 12 | 1.265840\% | 0.100365\% | 12 | 1.057802\% | 84 | 229.217114 | 0.040500 |
| 13 | 1.311699\% | 0.100365\% | 13 | 1.065131\% | 78 | 212.844463 | 0.048300 |
| 14 | 1.150543\% | 0.100365\% | 14 | 1.068796\% | 63 | 171.912835 | 0.054600 |
| 15 | 1.164982\% | 0.100365\% | 15 | 1.072461\% | 97 | 264.691191 | 0.064300 |
| 16 | 1.290926\% | 0.100365\% | 16 | 1.076125\% | 107 | 253.776090 | 0.073600 |
| 17 | 1.278850\% | 0.100365\% | 17 | 1.079790\% |  | 291.978942 | 0.084300 |
| 18 | 1.332639\% | 0.100365\% | 18 | 1.083455\% | 121 | 13.809144 | 0.095800 |
| 19 | 1.225254\% | 0.100365\% | 19 | 1.087119\% | 121 | 181795 |  |
| 20 | 1.315652\% | 0.100365\% | 20 | 1.090784\% | 135 | 368.384647 | 0.133500 |
| 21 | 1.292732\% | 0.100365\% | 21 | 1.094448\% | 119 | 324.724244 | 0.145400 |
| 22 | 1.107241\% | 0.100365\% | 22 | 1.098113\% | 114 | 311.080368 | 0.156800 |
| 23 | 1.280598\% | 0.100365\% | 23 | 1.101778\% | 126 | 343.825670 | 0.169400 |
| 24 | 1.154545\% | 0.100365\% | 24 | 1.105442\% | 120 | 327.453019 | 0.18:40C |
| 25 | 1.123032\% | 0.100365\% | 25 | 1.109107\% | 129 | 352.011996 | 0.194300 |
| ... | $\cdots$ | ... | ... | ... | ... | ... | .. |
| 9977 | 1.216750\% | 0.100365\% | 77 | 1.299669\% | 118 | 321.995465 | 0.8:5900 |
| 9978 | 1.335258\% | 0.100365\% | 78 | 1.303333\% | 123 | 335.639345 | 0.828200 |
| 9979 | 1.370529\% | 0.100365\% | 79 | 1.306998\% | 117 | 319.266694 | 0.839900 |
| 9980 | 1.084837\% | 0.100365\% | 80 | 1.310663\% | 139 | 379.299747 | 0.853800 |
| 9981 | 1.166542\% | 0.100365\% | 81 | 1.314327\% | 119 | 324.724244 | 0.865700 |
| 9982 | 1.156816\% | 0.100365\% | 82 | 1.317992\% | 127 | 346.554446 | 0.878400 |
| 9983 | 1.150059\% | 0.100365\% | 83 | 1.321657\% | 117 | 319.266694 | 0.890100 |
| 9984 | 1.155110\% | 0.100365\% | 84 | 1.325321\% | 98 | 267.419966 | 0.899900 |
| 9985 | 1.260633\% | 0.100365\% | 85 | 1.328986\% | 109 | 297.436493 | 0.910800 |
| 9986 | 1.187918\% | 0.100365\% | 86 | 1.332651\% | 104 | 283.792617 | 0.921200 |
| 9987 | 1.138569\% | 0.100365\% | 87 | 1.336315\% | 93 | 253.776090 | 0.930500 |
| 9988 | 1.102310\% | 0.100365\% | 88 | 1.339980\% | 101 | 275.606291 | 0.940600 |
| 9989 | 1.305210\% | 0.100365\% | 89 | 1.343645\% | 88 | 240.132214 | 0.949400 |
| 9990 | 1.197880\% | 0.100365\% | 90 | 1.347309\% | 89 | 242.860989 | 0.958300 |
| 9991 | 1.301417\% | 0.100365\% | 91 | 1.350974\% | 72 | 196.471812 | 0.965500 |
| 9992 | 1.161362\% | 0.100365\% | 92 | 1.354638\% | 64 | 174.641610 | 0.971900 |
| 9993 | 1.147143\% | 0.100365\% | 93 | 1.358303\% | 60 | 163.726510 | 0.977900 |
| 9994 | 1.193316\% | 0.100365\% | 94 | 1.361968\% | 61 | 166.455285 | 0.984000 |
| 9995 | 1.064663\% | 0.100365\% | 95 | 1.365632\% | 60 | 163.726510 | 0.990000 |
| 9996 | 1.100360\% | 0.100365\% | 96 | 1.369297\% | 38 | 103.693456 | 0.993800 |
| 9997 | 1.053617\% | 0.100365\% | 97 | 1.372962\% | 26 | 70.948154 | 0.997900 |
| 9998 | 1.295542\% | 0.100365\% | 98 | 1.376626\% | 15 | 43.660403 | 0.999500 |
| 9999 | 1.244660\% | 0.100365\% | 99 | 1.380291\% | 5 | 13.643876 | 1.000000 |
| 10000 | 1.191279\% | 0.100365\% | 100 |  |  |  |  |



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Table 4.17 Simulation Result : Weighting Structure 3

| ITERATION | RETURN | RISK | \# |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| - 1 | 0.688486\% | 0.143359\% | 1 | BINS | COUNTS | SCALE | TOTAL |
| 2 | 0.774728\% | 0.143359\% | 2 | 0.660854\% | 1 | 2.465348 | 0.000100 |
| 3 | $0.791894 \%$ | 0.143359\% | 3 | 0.664910\% | 86 | 212.019948 | 0.008700 |
| 4 | 0.805243\% | 0.143359\% | 4 | 0.668966\% | 131 | 322.960618 | 0.021800 |
| 5 | 0.755077\% | 0.143359\% | 5 | 0.673023\% | 105 | 258.861564 | 0.032300 |
| 6 | 0.909019\% | 0.143359\% | 6 | 0.677079\% | 83 | 204.623903 | 0.040600 |
| 7 | 0.932492\% | 0.143359\% | 7 | 0.681135\% | 104 | 256.396216 | 0.051000 |
| 8 | 0.975351\% | 0.143359\% | 8 | 0.685191\% | 101 | 249.000171 | 0.061100 |
| 9 | 0.808629\% | 0.143359\% | 9 | 0.689248 | 98 | 241.604127 | 0.070900 |
| 10 | 0.733799\% | 0.143359\% | 10 | .693304\% | 95 | 234.208082 | 0.080400 |
| 11 | 1.023777\% | 0.143359\% | 11 | \% | 97 | 239.138778 | 0.090100 |
| 12 | 0.973706\% | 0.143359\% | 12 | 05 | 99 | 244.069475 | 0.100000 |
| 13 | 0.923246\% | 0.143359\% | 13 | 0.70952 | 84 | 207.089251 | 0.108400 |
| 14 | 0.988134\% | 0.143359\% | 14 | 0.71358 | 100 | 246.534823 | 0.118400 |
| 15 | 0.790726\% | 0.143359\% | 15 | 0.717641\% | 114 | 281.049698 | 0.129800 |
| 16 | 0.924405\% | 0.143359\% | 16 | 0.721697\% | 99 | 244.069475 | 0.139700 |
| 17 | 0.699259\% | 0.143359\% | 17 | 0.725754\% | 100 | 244.069475 | 0.149600 |
| 18 | 0.798908\% | 0.143359\% | 18 | 0.729810\% |  | 246.534823 | 0.159600 |
| 19 | 0.807390\% | 0.143359\% | 19 | 0.733866\% |  | 258.861564 | 0.170100 |
| 20 | 0.904852\% | 0.143359\% | 20 | 0.737922\% | 104 | 266.257609 | 0.180900 |
| 21 | 0.941192\% | 0.143359\% | 21 | 0.741978\% | 105 |  |  |
| 22 | 0.849257\% | 0.143359\% | 22 | 0.746035\% | 103 | 253.930868 | 0.212100 |
| 23 | 0.847905\% | 0.143359\% | 23 | 0.750091\% | 94 | 231.742734 | 0.221500 |
| 24 | 0.781840\% | 0.143359\% | 24 | $0.754147 \%$ | 105 | 258.861564 | 0.232000 |
| 25 | 0.912436\% | 0.143359\% | 25 | 0.758203\% | 126 | 310.633877 | 0.244600 |
| ... | ... | ... | $\ldots$ | ... | ... | ... | ... |
| 9977 | 0.878108\% | 0.143359\% | 77 | 0.969127\% | 104 | 256.396216 | 0.763800 |
| 9978 | 0.697269\% | 0.143359\% | 78 | 0.973183\% | 98 | 241.604127 | 0.773600 |
| 9979 | 0.970509\% | 0.143359\% | 79 | 0.977239\% | 95 | 234.208082 | 0.783100 |
| 9980 | 0.874348\% | 0.143359\% | 80 | 0.981296\% | 115 | 283.515047 | 0.794600 |
| 9981 | 0.930247\% | 0.143359\% | 81 | 0.985352\% | 100 | 246.534823 | 0.804600 |
| 9982 | 0.917187\% | 0.143359\% | 82 | 0.989408\% | 101 | 249.000171 | 0.814700 |
| 9983 | 0.684967\% | 0.143359\% | 83 | 0.993464\% | 110 | 271.188305 | 0.825700 |
| 9984 | 0.938489\% | 0.143359\% | 84 | 0.997520\% | 107 | 263.792261 | 0.836400 |
| 9985 | 0.756053\% | 0.143359\% | 85 | 1.001577\% | 112 | 276.119002 | 0.847600 |
| 9986 | 0.665074\% | 0.143359\% | 86 | 1.005633\% | 92 | 226.812037 | 0.856800 |
| 9987 | 0.986822\% | 0.143359\% | 87 | 1.009689\% | 94 | 231.742734 | 0.866200 |
| 9988 | 0.927555\% | 0.143359\% | 88 | 1.013745\% | 90 | 221.881341 | 0.875200 |
| 9989 | 0.903070\% | 0.143359\% | 89 | 1.017802\% | 111 | 273.653654 | 0.886300 |
| 9990 | 0.850857\% | 0.143359\% | 90 | 1.021858\% | 111 | 273.653654 | 0.897400 |
| 9991 | 0.692546\% | 0.143359\% | 91 | 1.025914\% | 102 | 251.465520 | 0.907600 |
| 9992 | 0.700441\% | 0.143359\% | 92 | 1.029970\% | 104 | 256.396216 | 0.918000 |
| 9993 | 0.906592\% | 0.143359\% | 93 | 1.034026\% | 105 | 258.861564 | 0.928500 |
| 9994 | 0.668699\% | 0.143359\% | 94 | 1.038083\% | 103 | 253.930868 | 0.938800 |
| 9995 | 0.915717\% | 0.143359\% | 95 | 1.042139\% | 96 | 236.673430 | 0.948400 |
| 9996 | 0.918124\% | 0.143359\% | 96 | 1.046195\% | 103 | 253.930868 | 0.958700 |
| 9997 | 0.953215\% | 0.143359\% | 97 | 1.050251\% | 91 | 224.346689 | 0.967800 |
| 9998 | 0.730418\% | 0.143359\% | 98 | 1.054308\% | 109 | 268.722957 | 0.978700 |
| 9999 | 0.666189\% | 0.143359\% | 99 | 1.058364\% | 106 | 261.326913 | 0.989300 |
| 10000 | 0.919643\% | 0.143359\% | 100 | 1.062420\% | 107 | 263.792261 | 1.000000 |
| 1000 | $0.919643 \%$ |  |  |  |  |  |  |


| STATISTICAL SUMMARY |
| :--- |
| Minimum Maximum Median Mean Std. Deviation Probabllity UCL LCL <br> $0.65 \%$ $1.06 \%$ $0.86 \%$ $0.86 \%$ $0.12 \%$ $\mathrm{~V} / \mathrm{a}$ $0.86 \%$ $0.87 \%$ |

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Table 4.18 Simulation Result : Weighting Structure 4

| TIERATION | RETURN | RISK |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| - 1 | -5.232779\% | 4.196487\% | 1 | BINS | COUNTS | SCALE |  |
| 2 | 10.951915\% | 4.196487\% | 2 | -13.660016\% | 1 | SCALE 0.035829 | TOTAL |
| 3 | -9.130295\% | 4.196487\% | 3 | -13.380912\% | 0 | 0.035829 | 0.000100 |
| 4 | -7.020745\% | 4.196487\% | 4 | -13.101807\% | 2 | 0.071658 | 0.000300 |
| 5 | 6.402802\% | 4.196487\% | 5 | -12.822703\% | 5 | 0.179144 | 0.000800 |
| 6 | -4.162609\% | 4.196487\% | 6 | -12.543598\% | 3 | 0.107487 | 0.001100 |
| 7 | 10.493718\% | 4.196487\% | 7 | $\frac{-12.264494 \%}{-11.985389 \%}$ | 5 | 0.179144 | 0.001600 |
| 8 | 3.788625\% | 4.196487\% | 8 | -11.985389\% | 8 | 0.286631 | 0.002400 |
| 9 | 4.431085\% | 4.196487\% | 9 | -11.706284\% | 13 | 0.465775 | 0.003700 |
| 20 | 6.765474\% | 4.196487\% | 10 | 427180\% | 21 | 0.752406 | 0.005800 |
| 11 | -2.515979\% | 4.196487\% | 11 | 11.148075 | 18 | 0.644920 | 0.007600 |
| 12 | -1.983322\% | 4.196487\% | 12 | -10.589866\% | 25 | 0.895722 | 0.010100 |
| 13 | 6.377250\% | 4.196487\% | 13 | -10.3107 | 23 | 0.824064 | 0.012400 |
| 14 | -3.458507\% | 4.196487\% | 14 | -10.031 | 22 | 0.788235 | 0.014600 |
| 15. | 2.173874\% | 4.196487\% | 15 | -9.752553\% | 25 | 0.895722 | 0.017100 |
| 16 | -7.177695\% | 4.196487\% | 16 | -9.473448\% | 34 | 1.218182 | 0.020500 |
| 17 | -1.676736\% | 4.196487\% | 17 | -9.194344\% | 50 | 1.791444 | 0.025500 |
| 18 | -4.068714\% | 4.196487\% | 18 | -8.915239\% |  | 1.934759 | 0.030900 |
| 19 | 1.217665\% | 4.196487\% | 19 | -8.636135\% | 63 | .185561 | 0.037000 |
| 20 | 5.154474\% | 4.196487\% | 20 | -8.357030\% | 68 |  | 0.043300 |
| 21 | 10.895725\% | 4.196487\% | 21 | -8.077926\% | 78 | 2.794652 | 0.057900 |
| 22 | $0.358897 \%$ | 4.196487\% | 22 | -7.798821\% | 96 | 3.439572 | 0.067500 |
| 23 | 4.763407\% | 4.196487\% | 23 | -7.519717\% | 86 | 3.081283 | 0.076100 |
| 24 | 2.525567\% | 4.196487\% | 24 | -7.240612\% | 96 | 3.439572 | 0.085700 |
| 25 | -3.475312\% | 4.196487\% | 25 | -6.961507\% | 120 | 4.299464 | 0.097700 |
| ... | ... | $\ldots$ | $\ldots$ | ... | ... | ... | ... |
| 9977 | 4.305273\% | 4.196487\% | 77 | 7.551928\% | 94 | 3.367914 | 0.893800 |
| 9978 | -2.581649\% | 4.196487\% | 78 | 7.831033\% | 109 | 3.905347 | 0.904700 |
| 9979 | 9.410720\% | 4.196487\% | 79 | 8.110137\% | 105 | 3.762031 | 0.915200 |
| 9980 | 9.489234\% | 4.196487\% | 80 | 8.389242\% | 94 | 3.367914 | 0.924600 |
| 9981 | -3.122181\% | 4.196487\% | 81 | 8.668346\% | 84 | 3.009625 | 0.933000 |
| 9982 | -7.336484\% | 4.196487\% | 82 | 8.947451\% | 82 | 2.937967 | 0.941200 |
| 9983 | 9.965083\% | 4.196487\% | 83 | 9.226555\% | 86 | 3.081283 | 0.949800 |
| 9984 | -3.948945\% | 4.196487\% | 84 | 9.505660\% | 55 | 1.970588 | 0.955300 |
| 9985 | -8.425936\% | 4.196487\% | 85 | 9.784764\% | 71 | 2.543850 | 0.962400 |
| 9986 | 6.777925\% | 4.196487\% | 86 | 10.063869\% | 68 | 2.436363 | 0.969200 |
| 9987 | -1.454634\% | 4.196487\% | 87 | 10.342973\% | 51 | 1.827272 | 0.974300 |
| 9988 | 1.463620\% | 4.196487\% | 88 | 10.622078\% | 40 | 1.433155 | 0.978300 |
| 9989 | -6.585147\% | 4.196487\% | 89 | 10.901182\% | 42 | 1.504813 | 0.982500 |
| 9990 | 8.089498\% | 4.196487\% | 90 | 11.180287\% | 38 | 1.361497 | 0.986300 |
| 9991 | -3.431342\% | 4.196487\% | 91 | 11.459391\% | 37 | 1.325668 | 0.990000 |
| 9992 | 0.905564\% | 4.196487\% | 92 | 11.738496\% | 23 | 0.824064 | 0.992300 |
| 9993 | 7.953608\% | 4.196487\% | 93 | 12.017601\% | 22 | 0.788235 | 0.994500 |
| 9994 | 0.744719\% | 4.196487\% | 94 | 12.296705\% | 17 | 0.609091 | 0.996200 |
| 9995 | 11.072469\% | 4.196487\% | 95 | 12.575810\% | 15 | 0.537433 | 0.997700 |
| 9996 | 1.220101\% | 4.196487\% | 96 | 12.854914\% | 8 | 0.286631 | 0.998500 |
| 9997 | -5.927997\% | 4.196487\% | 97 | 13.134019\% | 6 | 0.107487 | 0.999400 |
| 9998 | 5.204874\% | 4.196487\% | 98 | 13.413123\% | 5 | 0.179144 | 0.999900 |
| 9999 | 6.334164\% | 4.196487\% | 99 | .692228\% | 1 | 0.035829 | 1.000000 |
| 10000 | -4.557526\% | 4.196487\% | 100 | $13.971332 \%$ |  |  |  |


| STATISTICAL SUMMARY |
| :--- |
| Minimum Maximum Median Mean Std. Deviation Probability UCL LQ <br> $-13.66 \%$ $13.97 \%$ $0.34 \%$ $0.38 \%$ $5.49 \%$ $43.40 \%$ $0.16 \%$ $0.59 \%$ |

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Table 4.19 Simulation Result : Weighting Structure 5

| TERATION | RETURN | RISK | \# |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | -5.364571\% | 4.214640\% | 1 | -138084 | COUNTS | SCALE | TOTAL |
| 2 | 10.961933\% | 4.214640\% | 2 | -13.526510\% | 1 | 0.035467 | 0.000100 |
| 3 | -9.169154\% | 4.214640\% | 3 | -13.244555\% | 0 | 0.000000 | 0.000100 |
| 5 | -7.060394\% | 4.214640\% | 4 | -12.962600\% | 2 | 0.070933 | 0.000300 |
| 5 | 6.418697\% | 4.214640\% | 5 | -12.680646\% | 2 | 0.070933 | 0.000500 |
|  |  | $4.214640 \%$ | 6 | -12.398691\% | 5 | 0.177333 | 0.001000 |
|  |  | 4.214640\% | 7 | -12.116736\% | 5 | 0.212800 | 0.001600 |
|  |  | 4.214640\% | 8 | -11.834782\% | 16 | 0.177333 | 0.002100 |
| 10 |  | 4.214640\% | 9 | -11.552827\% | 14 | 0.567467 | 0.003700 |
| 11 |  | 4.214640\% | 10 | -11.270872\% | $\frac{14}{21}$ | 0.496534 | 0.005100 |
| 12 |  | 4.214640\% | 11 | -10.988918\% | 25 | 0.744801 | 0.007200 |
| 13 |  | 4.214640\% | 12 | -10.706963\% | 28 | 0.886667 | 0.009700 |
| 14 | -3.553975\% | 4.214640\% | 13 | -10.425008\% | 16 | 0.993067 | 0.012500 |
| 15 | 2.133829\% | 4.214640\% | 14 | -10.143054\% | 22 | 0.567467 0.780267 | 0.014100 |
| 16 | -7.204880\% | 4.214640\% | 15 | -9.861099\% | 37 | 1.312268 | $\frac{0.016300}{0.02000}$ |
| 17 | -1.782742\% | 4.214640\% | 16 | -9.579145\% | 43 | 1.525068 | 0.020000 |
|  |  |  | 17 | -9.297190\% | 54 | 1.915202 | 0.0243700 |
|  |  |  | 18 | -9.015235\% | 60 | 2.128002 | 0.035700 |
|  |  |  | 19 | -8.733281\% | 67 | 2.376269 | 0.042400 |
|  |  |  | 20 | -8.451326\% | 69 | 2.447202 | 0.049300 |
|  |  |  | 21 | -8.169371\% | 77 | 2.730936 | 0.057000 |
|  |  |  |  | -7.887417\% | 86 | 3.050136 | 0.065600 |
|  |  |  |  | -7.323507\% | 94 | 3.333869 | 0.084600 |
|  |  |  |  |  |  | 3.688536 | 0.906700 |
|  |  |  |  |  | 85 |  |  |
|  |  |  |  |  |  | 3.156536 |  |
|  | -3.859159\% | 4.214640\% | 84 |  |  |  |  |
|  | -8.491828\% | 4.214640\% | 85 | 9.8 | 75 | 2.660002 | 0.964400 |
| 9986 | 6.570163\% | 4.214640\% | 86 | 10.157682\% | 62 | 2.198935 | 0.970600 |
| 99887 | -1.378965\% | 4.214640\% | 87 | 10.439636\% | 43 | 1.525068 | 0.975700 |
| 9988 | 1.524638\% | 4.214640\% | 88 | 11.003546\% | 38 | 1.347734 | 0.980000 |
| 99899 | -6.658890\% | 4.214640\% | 89 | 11.285500\% | 38 | 1.347734 | 0.9887600 |
|  | 8.063970\% | 4.214640\% | 91 | 11.567455\% | 31 | 1.099468 | 0.990700 |
| 9992 | -3.412786\% | 4.214640\% | 92 | 11.849410\% | 21 | 0.744801 | 0.992800 |
| 9993 | 7.884684\% | 4.214640\% | 93 | 12.131364\% | 23 | 0.815734 | 0.995100 |
| 9994 | 0.687140\% | 4.214640\% | 94 | 12.413319\% | 15 | 0.532000 | 0.996600 |
| 9995 | 11.201366\% | 4.214640\% | 95 | 12.695274\% | 13 | 0.461067 | 0.997900 |
| 9996 | 1.243034\% | 4.214640\% | 96 | 12.977228\% | 7 | 0.248267 | 0.998600 |
| 9997 | -5.886900\% | 4.214640\% | 97 | 13.259183\% | 6 | 0.212800 | 0.999200 |
| 9998 | 5.188035\% | 4.214640\% | 98 | 13.541137\% | 5 | 0.177333 | 0.999700 |
| 9999 | 6.288099\% | 4.214640\% | 99 | 13.823092\% | 2 | 0.070933 | 0.999900 |
| 10000 | -4.489554\% | 4.214640\% | 100 | 14.105047\% | 0 |  |  |


| STATISTICAL SUMMARY |
| :--- |
| Minimum Maximum Medlan Mean Std. Devlation Probability UCL LCL <br> $.13 .81 \%$ $14.11 \%$ $0.31 \%$ $0.36 \%$ $5.51 \%$ $43.30 \%$ $0.14 \%$ $0.57 \%$ |

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Table 4.20 Simulation Result : Weighting Structure 6

| MERATION | RETURN | RISK | \# |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| - 1 | 1.094165\% | 0.066869\% | 1 | BINS | COUNTS | SCALE | TOTAL |
| 2 | 1.011777\% | 0.066869\% | 2 | 0.685456\% | 1 | 1.205471 | TOTAL |
| 3 | 0.918967\% | 0.066869\% | 3 | 0.693752\% | 0 | 0.000000 | 0.000100 |
| 4 | 1.172221\% | 0.066869\% | 4 | 0.702047\% | 0 | 0.000000 | 0.000100 |
| 5 | 1.200803\% | 0.066869\% | 5 | 0.710343\% | 1 | 1.205471 | 0.000200 |
| 6 | 1.222357\% | 0.066869\% | 6 | 0.718638\% | 0 | 0.000000 | 0.000200 |
| 7 | 1.192183\% | 0.066869\% | 7 | 0.726934\% | 4 | 4.821886 | 0.000600 |
| 8 | 1.133523\% | 0.066869\% | 8 | 0.735229\% | 1 | 1.205471 | 0.000700 |
| 9 | 1.124974\% | 0.066869\% | 9 | 0.743525\% | 4 | 4.821886 | 0.001100 |
| 10 | 1.070052\% | 0.066869\% | 10 | 0.751820\% | 2 | 2.410943 | 0.001300 |
| 11 | 1.088891\% | 0.066869\% | 11 | .760116\% | 10 | 12.054714 | 0.002300 |
| 12 | 1.181262\% | 0.066869\% | 12 | 0.76841 | 5 | 6.027357 | 0.002800 |
| 13 | 1.065060\% | 0.066869\% | 13 | 0.78500 | 6 | 7.232828 | 0.003400 |
| 14 | 1.199605\% | 0.066869\% | 14 | 0.7932 | 7 | 8.438300 | 0.004100 |
| 15 | 1.214719\% | 0.066869\% | 15 | 0.801593\% | 10 | 12.054714 | 0.005100 |
| 16 | 1.077692\% | 0.066869\% | 16 | 0.809889 | 11 | 13.260185 | 0.006200 |
| 17 | 1.313979\% | 0.066869\% | 17 | 0.818184\% | 15 | 18.082071 | 0.007700 |
| 18 | 1.255240\% | 0.066869\% | 18 | 0.826480\% | 25 | 24.109428 | 0.009700 |
| 19 | 1.376909\% | 0.066869\% | 19 | 0.834775\% | 21 | 30.136785 | 0.012200 |
| 20 | 1.301080\% | 0.066869\% | 20 | 0.843071\% | 32 | 25.314899 | 0.014300 |
| 21 | 1.159243\% | 0.066869\% | 21 | 0.851366\% | 26 | 38.575085 | 0.017500 |
| 22 | 1.185305\% | 0.066869\% | 22 | 0.859662\% | 36 |  |  |
| 23 | 0.994959\% | 0.066869\% | 23 | 0.867957\% | 46 | 55.451684 | 0.028300 |
| 24 | 1.041162\% | 0.066869\% | 24 | 0.876253\% | 54 | 65.095455 | 0.033700 |
| 25 | 0.983159\% | 0.066869\% | 25 | 0.884548\% | 50 | 60.273570 | 0.038700 |
| ... | ... | ... | ... | .. | ... | ... | ... |
| 9977 | 1.045082\% | 0.066869\% | 77 | 1.315915\% | 97 | 116.930725 | 0.929000 |
| 9978 | 1.265437\% | 0.066869\% | 78 | 1.324210\% | 82 | 98.848654 | 0.937200 |
| 9979 | 1.505167\% | 0.066869\% | 79 | 1.332506\% | 72 | 86.793940 | 0.944400 |
| 9980 | 1.024581\% | 0.066869\% | 80 | 1.340801\% | 77 | 92.821297 | 0.952100 |
| 9981 | 1.091208\% | 0.066869\% | 81 | 1.349097\% | 74 | 89.204883 | 0.959500 |
| 9982 | 0.989025\% | 0.066869\% | 82 | 1.357392\% | 59 | 71.122812 | 0.965400 |
| 9983 | 1.194183\% | 0.066869\% | 83 | 1.365688\% | 52 | 62.684512 | 0.970600 |
| 9984 | 1.200397\% | 0.066869\% | 84 | 1.373983\% | 39 | 47.013384 | 0.974500 |
| 9985 | 1.246913\% | 0.066869\% | 85 | 1.382279\% | 34 | 40.986027 | 0.977900 |
| 9986 | 1.301940\% | 0.066869\% | 86 | 1.390574\% | 31 | 37.369613 | 0.981000 |
| 9987 | 1.017879\% | 0.066869\% | 87 | 1.398870\% | 30 | 36.164142 | 0.984000 |
| 9988 | 0.947541\% | 0.066869\% | 88 | 1.407165\% | 27 | 32.547728 | 0.986700 |
| 9989 | 1.099750\% | 0.066869\% | 89 | 1.415461\% | 24 | 28.931313 | 0.989100 |
| 9990 | 1.137558\% | 0.066869\% | 90 | 1.423756\% | 19 | 22.903956 | 0.991000 |
| 9991 | 1.003490\% | 0.066869\% | 91 | 1.432052\% | 19 | 22.903956 | 0.992900 |
| 9992 | 1.157325\% | 0.066869\% | 92 | 1.440347\% | 15 | 18.082071 | 0.994400 |
| 9993 | 1.265337\% | 0.066869\% | 93 | 1.448643\% | 20 | 24.109428 | 0.996400 |
| 9994 | 0.934052\% | 0.066869\% | 94 | 1.456938\% | 6 | 7.232828 | 0.997000 |
| 9995 | 1.006486\% | 0.066869\% | 95 | 1.465234\% | 6 | 7.232828 | 0.997600 |
| 9996 | 1.021833\% | 0.066869\% | 96 | 1.473529\% | 3 | 3.616414 | 0.997900 |
| 9997 | 0.919298\% | 0.066869\% | 97 | 1.481825\% | 6 | 7.232828 | 0.998500 |
| 9998 | 1.084285\% | 0.066869\% | 98 | 1.490121\% | 7 | 8.438300 | 0.999200 |
| 9999 | 1.173706\% | 0.066869\% | 99 | 1.498416\% | 4 | 4.821886 | 0.999600 |
| 10000 | 0.950706\% | 0.066869\% | 100 | 1.506712\% | 4 | 4.821886 | 1.000000 |


| STATISTICAL SUMMARY |  |  |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| MInimum | Maximum | Median | Mean | Std. Deviation | Probablity | UCI | LCL |
| $0.69 \%$ | $1.51 \%$ | $1.12 \%$ | $1.12 \%$ | $0.13 \%$ | $0.10 \%$ | $1.11 \%$ | $1.12 \%$ |

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Table 4.21 Simulation Result : Weighting Structure 7


| STATISTICAL SUMMARY |
| :--- |
| MInImum Maximum Median Mean Std. Deviation Probabillty UCL LCI <br> $0.77 \%$ $1.41 \%$ $1.08 \%$ $1.08 \%$ $0.10 \%$ n/a $1.08 \%$ $1.09 \%$ |

Table 4.22 Simulation Result : Weighting Structure 8

| HERATION | RETURN | RISK | \# |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| - 1 | 0.731747\% | $0.130352 \%$ | 1 | BINS | COUNTS | SCALE |  |
| 2 | 0.809188\% | 0.130352\% | 2 | 0.508973\% | N | SCALE 1.459371 | TOTAL |
| 3 | 0.816695\% | 0.130352\% | 3 | 0.515825\% | 1 | 1.459371 | 0.000100 |
| 4 | 0.887935\% | 0.130352\% | 4 | 0.522677\% | 10 | 14.593710 | 0.000200 |
| 5 | 0.879119\% | 0.130352\% | 5 | 0.529530\% | 7 | 10.215597 | 0.001900 |
| 6 | 0.893717\% | 0.130352\% | 6 | 0.536382\% | 15 | 21.890565 | 0.003400 |
| 7 | 1.013103\% | 0.130352\% | 7 | 0.543234\% | 18 | 26.268678 | 0.005200 |
| 8 | 1.037850\% | $0.130352 \%$ | 8 | 0.550087\% | 22 | 32.106162 | 0.007400 |
| 9 | 0.857165\% | 0.130352\% | 9 | \% | 26 | 37.943646 | 0.010000 |
| 10 | $0.733664 \%$ | 0.130352\% | 10 | 573791\% | 38 | 55.456099 | 0.013800 |
| 11 | 1.023838\% | 0.130352\% | 11 | $0.570643 \%$ | 29 | 42.321759 | 0.016700 |
| 12 | 0.948130\% | 0.130352\% | 12 | 0.584348\% | 48 | 70.049809 | 0.021500 |
| 13 | 0.848939\% | 0.130352\% | 13 |  | 36 | 52.537357 | 0.025100 |
| 14 | 0.984165\% | 0.130352\% | 14 | 0.591200\% | 52 | 75.887293 | 0.030300 |
| 15 | 0.862427\% | 0.130352\% | 15 | 0.598052\% | 51 | 74.427922 | 0.035400 |
| 16 | 0.865799\% | 0.130352\% | 16 | 0.604905\% | 56 | 81.724777 | 0.041000 |
| 17 | 0.800956\% | 0.130352\% | 17 | 0.611757\% | 79 | 115.290310 | 0.048900 |
| 18 | 0.833294\% | 0.130352\% | 18 | 0.625461\% | 70 | 102.155971 | 0.055900 |
| 19 | 0.914431\% | 0.130352\% | 19 | 0.632314\% | 78 | 113.830939 | 0.063700 |
| 20 | 0.952088\% | 0.130352\% | 20 | 0.639166\% | 69 | 100.696600 | 0.070600 |
| 21 | 0.920289\% | 0.130352\% | 21 | 0.646018\% |  | 96.318487 | 0.077200 |
| 22 | 0.854568\% | 0.130352\% | 22 | 0.652871\% | 81 | 9 |  |
| 23 | 0.750089\% | 0.130352\% | 23 | 0.659723\% | 97 |  |  |
| 24 | 0.771831\% | 0.130352\% | 24 | 0.666575\% | 103 | 150.315215 | 0.114100 |
| 25 | 0.853738\% | 0.130352\% | 25 | 0.673427\% | 92 | 134.262133 | 0.123300 |
| $\cdots$ | ... | ... | $\ldots$ | ... | ... | ... | ... |
| 9977 | 0.794979\% | 0.130352\% | 77 | 1.029745\% | 115 | 167.827667 | 0.894300 |
| 9978 | 0.737449\% | 0.130352\% | 78 | 1.036598\% | 86 | 125.505907 | 0.902900 |
| 9979 | 1.080354\% | 0.130352\% | 79 | 1.043450\% | 82 | 119.668423 | 0.911100 |
| 9980 | 0.848384\% | 0.130352\% | 80 | 1.050302\% | 89 | 129.884020 | 0.920000 |
| 9981 | 0.798531\% | 0.130352\% | 81 | 1.057154\% | 89 | 129.884020 | 0.928900 |
| 9982 | 0.787252\% | 0.130352\% | 82 | 1.064007\% | 73 | 106.534084 | 0.936200 |
| 9983 | 0.786227\% | 0.130352\% | 83 | 1.070859\% | 69 | 100.696600 | 0.943100 |
| 9984 | 1.040745\% | 0.130352\% | 84 | 1.077711\% | 72 | 105.074713 | 0.950300 |
| 9985 | 0.829909\% | 0.130352\% | 85 | 1.084563\% | 63 | 91.940374 | 0.956600 |
| 9986 | 0.761923\% | 0.130352\% | 86 | 1.091416\% | 61 | 89.021632 | 0.962700 |
| 9987 | 0.926602\% | 0.130352\% | 87 | 1.098268\% | 52 | 75.887293 | 0.967900 |
| 9988 | 0.920145\% | 0.130352\% | 88 | 1.105120\% | 51 | 74.427922 | 0.973000 |
| 9989 | 0.790088\% | 0.130352\% | 89 | 1.111972\% | 49 | 71.509180 | 0.977900 |
| 9990 | 0.895944\% | 0.130352\% | 90 | 1.118825\% | 44 | 64.212325 | 0.982300 |
| 9991 | 0.606818\% | 0.130352\% | 91 | 1.125677\% | 33 | 48.159244 | 0.985600 |
| 9992 | $0.753678 \%$ | 0.130352\% | 92 | 1.132529\% | 26 | 37.943646 | 0.988200 |
| 9993 | 1.001292\% | $0.130352 \%$ | 93 | 1.139382\% | 35 | 51.077986 | 0.991700 |
| 9994 | 0.537441\% | 0.130352\% | 94 | 1.146234\% | 26 | 37.943646 | 0.994300 |
| 9995 | 0.956082\% | 0.130352\% | 95 | 1.153086\% | 24 | 35.024904 | 0.996700 |
| 9996 | 0.806137\% | 0.130352\% | 96 | 1.159938\% | 11 | 16.053081 | 0.997800 |
| 9997 | 0.825224\% | 0.130352\% | 97 | 1.166791\% | 11 | 16.053081 | 0.998900 |
| 9998 | 0.660025\% | 0.130352\% | 98 | 1.173643\% | 7 | 10.215597 | 0.999600 |
|  |  | 0.130352\% | 99 | 1.180495\% | 3 | 4.378113 | 0.999900 |
| $\underline{9999}$ | 0.717034\% | 0.130352\% | 100 | 1.187347\% | 0 | 0.000000 | 0.999900 |
| 10000 | 0.781243\% | 0.130352\% |  |  |  |  |  |


| STATISTICAL SUMMARY | Median | Mean | Std. Deviation | Probability | UCL | LCL |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Minimum | Maximum | Media | $0.84 \%$ | $0.85 \%$ |  |  |
| $0.51 \%$ | $1.19 \%$ | $0.85 \%$ | $0.85 \%$ | $0.14 \%$ | n/a | 0.84 |

Table 4.23 Simulation Result : Weighting Structure 9

| TERATION | RETURN | RISK | \# |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| H1 | 0.924079\% | $0.067734 \%$ | 4 | BINS | COUNTS |  |  |
| 2 | $0.947241 \%$ | 0.067734\% | 1 | 0.709335\% | $\frac{\text { CoUnis }}{1}$ | SCALE | TOTAL |
| 3 | $0.933503 \%$ | 0.067734\% | 3 | $0.715596 \%$ | 0 | 1.597204 | 0.000100 |
| 4 | 1.061084\% | $0.067734 \%$ | 3 | $0.721856 \%$ | 0 | 0.000000 | 0.000100 |
| 5 | 1.065447\% | $0.067734 \%$ | 4 | $0.728117 \%$ | 4 | 0.000000 | 0.000100 |
| 6 | 1.044383\% | $0.067734 \%$ | 6 | $0.734378 \%$ | 3 | 6.388814 | 0.000500 |
| 7 | 1.057560\% | 0.067734\% | 6 | 0.740639\% | 3 | 4.791611 | 0.000800 |
| 8 | 1.130750\% | $0.067734 \%$ | 8 | $0.746900 \%$ | 6 | 4.791611 | 0.001100 |
| 9 | 1.020037\% | $0.067734 \%$ | 9 | $0.753161 \%$ | 1 | 9.583221 | 0.001700 |
| 10 | 0.894924\% | $0.067734 \%$ | 10 | $0.759422 \%$ | 6 | 204 | 0.001800 |
| 11 | 1.140385\% | $0.067734 \%$ | 11 | 0.765683\% | 12 | 19.166442 | 0.002400 |
| 12 | 1.147945\% | $0.067734 \%$ | 12 | $0.771944 \%$ | 8 | 12.777628 | 0.004400 |
| 13 | 1.049781\% | 0.067734\% | 13 | \% | 22 | 35.138477 | 0.006600 |
| 14 | 1.063988\% | $0.067734 \%$ | 14 |  | 17 | 27.152460 | 0.008300 |
| 15 | 1.031427\% | $0.067734 \%$ | 15 | 0.790727\% | 18 | 28.749663 | 0.010100 |
| 16 | 1.040935\% | $0.067734 \%$ | 16 | $0.796988 \%$ | 25 | 39.930088 | 0.012600 |
| 17 | 1.073344\% | $0.067734 \%$ | 17 | \% | 31 | 49.513309 | 0.015700 |
| 18 | 1.106406\% | $0.067734 \%$ | 18 | 0\% | 32 | 51.110512 | 0.018900 |
| 19 | 1.118970\% | $0.067734 \%$ | 19 | 1\% | 42 | 67.082547 | 0.023100 |
| 20 | 1.165796\% | $0.067734 \%$ | 20 | 2\% | 37 | 59.096530 | 0.026800 |
| 21 | 1.091839\% | $0.067734 \%$ | 21 |  | 59 | 94.235007 | 0.032700 |
| 22 | 1.008268\% | $0.067734 \%$ | 22 | 840 | 55 | 87.846193 | 0.038200 |
| 23 | 0.968244\% | $0.067734 \%$ | 23 | 0.8408 | 60 | 95.832211 | 0.044200 |
| 24 | 0.938440\% | $0.067734 \%$ | 24 | 0.8533 | 58 | 92.637803 | 0.050000 |
| 25 | 0.952364\% | $0.067734 \%$ | 25 | 0.6734 |  |  |  |
| 9977 | $0.956661 \%$ |  |  |  | $\ldots$ | $\ldots$ | ... |
| 9977 | $0.956661 \%$ | $0.067734 \%$ | 77 | 1.185166\% | 62 | 99.026618 | 0.943200 |
| 9978 | 1.043655\% | $0.067734 \%$ | 78 | 1.191427\% | 63 | 100.623821 | 0.949500 |
| 9979 | 1.276491\% | $0.067734 \%$ | 79 | 1.197688\% | 67 | 107.012635 | 0.956200 |
| 9980 | 0.936628\% | 0.067734\% | 80 | 1.203949\% | 54 | 86.248989 | 0.961600 |
| 9981 | 0.952377\% | $0.067734 \%$ | 81 | 1.210210\% | 45 | 71.874158 | 0.966100 |
| 9982 | 0.888165\% | $0.067734 \%$ | 82 | 1.216471\% | 60 | 95.832211 | 0.972100 |
| 9983 | 0.977032\% | $0.067734 \%$ | 83 | 1.222732\% | 40 | 63.888140 | 0.976100 |
| 9984 | 1.171622\% | 0.067734\% | 84 | 1.228993\% | 36 | 57.499326 | 0.979700 |
| 9985 | 1.083266\% | 0.067734\% | 85 | 1.235254\% | 33 | 52.707716 | 0.983000 |
| 9986 | 0.987827\% | 0.067734\% | 86 | 1.241515\% | 30 | 47.916105 | 0.986000 |
| 9987 | 1.046905\% | 0.067734\% | 87 | 1.247776\% | 34 | 54.304919 | 0.989400 |
| 9988 | 0.984187\% | 0.067734\% | 88 | 1.254037\% | 15 | 23.958053 | 0.990900 |
| 9989 | 0.990270\% | 0.067734\% | 89 | 1.260298\% | 23 | 36.735681 | 0.993200 |
| 9990 | 1.034957\% | 0.067734\% | 90 | 1.266558\% | 14 | 22.360849 | 0.994600 |
| 9991 | $0.923172 \%$ | 0.067734\% | 91 | 1.272819\% | 14 | 22.360849 | 0.996000 |
| 9992 | 0.960206\% | 0.067734\% | 92 | 1.279080\% | 15 | 23.958053 | 0.997500 |
| 9993 | 1.130109\% | $0.067734 \%$ | 93 | 1.285341\% | 4 | 6.388814 | 0.997900 |
| 9994 | 0.783055\% | $0.067734 \%$ | 94 | 1.291602\% | 5 | 7.986018 | 0.998400 |
| 9995 | 1.020463\% | 0.067734\% | 95 | 1.297863\% | 4 | 6.388814 | 0.998800 |
| 9996 | 0.918795\% | $0.067734 \%$ | 96 | 1.304124\% | 4 | 6.388814 | 0.999200 |
| 9997 |  | $0.067734 \%$ | 97 | 1.310385\% | 3 | 4.791611 | 0.999500 |
|  | $0.932367 \%$ |  | 98 | 1.316646\% | 2 | 3.194407 | 0.999700 |
| 9998 | $0.972181 \%$ | $0.067734 \%$ | 98 | 1.322907\% | 1 | 1.597204 | 0.999800 |
| 9999 | 0.996334\% | 0.067734\% | 99 |  | 1 | 1.597204 | 0.999900 |
| 10000 | 0.962168\% | 0.067734\% | 100 | 1.329168\% | 1 |  |  |


| STATISTICAL SUMMARY |
| :--- |
| Minimum Maximum Median Mean Std. Deviation Probability UCL LCL <br> $0.71 \%$ $1.33 \%$ $1.02 \%$ $1.02 \%$ $0.10 \%$ Va $1.01 \%$ $1.02 \%$ |

Table 4.24 Simulation Result : Weighting Structure 10

| TIERATION | RETURN | RISK |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | -3.248153\% | 2.797923\% | 1 | BINS | COUNTS |  |  |
| 2 | 7.554719\% | 2.797923\% | 2 | -8.933950\% | 1 | SCALE | TOTAL |
| 3 | -5.824833\% | 2.797923\% | 3 | -8.744854\% | 0 | 0.052883 | 0.000100 |
| 4 | -4.364284\% | 2.797923\% | 4 | -8.555757\% | 1 | 0.000000 | 0.000100 |
| 5 | 4.583262\% | 2.797923\% | 5 | -8.366660\% | 5 | 0.052883 | 0.000200 |
| 6 | -2.467476\% | 2.797923\% | 6 | -8.177564\% | 5 | 0.264415 | 0.000700 |
| 7 | 7.429474\% | 2.797923\% | 7 | -7.988467\% | 4 | 0.264415 | 0.001200 |
| 8 | 2.876235\% | 2.797923\% | 8 | -7.799371\% | 6 | 0.211532 | 0.001600 |
| 9 | 3.293629\% | 2.797923\% | 9 | -7.610274\% | 13 | 0.687479 | 0.002200 |
| 10 | 4.715198\% | 2.797923\% | 10 | -7.421177\% | 16 | 0.846128 | 0.003500 |
| 11 | -1.315212\% | 2.797923\% | 11 | -7.232081\% | 19 | 1.004777 | 0.005100 |
| 12 | -1.055752\% | 2.797923\% | 12 | -6.853888\% | 28 | 1.480725 | 0.009800 |
| 13 | 4.493647\% | 2.797923\% | 13 | -6.664791\% | 24 | 1.269192 | 0.012200 |
| 14 | -1.994693\% | 2.797923\% | 14 | -6.475694\% | 20 | 1.057660 | 0.014200 |
| 15 | 1.779472\% | 2.797923\% | 15 | -6.286598\% | 23 | 1.216309 | 0.016500 |
| 16 | -4.493035\% | 2.797923\% | 16 | -6.097501\% | 33 | 1.745140 | 0.019800 |
| 17 | -0.823193\% | 2.797923\% | 17 | -5.908405\% | 49 | 2.591268 | 0.024700 |
| 18 | -2.364541\% | 2.797923\% | 18 | -5.719308\% | 53 | 2.802800 | 0.030000 |
| 19 | 1.176599\% | 2.797923\% | 19 | -5.530211\% | 58 | 3.067215 | 0.035800 |
| 20 | 3.769886\% | 2.797923\% | 20 | -5.341115\% | 61 | 3.225864 | 0.041900 |
| 21 | $7.551881 \%$ | 2.797923\% | 21 | -5.152018\% | 68 | 3.596045 | 0.048700 |
| 22 | 0.466743\% | 2.797923\% | 22 | -4.962921\% | 76 | 4.019109 | 0.056300 |
| 23 | 3.335146\% | 2.797923\% | 23 | -4.773825\% | 94 | 4.971004 | 0.065700 |
| 24 | 1.903563\% | 2.797923\% | 24 | -4.584728\% |  | 4.706589 | 0.074600 |
| 25 | -2.068056\% | 2.797923\% | 25 | -4.395632\% | 106 | 5.341185 | 0.084700 |
|  |  |  |  |  |  | 5.605600 | 0.095300 |
|  |  |  |  |  |  | 6.240196 | 0.910800 |
|  |  |  |  |  |  | 4.653706 | 0.929100 |
|  |  | $2.797923 \%$ | 81 | 6.193779\% |  |  |  |
| 9983 | 6.919520\% | 2.797923\% | 83 | 6.571972\% | 71 | 3.754694 | 0.953300 |
| 9984 | -2.217074\% | 2.797923\% | 84 | 6.761069\% | 65 | 3.437396 | 0.959800 |
| 9985 | -5.289891\% | 2.797923\% | 85 | 6.950165\% | 71 | 3.754694 | 0.966900 |
| 9986 | 4.748573\% | 2.797923\% | 86 | 7.139262\% | 47 | 2.485502 | 0.971600 |
| 9987 | -0.685215\% | 2.797923\% | 87 | 7.328359\% | 58 | 3.067215 | 0.977400 |
| 9988 | 1.303948\% | 2.797923\% | 88 | 7.517455\% | 35 | 1.850906 | 0.980900 |
| 9989 | -4.147243\% | 2.797923\% | 89 | 7.706552\% | 44 | 2.326853 | 0.985300 |
| 9990 | 5.708168\% | 2.797923\% | 90 | 7.895648\% | 30 | 1.586491 | 0.988300 |
| 9991 | -2.104260\% | 2.797923\% | 91 | 8.084745\% | 33 | 1.745140 | 0.991600 |
| 9992 | 0.854789\% | 2.797923\% | 92 | 8.273842\% | 18 | 0.951894 | 0.993400 |
| 9993 | 5.593279\% | 2.797923\% | 93 | 8.462938\% | 24 | 1.269192 | 0.995800 |
| 9994 | 0.671830\% | 2.797923\% | 94 | 8.652035\% | 13 | 0.687479 | 0.997100 |
| 9995 | 7.740040\% | 2.797923\% | 95 | 8.841131\% | 10 | 0.528830 | 0.998100 |
| 9996 | 1.120618\% | 2.797923\% | 96 | 9.030228\% | 6 | 0.317298 | 0.998700 |
| 9997 | -3.682023\% | 2.797923\% | 97 | 9.219325\% | 6 | 0.317298 | 0.999300 |
| 9998 | 3.645773\% | 2.797923\% | 98 | 9.408421\% | 5 | 0.264415 | 0.999800 |
| 9999 | 4.443622\% | 2.797923\% | 99 | 9.597518\% | 1 | 0.052883 | 0.999900 |
| 10000 | -2.796857\% | 2.797923\% | 100 | 9.786615\% | 0 |  |  |


| STATISTICAL SUMMARY |
| :--- |
| MInImum Maximum Median Mean Std. Devlation Probability UCL <br> $-8.93 \%$ $9.79 \%$ $0.51 \%$ $0.54 \%$ $3.67 \%$ $41.60 \%$ $0.39 \%$ |

Table 4.25 Simulation Result : Weighting Structure 11

| MTERATION | RETURN | RISK | \# |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | 0.999364\% | 0.059338\% | 1 | BINS | COUNTS | SCAIE |  |
| 2 | 0.988522\% | 0.059338\% | 2 | 0.771814\% | 1 | SCALE | TOTAL |
| 3 | $0.970361 \%$ | 0.059338\% | 3 | 0.778356\% | 2 | 1.528504 | 0.000100 |
| 4 | 1.139063\% | 0.059338\% | 4 | 0.784898\% | 3 | 3.057008 | 0.000300 |
| 5 | 1.143371\% | 0.059338\% | 5 | $0.791441 \%$ | 1 | 4.585512 | 0.000600 |
| 6 | 1.117235\% | 0.059338\% | 6 | 0.797983\% | 2 | 1.528504 | 0.000700 |
| 7 | 1.070430\% | 0.059338\% | 7 | 0.804525\% | 6 | 9.0571024 | 0.000900 |
| 8 | 1.157932\% | 0.059338\% | 8 | 0.811068\% | 3 | 4.585512 | 0.001500 |
| 9 | 1.074101\% | 0.059338\% | 9 | 0.817610\% | 3 | 4.585512 | 0.002100 |
| 10 | 0.953883\% | 0.059338\% | 10 | \% | 10 | 15.285040 | 0.003100 |
| 11 | 1.178089\% | 0.059338\% | 11 | 37237\% | 12 | 18.342048 | 0.004300 |
| 12 | 1.243327\% | 0.059338\% | 12 | \% | 7 | 10.699528 | 0.005000 |
| 13 | 1.125071\% | 0.059338\% | 13 | 0.843780\% | 18 | 27.513071 | 0.006800 |
| 14 | 1.104428\% | 0.059338\% | 14 | $0.856864 \%$ | 20 | 30.570079 | 0.008800 |
| 15 | 1.104198\% | 0.059338\% | 15 | 0.863407\% | 21 | 32.098583 | 0.010900 |
| 16 | 1.099994\% | 0.059338\% | 16 | 0.869949\% | 31 | 47.383623 | 0.014000 |
| 17 | 1.179755\% | 0.059338\% | 17 | 0.876491\% | 25 | 38.212599 | 0.016500 |
| 18 | 1.216599\% | 0.059338\% | 18 | 0.883034\% | 32 | 48.912127 | 0.019700 |
| 19 | 1.209248\% | 0.059338\% | 19 | 0.889576\% | 46 | 61.140158 | 0.023700 |
| 20 | 1.253229\% | 0.059338\% | 20 | 0.896118\% |  | 70.311182 | 0.028300 |
| 21 | 1.158793\% | 0.059338\% | 21 | 0.902661\% | 44 | 74.896694 | 0.033200 |
| 22 | 1.082118\% | 0.059338\% | 22 | 0.909203\% | 73 | 67.254174 | 0.037600 |
| 23 | 1.042720\% | 0.059338\% | 23 | 0.915745\% | 86 | 131.451340 | 0.044900 |
| 24 | 0.991883\% | 0.059338\% | 24 | 0.922288\% | 77 | 117.694805 | 0.061200 |
| 25 | 0.987521\% | 0.059338\% | 25 | 0.928830\% | 94 | 143.679372 | 0.070600 |
| $\cdots$ | $\cdots$ | $\ldots$ | $\ldots$ | ... | ... | ... | ... |
| 9977 | 1.008428\% | 0.059338\% | 77 | 1.269032\% | 71 | 108.523781 | 0.957300 |
| 9978 | 1.162487\% | 0.059338\% | 78 | 1.275574\% | 61 | 93.238742 | 0.963400 |
| 9979 | 1.363174\% | 0.059338\% | 79 | 1.282117\% | 55 | 84.067718 | 0.968900 |
| 9980 | 0.967991\% | 0.059338\% | 80 | 1.288659\% | 47 | 71.839686 | 0.973600 |
| 9981 | 1.025521\% | 0.059338\% | 81 | 1.295201\% | 43 | 65.725670 | 0.977900 |
| 9982 | 0.921328\% | 0.059338\% | 82 | 1.301744\% | 31 | 47.383623 | 0.981000 |
| 9983 | 1.042776\% | 0.059338\% | 83 | 1.308286\% | 36 | 55.026143 | 0.984600 |
| 9984 | 1.236299\% | 0.059338\% | 84 | 1.314828\% | 25 | 38.212599 | 0.987100 |
| 9985 | 1.183484\% | 0.059338\% | 85 | 1.321371\% | 23 | 35.155591 | 0.989400 |
| 9986 | 1.069272\% | 0.059338\% | 86 | 1.327913\% | 27 | 41.269607 | 0.992100 |
| 9987 | 1.108612\% | 0.059338\% | 87 | 1.334455\% | 13 | 19.870551 | 0.993400 |
| 9988 | 0.999228\% | 0.059338\% | 88 | 1.340998\% | 16 | 24.456063 | 0.995000 |
| 9989 | 1.072453\% | 0.059338\% | 89 | 1.347540\% | 17 | 25.984567 | 0.996700 |
| 9990 | 1.074231\% | 0.059338\% | 90 | 1.354082\% | 7 | 10.699528 | 0.997400 |
| 9991 | 1.041853\% | 0.059338\% | 91 | 1.360625\% | 4 | 5.114016 | 0.997800 |
| 9992 | 1.038994\% | 0.059338\% | 92 | 1.367167\% | 5 | 7.642520 | 0.998300 |
| 9993 | 1.189218\% | 0.059338\% | 93 | 1.373709\% | 3 | 4.585512 | 0.998600 |
| 9994 | 0.874102\% | 0.059338\% | 94 | 1.380252\% | 4 | 6.114016 | 0.999000 |
| 9995 | 1.044343\% | 0.059338\% | 95 | 1.386794\% | 4 | 6.114016 | 0.999400 |
| 9996 | 0.970344\% | 0.059338\% | 96 | 1.393336\% | 3 | 4.585512 | 0.999700 |
| 9997 | $0.990381 \%$ | 0.059338\% | 97 | 1.399879\% | 1 | 2.528504 | 0.999800 |
| 9998 | 1.096530\% | 0.059338\% | 98 | 1.406421\% | 1 | 1.528504 | 0.999900 |
| 9999 | 1.109016\% | 0.059338\% | 99 | 1.412964\% | 1 | 1.528504 | 1.000000 |
| 10000 | 1.046482\% | 0.059338\% | 100 | 1.419506\% |  |  |  |


| STATISTICAL SUMMARY |
| :--- |
| Minimum Maximum Median Mean Std. Deviation Probability UCL LCL <br> $0.77 \%$ $1.42 \%$ $1.09 \%$ $1.09 \%$ $0.11 \%$ N/a $1.08 \%$ $1.09 \%$ |

Table 4.26 Simulation Result : Weighting Structure 12

| TERATION | RETURN | RISK | \# |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| -1 | 0.924712\% | 0.067595\% | $\underline{1}$ | BINS | COUNTS |  |  |
| - 2 | $0.947089 \%$ | $0.067595 \%$ | $\frac{1}{2}$ | $0.709226 \%$ | 1 | SCALE | TOTAL |
| 3 | 0.933656\% | 0.067595\% | 2 | 0.715500\% | 0 | 1.593879 | 0.000100 |
| 4 | 1.062253\% | 0.067595\% | 3 | $0.721774 \%$ | 0 | 0.000000 | 0.000100 |
| 5 | 1.066361\% | 0.067595\% | 4 | $0.728048 \%$ | 4 | 0.000000 | 0.000100 |
| 6 | 1.045269\% | 0.067595\% | 5 | $0.734322 \%$ | 3 | 6.375515 | 0.000500 |
| 7 | 1.057544\% | 0.067595\% | 7 | 0.740596\% | 3 | 4.781636 | 0.000800 |
| 8 | 1.130854\% | 0.067595\% | 8 | $0.746870 \%$ | 6 | 4.781636 | 0.001100 |
| 9 | 1.020304\% | 0.067595\% | 9 | $0.753144 \%$ | 2 | 9.563272 | 0.001700 |
| 10 | 0.895269\% | 0.067595\% | 10 | 0.759418\% | 5 | $\frac{3.187757}{7.969394}$ | $\frac{0.001900}{0.002400}$ |
| 11 | 1.140380\% | 0.067595\% | 11 | 0.765692\% | 13 | 20.720423 | 0.003700 |
| 12 | 1.149194\% | 0.067595\% | 12 | 0.771966\% | 7 | 11.157151 | 0.004400 |
| 13 | 1.050040\% | 0.067595\% | 13 | 8240\% | 20 | 31.877574 | 0.006400 |
| 14 | 1.064523\% | 0.067595\% | 14 | 0.784514\% | 18 | 28.689817 | 0.008200 |
| 15 | 1.032219\% | 0.067595\% | 15 |  | 18 | 28.689817 | 0.010000 |
| 16 | 1.041011\% | 0.067595\% | 16 |  | 25 | 39.846968 | 0.012500 |
| 17 | 1.074377\% | 0.067595\% | 17 | 03336\% | 28 | 44.628604 | 0.015300 |
| 18 | 1.107446\% | 0.067595\% | 18 | 159610\% | 34 | 54.191876 | 0.018700 |
| 19 | 1.120207\% | 0.067595\% | 19 | 82215884\% | 41 | 65.349027 | 0.022800 |
| 20 | 1.166698\% | 0.067595\% | 20 | $22158{ }^{\circ}$ | 39 | 62.161269 | 0.026700 |
| 21 | 1.092169\% | $0.067595 \%$ | 21 |  | 57 | 90.851086 | 0.032400 |
| 22 | 1.009340\% | $0.067595 \%$ | 22 |  | 56 | 89.257 | 0.038000 |
| 23 | 0.968290\% | 0.067595\% | 23 |  | 62 |  | 44 |
| 24 | 0.938503\% | 0.067595\% | 24 |  |  | 94.038 | 0.050100 |
| 25 | 0.952370\% | $0.067595^{\circ}$ |  | 59802 |  | 106.789 | 0.056800 |
|  |  |  |  |  |  |  | 0.063600 |
|  |  |  |  | ... | ... | ... | ... |
| 9977 | 0.956583\% | 0.067595\% | 77 | 1.186050\% | 58 | 92,444965 | 0.943200 |
| 9978 | 1.044616\% | 0.067595\% | 78 | 1.192324\% | 63 | 100.414358 | 0.949500 |
| 9979 | 1.277628\% | 0.067595\% | 79 | 1.198598\% | 70 | 111.571509 | 0.956500 |
| 9980 | $0.936621 \%$ | $0.067595 \%$ | 80 | 1.204872\% | 52 | 82.881693 | 0.961700 |
| 9981 | 0.953121\% | $0.067595 \%$ | 81 | 1.211146\% | 47 | 74.912299 | 0.966400 |
| 9982 | 0.887925\% | 0.067595\% | 82 | 1.217420\% | 56 | 89.257207 | 0.972000 |
| 9983 | $0.977407 \%$ | 0.067595\% | 83 | $1.223694 \%$ | 42 | 66.942906 | 0.976200 |
| 9984 | 1.172724\% | 0.067595\% | 84 | 1.229968\% | 37 | 58.973512 | 0.979900 |
| 9985 | 1.084304\% | 0.067595\% | 85 | 1.236242\% | 32 | 51.004119 | 0.983100 |
| 9986 | 0.988468\% | 0.067595\% | 86 | 1.242516\% | 34 | 54.191876 | 0.986500 |
| 9987 | 1.047684\% | 0.067595\% | 87 | 1.248790\% | 29 | 46.222482 | 0.989400 |
| 9988 | 0.983895\% | 0.067595\% | 88 | 1.255064\% | 16 | 25.502059 | 0.991000 |
| 9989 | 0.990708\% | 0.067595\% | 89 | 1.261338\% | 22 | 35.065332 | 0.993200 |
| 9990 | 1.034877\% | 0.067595\% | 90 | 1,267612\% | 15 | 23.908181 | 0.994700 |
| 9991 | $0.923761 \%$ | 0.067595\% | 91 | 1.273886\% | 13 | 20.720423 | 0.996000 |
| 9992 | 0.960824\% | 0.067595\% | 92 | 1.280160\% | 15 | 23.908181 | 0.997500 |
| 9993 | 1.131023\% | 0.067595\% | 93 | 1.286434\% | 5 | 7.969394 | 0.998000 |
| 9994 | 0.783233\% | 0.067595\% | 94 | 1.292708\% | 4 | 6.375515 | 0.998400 |
| 9995 | 1.020563\% | $0.067595 \%$ | 95 | 1.298982\% | 4 | 6.375515 | 0.998800 |
| 9996 | 0.919209\% | 0.067595\% | 96 | 1.305256\% | 4 | 6.375515 | 0.999200 |
| 9996 |  |  |  | 1.311530\% | 2 | 3.187757 | 0.999400 |
| 9997 | 0.933115\% | 0.067595\% | 97 | 1.317804\% | 3 | 4.781636 | 0.999700 |
| 9998 | 0.973120\% | 0.067595\% | 98 | 1.324078\% | 1 | 1.593879 | 0.999800 |
| 9999 | $0.997299 \%$ | 0.067595\% | 99 |  | 2 | 3.187757 | 1.000000 |
| 10000 | 0.962909\% | 0.067595\% | 100 | 1.330352\% |  |  |  |


| STATISTICAL SUMMARY |  |  | $\frac{\text { Mean }}{1.02 \%}$ | 5td Devlation | $\frac{\text { Probabillty }}{N / a}$ | $\frac{\mathrm{UCL}}{1.01 \%}$ | $\frac{\mathrm{LCl}}{1.02 \%}$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Minimum | Maxlmum | Medlan |  | Sta. $0.10 \%$ |  |  |  |
| 0.71\% | 1.33\% | 1.02\% |  |  |  |  |  |

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Table 4.27 Simulation Result : Weighting Structure 13

| TERATION | RETURN | RISK |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| 1 | -2.128546\% | 2.080900\% | H | BINS | COUNTS |  |  |
| 2 | 5.849011\% | 2.080900\% | 1 | -6.425938\% | 1 | SCALE | TOTAL |
| 3 | -4.139049\% | 2.080900\% | 3 | -6.284470\% | 0 | 0.070688 | 0.000100 |
| 4 | -2.998072\% | 2.080900\% | $\frac{3}{4}$ | -6.143003\% | 3 | 0.000000 | 0.000100 |
| 5 | 3.659665\% | 2.080900\% | $\frac{4}{5}$ | -6.001535\% | 4 | 0.212063 | 0.000400 |
| 6 | -1.547161\% | 2.080900\% | $\frac{5}{6}$ | -5.860067\% | 4 | 0.282750 | 0.000800 |
| 7 | 5.858517\% | 2.080900\% | 7 | -5.718600\% | 7 | 0.282750 | 0.001200 |
| 8 | 2.385100\% | 2.080900\% | 8 | -5.577132\% | 12 | 0.494813 | 0.001900 |
| 9 | 2.713823\% | 2.080900\% | 9 | -5.435665\% | 8 | 0.848251 | 0.003100 |
| 10 | 3.815353\% | 2.080900\% | 10 | -5.294197\% | 14 | 0.5689626 | 0.003900 |
| 11 | -0.787269\% | 2.080900\% | 11 | -5.152730\% | 25 | 1.767190 | 0.005300 |
| 12 | -0.614157\% | 2.080900\% | 12 | -5.011262\% | 25 | 1.767190 | 0.010300 |
| 13 | 3.500832\% | 2.080900\% | 13 | -4.869795\% | 22 | 1.555127 | 0.012500 |
| 14 | -1.169314\% | 2.080900\% | 14 | -4.728327\% | 19 | 1.343064 | 0.014400 |
| 15 | 1.625986\% | 2.080900\% | 15 | 886860\% | 25 | 1.767190 | 0.016900 |
| 16 | -3.122440\% | 2.080900\% | 16 | -4.4.303925\% | 41 | 2.898191 | 0.021000 |
| 17 | -0.286812\% | 2.080900\% | 17 | -4.162457\% | 46 | 3.251629 | 0.025600 |
| 18 | -1.516999\% | 2.080900\% | 18 | -4.020989\% | 57 | 4.029193 | 0.031300 |
| 19 | 1.255709\% | 2.080900\% | 19 | -3.879522\% | 61 | 4.311943 | 0.037400 |
| 20 | 3.085837\% | 2.080900\% | 20 | -3.738054\% | 58 | 4.099880 | 0.043200 |
| 21 | 5.818229\% | 2.080900\% | 21 | -3.596587\% | 73 | 5.160194 | 0.050500 |
| 22 | 0.667692\% | 2.080900\% | 22 | -3.455119\% | 78 | 5.513632 | 0.058300 |
| 23 | 2.649456\% | 2.080900\% | 23 | -3.313652\% | 82 | 5.796383 | 0.066500 |
| 24 | 1.683309\% | 2.080900\% | 24 | -3.172184\% | 91 | 6.432571 | 0.075600 |
| 25 | -1.322459\% | 2.080900\% | 25 | -3.030717\% | 97 | 7.987698 | 0.086900 |
| .- | $\ldots$ | $\ldots$ | ... |  | 97 | 6.856697 | 0.096600 |
| 9977 | 2.590445\% | 2.080900\% | 77 | 4.325595\% | 112 | ... | .. |
| 9978 | -0.767472\% | 2.080900\% | 78 | 4.467063\% | 112 | 7.917010 | 0.902400 |
|  |  |  |  |  | 95 | 6.715321 | 0.930600 |
|  | -0.377372\% | 2.080900\% | 87 | 5.740271\% | 55 | 3.887818 | 0.977500 |
|  | 1.167791\% | 2.080900\% | 88 | 5.881738\% | 35 | 2.474066 | 0.981000 |
|  | -2.858279\% | 2.080900\% | 89 | 6.023206\% | 49 | 3.463692 | 0.985900 |
| 9990 | 4.548269\% | 2.080900\% | 90 | 6.164673\% | 22 | 2.332691 | 0.988100 |
| 9991 | -1.459417\% | 2.080900\% | 91 | 6.306141\% | 20 | 1.413752 | 0.991400 |
|  | 0.941773\% | 2.080900\% | 92 | 6.589076\% | 27 | 1.908565 | 0.996100 |
| 9996 | 1.056681\% | 2.080900\% | 96 | 7.013479\% | 5 | 0.353438 | 0.998800 |
| 9997 | -2.600413\% | 2.080900\% | 97 | 7.154946\% | 6 | 0.424126 | 0.999400 |
| 9998 | 2.881449\% | 2.080900\% | 98 | 7.296414\% | 3 | 0.212063 | 0.999700 |
| 9999 | 3.542723\% | 2.080900\% | 99 | 7.437881\% | 2 | 0.141375 | 0.999900 |
| 10000 | -1.986994\% | 2.080900\% | 100 | 7.579349\% | 0 | 0.000000 | 0.99990 |

STATISTICAL SUMMARY

| MInimum | Maximum | Median | Mean | Std. Deviation | Probability | UCL |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $-6.43 \%$ | $7.58 \%$ | $0.63 \%$ | $0.63 \%$ | $2.75 \%$ | $39.80 \%$ | $0.53 \%$ |

Table 4.28 Simulation Result : Weighting Structure 14


[^1]Table 4.29 Simulation Result : Weighting Structure 15

| TERATION | RETURN | RISK | \# |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| - | -2.275342\% | 2.104564\% | 1 | BINS | COUNTS |  |  |
| - 2 | 5.870005\% | $2.104564 \%$ | 2 | -6.623306\% | 1 | SCALE | TOTAL |
| - 3 | -4.090102\% | 2.104564\% | 3 | -6.479541\% | 0 | 0.069558 | 0.000100 |
| -4 | -3.003291\% | 2.104564\% | 4 | -6.335776\% | 0 | 00000 | 0.000100 |
| 5 | 3.723156\% | 2.104564\% | 5 | -6.192011\% | 2 | 0.000000 | 0.000100 |
| 6 | -1.671737\% | 2.104564\% | 6 | -6.048246\% | 2 | 0.139116 | 0.000300 |
| 7 | 5.774284\% | 2.104564\% | 7 | -5.904481\% | 6 | 0.417347 | 0.000500 |
| 8 | 2.440165\% | 2.104564\% | 8 | -5.760716\% | 6 | 0.417347 | 0.001100 |
| 9 | 2.712747\% | 2.104564\% | 9 | -5.616951\% | 5 | 0.347790 | 0,001700 |
| 10 | 3.699001\% | 2.104564\% | 10 | -5.329421\% | 8 | 0.556463 | 0.002200 |
| 11 | -0.549588\% | 2.104564\% | 11 | -5.185655\% | 21 | 1.460716 | 0.005100 |
| 12 | -0.483186\% | 2.104564\% | 12 | -5.041890\% | 22 | 1.530274 | 0.007300 |
| 13 | 3.682747\% | 2.104564\% | 13 | -4.898125\% | 23 | 1.599832 | 0.009600 |
| 14 | -1.362010\% | 2.104564\% | 14 | -4.754360\% | 25 | 1.738948 | 0.012100 |
| 15 | 1.544199\% | 2.104564\% | 15 | -4.610595\% | 18 | 1.252042 | 0.013900 |
| 16 | -3.133376\% | 2.104564\% | 16 | -4.466830\% | 21 | 1.460716 | 0.016000 |
| 17 | -0.472097\% | 2.104564\% | 17 | -4.323065\% | 45 | 2.643201 | 0.019800 |
| 18 | -1.487275\% | 2.104564\% | 18 | -4.179300\% | 45 | 3.130106 | 0.024300 |
| 19 | 1.057456\% | 2.104564\% | 19 | -4.035535\% | 49 | 4.103917 | 0.030200 |
| 20 | 3.089863\% | 2.104564\% | 20 | -3.891770\% | 74 | 3.408338 | 0.035100 |
| 21 | 5.968384\% | 2.104564\% | 21 | -3.748005\% | 64 | 5.147286 | 0.042500 |
| 22 | 0.511309\% | 2.104564\% | 22 | -3.604239\% | 83 | 4.451707 | 0.048900 |
| 23 | 2.806248\% | 2.104564\% | 23 | -3.460474\% | 91 | 5.3739770 | 0.057200 |
| 24 | 1.596681\% | 2.104564\% | 24 | -3.316709\% | 100 | 6.955792 | 0.076300 |
| 25 | -1.282411\% | 2.104564\% | 25 | -3.172944\% | 93 | 6.468886 | 0.085600 |
| -- | ... | $\ldots$ | $\ldots$ | ... | ... | ... | ... |
| 9977 | 2.620062\% | 2.104564\% | 77 | 4.302841\% | 115 | 7.999160 | 0.898700 |
| 9978 | -0.832079\% | 2.104564\% | 78 | 4.446606\% | 100 | 6.955792 | 0.908700 |
| 9979 | 5.180178\% | 2.104564\% | 79 | 4.590371\% | 107 | 7.442697 | 0.919400 |
| 9980 | 5.252189\% | 2.104564\% | 80 | 4.734136\% | 82 | 5.703749 | 0.927600 |
| 9981 | -1.155394\% | 2.104564\% | 81 | 4.877901\% | 90 | 6.260212 | 0.936600 |
| 9982 | -3.351186\% | 2.104564\% | 82 | 5.021666\% | 76 | 5.286402 | 0.944200 |
| 9983 | 5.301181\% | 2.104564\% | 83 | 5.165431\% | 79 | 5.495075 | 0.952100 |
| 9984 | -1.338355\% | 2.104564\% | 84 | 5.309196\% | 79 | 5.495075 | 0.960000 |
| 9985 | -3.725219\% | 2.104564\% | 85 | 5.452961\% | 59 | 4.103917 | 0.965900 |
| 9986 | 3.659272\% | 2.104564\% | 86 | 5.596726\% | 59 | 4.103917 | 0.971800 |
| 9987 | -0.192985\% | 2.104564\% | 87 | 5.740491\% | 49 | 3.408338 | 0.976700 |
| 9988 | 1.233692\% | 2.104564\% | 88 | 5.884257\% | 43 | 2.990990 | 0.981000 |
| 9989 | -2.892941\% | 2.104564\% | 89 | 6.028022\% | 37 | 2.573643 | 0.984700 |
| 9990 | 4.512933\% | 2.104564\% | 90 | 6.171787\% | 35 | 2.434527 | 0.988200 |
| 9991 | -1.286011\% | 2.104564\% | 91 | 6.315552\% | 30 | 2.086737 | 0.991200 |
| 9992 | 0.754001\% | 2.104564\% | 92 | 6.459317\% | 26 | 1.808506 | 0.993800 |
| 9993 | 4.411477\% | 2.104564\% | 93 | 6.603082\% | 16 | 1.112927 | 0.995400 |
| 9994 | 0.753103\% | 2.104564\% | 94 | 6.746847\% | 15 | 1.043369 | 0.996900 |
| 9995 | 6.119413\% | 2.104564\% | 95 | 6.890612\% | 12 | 0.8346965 | 0.998100 |
| 9996 | 1.056841\% | 2.104564\% | 96 | 7.034377\% | 8 | 0.278232 | 0.999300 |
| 9997 | -2.461220\% | 2.104564\% | 97 | 7.178142\% | 5 | 0.347790 | 0.999800 |
| 9998 | 3.045611\% | 2.104564\% | 98 | 7.321907\% | 1 | 0.069558 | 0.999900 |
| 9999 | 3.580587\% | 2.104564\% | 99 | 7.465673\% | 1 | 0.069558 | 1.000000 |
| 10000 | -1.742019\% | 2.104564\% | 100 | 7.609438\% |  |  |  |


| STATISTICAL. SUMMARY |
| :--- |
| MinImum MaxImum Median Mean Std. Deviation Probablitit UCL LCL <br> $-6.62 \%$ $7.61 \%$ $0.64 \%$ $0.65 \%$ $2.75 \%$ $40.10 \%$ $0.55 \%$ $0.76 \%$ |

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Table 4.30 Simulation Result : Weighting Structure 16


| STATISTICAL SUMMARY | Median | Mean | Std. Deviatlon | Probabilly | UCL | LCL |
| :--- | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Minlmum | Maximum | Mel | n/a | $1.08 \%$ | $1.09 \%$ |  |
| $0.77 \%$ | $1.42 \%$ | $1.09 \%$ | $1.09 \%$ | $0.11 \%$ |  |  |

Table 4.31 Simulation Result : Weighting Structure 17


| STATISTICAL SUMMARY |
| :--- |
| Minimum MaxImum Medlan Mean Std. Devlation Probability UCL LCL <br> $0.77 \%$ $1.42 \%$ $1.09 \%$ $1.09 \%$ $0.11 \%$ n/a $1.08 \%$ $1.09 \%$ |

## ATTACHMENT - LIST OF FIGURES



Figure 4.5 Histogram of WS-1 Simulation


Figure 4.6 Histogram of WS-2 Simulation


Figure 4.7 Histogram of WS-3 Simulation


Figure 4.8 Histogram of WS-4 Simulation


Figure 4.9 Histogram of WS-5 Simulation


Figure 4.10 Histogram of WS-6 Simulation


Figure 4.11 Histogram of WS-7 Simulation


Figure 4.12 Histogram of WS-8 Simulation


Figure 4.13 Histogram of WS-9 Simulation


Figure 4.14 Histogram of WS-10 Simulation


Figure 4.15 Histogram of WS-11 Simulation


Figure 4.16 Histogram of WS-12 Simulation


Figure 4.17 Histogram of WS-13 Simulation


Figure 4.18 Histogram of WS-14 Simulation


Figure 4.19 Histogram of WS-15 Simulation


Figure 4.20 Histogram of WS-16 Simulation


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Figure 4.21 Histogram of WS-17 Simulation



[^0]:    Source : Bank Indonesta

[^1]:    | STATISTICAL SUMMARY |
    | :--- |
    | Minimum MaxImum Median Mean Std. Devlation Probabilly UCL LCL <br> $0.71 \%$ $1.33 \%$ $1.02 \%$ $1.02 \%$ $0.10 \%$ n/a $1.02 \%$ $1.02 \%$ |

