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CAPITAL ASSET PRICING MODEL IN BUILDING INVESTMENT PORTFOLIO

Case: A comparision between two portfolios combine stocks from same and different industries

LAHTI UNIVERSITY OF APPLIED SCIENCES
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ABSTRACT

Investing is one of the most interesting subjects for businesses and individuals. In investment finance, stock is a financial instrument that has been giving investors the highest return in comparison with others. However, it is also considered as the riskiest asset in investment. Therefore, investors need to fully understand the characteristics of stocks as well as approaches to trading.

The author was inspired from one of the greatest investors Warren Buffett, and this study was made in order to help him as well as investors, to understand the basics of investing. The thesis consists of three main ideas: risks and returns in investment, the diversification principle and the capital asset pricing model. Following that is a study which proved the diversification effect and also found the optimal portfolio for investors using efficient frontier and capital market line – two key relationships in capital asset pricing model. In the empirical study, random stocks were chosen in order to test the hypotheses.

This study applied the deductive approach and quantitative research method. Also, a variety of sources were utilized, from published books to trusted internet sources, to provide knowledge and also clarify the subjects. The structure started from basics into details and more complicated matters. Hence, it is crucial that readers need to understand these from chapter to chapter.

However, the author reminds the readers that this study is only an approach and it is always different from theories to practices. Thus, investing in stocks requires responsibility.

Key words: capital asset pricing model, stock, portfolio, risks, return, diversification, investment.

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GLOSSARY

CAPM	Capital Asset Pricing Model
CML	Capital market line
Cov	Covariance
CV	Coefficient of variation
D	Dividend
P	Price
p	Probability
R	Return
$R_{(S)}$	Expected return of security
$R_{e(p)}$, ER_p	Expected return of portfolio
R_e, E(R)	Expected return
RFR, R_F, r_f	Risk free rate
R_M, $E[R_{Mkt}]$, ER_m	Expected return on market
R_{pr}	Market risk premium
SML	Security market line
w	Weight
β	Beta of an asset
ρ	Correlation coefficient
б, SD	Standard deviation

1 INTRODUCTION

1.1 Research background

Finance is a term which describes how money is managed and processed to acquire needed fund. It is divided into three majors: corporate finance, personal finance and public finance. (Kurt 2013) Unlike corporate and public finance, personal finance deals with investment. The main goals are to provide safeness, income and growth of capital (Bergen 2004).

Investing helps investors create the second source of earning by making money work for them. There are two ways that money can work: Savings and investments. By saving, money can earn money through compound interest. On the other hand, investment is an act of putting stakes or capital into potential opportunities with the expectation of obtaining additional profit (Investopedia). Investors would hope for the value of their investment increases in future. The difference between investing and working is that it involves risks. Traditionally, we are taught to make living through working and we most likely do it. But we are limited by hours of work we can do and energy. As one of the greatest investors, Warren Buffett, has said, "*Never depend on single income. Make investment to create a second source."*

The reason why investing is important is that besides working, investors still can earn income through invesments. Instead of putting your capital into savings, they can work simultaneously while you are doing your day job. It seems simple, but an investor must understand all characteristics of investing as well as having objectives and risk tolerance mindset. There are many markets to invest such as stocks, bonds, foreign currencies, real estates and each of them has different components involved (Investopedia). In addition, stock exchange markets open all days around through countries and continents. The table 1 below will demonstrate the top ten biggest stock exchange markets in the world.

Table 1: Top 10 biggest stock exchange markets

Source: (Forbes 2010)

Stock Exchange Markets	Market Capitalization (trillion USD)
1. New York Stock Exchange	13.4
2. NASDAQ	3.9
3. Tokyo Stock Exchange	3.8
4. London Stock Exchange	3.6
5. Euronext	2.9
6. Shanghai Stock Exchange	2.7
7. Hong Kong Stock Exchange	2.7
8. Toronto Stock Exchange	2.2
9. Bombay Stock Exchange	1.6
10. BM&F Bovespa (Brazil)	1.5

Investors do not invest in a single asset, because the risks are not diversified and it will cause mass destruction to the portfolio. Therefore, investors need diversification. Diversification is one of risk-management techniques that combines a variety of investment in order to minimize the risks between securities in case one security has big impact on overall performance. Divesification lowers your portfolio risks as it spreads the risk impacts on many securities.

Even though, diversified portfolio still remains some risks which cannot be eliminated. There are two risks involve in investment: Systematic risks and specific risks. A diversified portfolio, investors only deal with systematic risks, because all the specific risks are ignored from diversification. Following is table 2 which shows the percentage of risks that investors minimize through diversification.

Table 2: How to remove portfolio risks

Source: (Pike, et al. 2009, 231)

Number of securities	Reduction in specific risks (%)
1	0
2	46
4	72
8	81
16	93
32	96
64	98
500	99

As a result, the author attempted to test and apply the capital asset pricing model in portfolio. By doing that, it was not only for the purpose of studying the model but also the author will use it in reality. Undestanding the meaning of diversification and combining an efficient portfolio, investors in general are able to trade profitably and consistently. Figure 1 will demonstrate the theoretical background of this thesis.

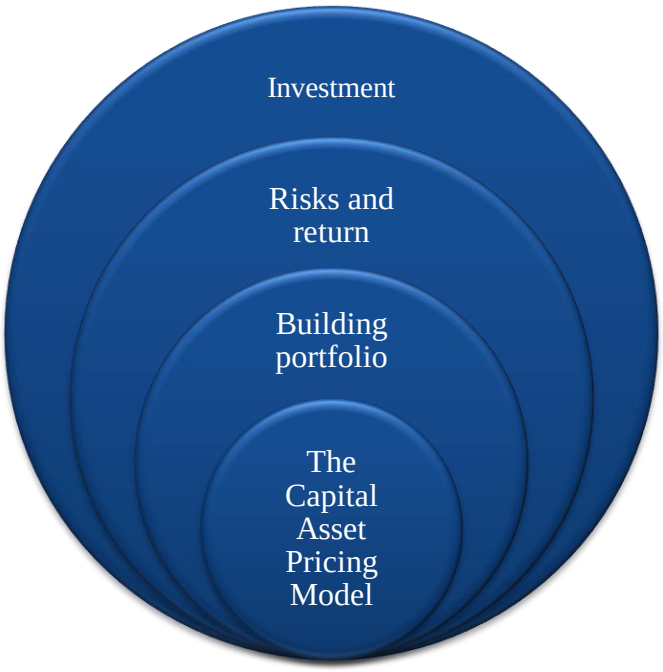


Figure 1: Theoretical background

1.2 Thesis objectives and research questions

The purpose of this thesis is to provide investors basic knowledge of portfolio and how to position securities suitably. As investment involves several risks which cannot be predicted or forecasted correctly. By using tools and capital asset pricing model, investors will know what they should get when trading. Furthermore, depending on type of traders, risk-averse or risk-tolerated, will have totally different portfolio.

With the aim of understand from economic point of view such as risks and returns to adapting it in investment finance using capital asset pricing model, the author will point out some basic required information before buying stocks. In order to achieve the objectives, the main research question is:

- How to apply capital asset pricing model individually to create an optimal portfolio?

To answer it, three sub questions are identified as:

1. What are the risks and returns of an investment for investors?
2. What is diversification and its advantages?
3. How can investors position assets in a portfolio using CAPM?

While the theories are crucial to finance, empirical studies cannot be ignored. Because of that, the research will answer these questions in each chapter following a reality study based on two sets of three chosen stocks for the comparison.

1.3 Research methodology

Research methods consist of two different approaches: deductive and inductive method. The deductive method presents the research based on previous studies to recent issues. It starts with a theory and leads to new hypothesis which is going to be confirmed or rejected. The inductive method works in opposite way by observing realities to a broader hypothesis. (Saunders, et al. 2009, 124-127) Following is figure 2 which explains the deductive method.

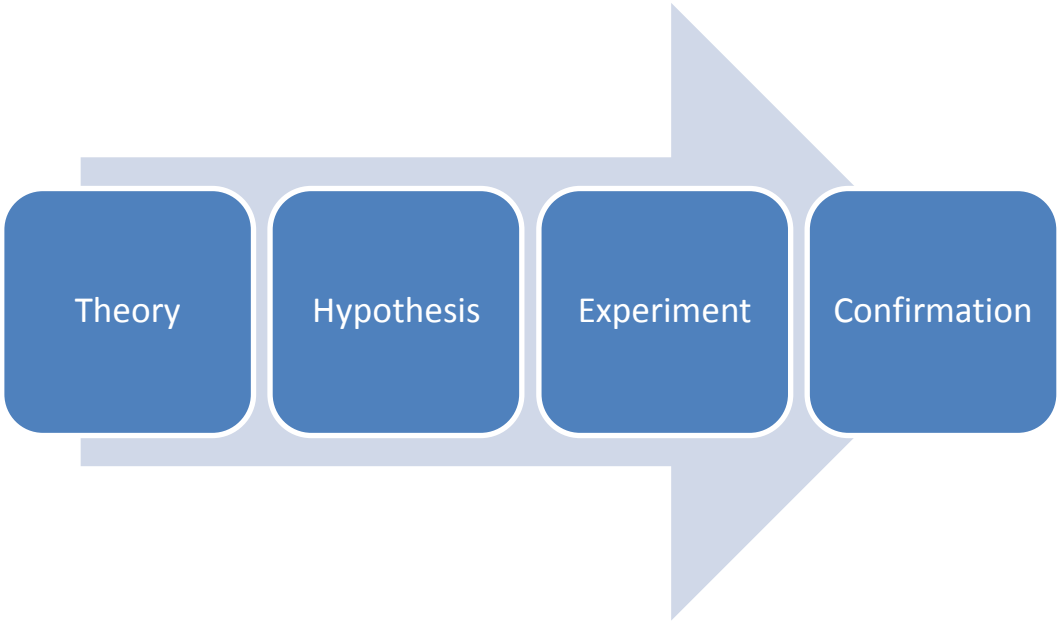


Figure 2: The deductive approach framework

According to Edmonds et al. (2013), there are three different types of research method. They are qualitative, quantitative and mixed method. The study stated that research in quantitative method is essentialy based on systematic steps of scientific method while utilizing quantitative properties such as numerical. (Edmonds, et al. 2013, 20) Also, following the study by Saunders et al. (2009), the deductive approach explains causal relationships between variables and requires a collection of quantitative data. Regarding to the nature of deductive approach and this thesis, the author later will employ the quantitative method with SPSS program to analyse the statistics.

Lastly, information provided in this thesis is collected through primary and secondary sources. Unlike primary sources, also known as first-hand information, secondary sources are from published materials (Thomas 2014). In order to illustrate the theoretical part and emprirical study, both types of source will be referenced.

1.4 Scope and limitations

The aim of this thesis is to aid the author and readers to understand the portfolio theory and how to use capital asset pricing model. Readers can use the

information before starting to enter the stock market. Through the process, the thesis can create a framework and show investors what they need to consider.

The first limitation of this thesis is that the author is not dealing with the sophisticated and complex development of the Capital Asset Pricing Model. At first, the CAPM was developed by William F. Sharpe, John Linter and Jan Mossing based on modern portfolio theory, which was founded by Harry Markowitz in 1952. The first model was quite simple but due to some assumptions and several tests in reality, it needed to be modified to be more accurate. The author focuses on the simpler model. The model was developed through multiple branches and this raised confusion among investors. The figure 3 below shows its roots.

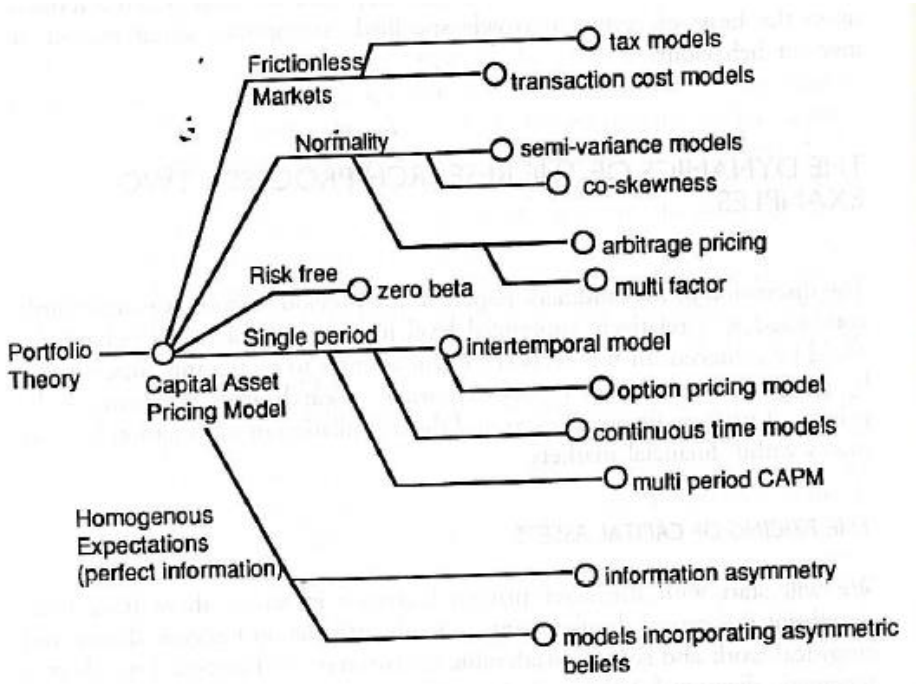


Figure 3: Theoretical development of the CAPM

(Ryan, et al. 1992, 34)

Due to the limit of knowledge concerning the theory, the author will only investigate the model associated with risk free, beta and risks involved in single-period.

The second limitation is that chosen securities in this thesis will not provide the whole picture of business risks worldwide. As mentioned before, only three stocks

were chosen in certain industries. Therefore, only risks exist in those industries are examined. Moreover, stocks are from a single market which is US, so it is limited in one country. Also, Standard&Poor 500 will be chosen as market to the stocks. The reason is that S&P 500 reflects almost the standards of US stock market. Hence, if your portfolio contains stock from international market, this thesis would not serve the purpose.

The next limitation is nature of this thesis as it only focuses on risk-averse investors. Hence, the thesis's approach and result only aid investors who are looking to minimize risks with the possible highest expected return. Though, there is also risk-tolerated investors but that would be too risky for whom would start trading as a beginner.

In addition, the capital asset pricing model was developed during 1960s, as the result, behind the model still exist few assumptions. The current market has changed and it is different from history. So, the conditions applied in the model somehow do not appear in practices. These assumptions will be mentioned in later chapter.

For the purpose of this study, only capital asset pricing model is examined. Though, there has been some development with other models, but CAPM is broadly used by investors and mentioned in modern finance.

1.5 Thesis structure

The thesis starts with introduction in chapter one that explains the author's purpose and objectives, the research methodology and background. A traditional approach to the issue based on theoretical studies lead to empirical part is applied. This type of framework is logical and easy for readers to follow the information. The figure 4 in the next page will demonstrate the structure of this study.

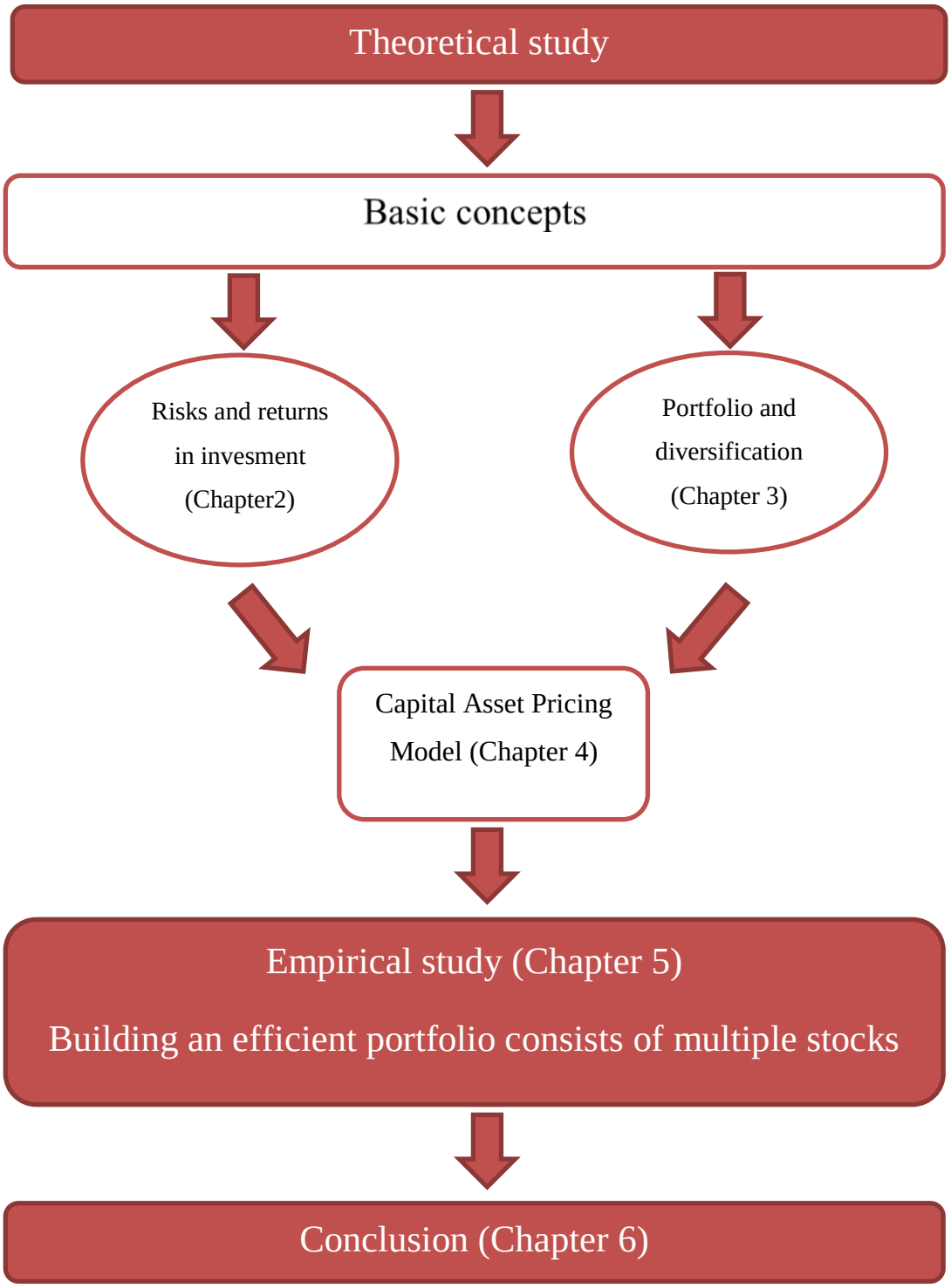


Figure 4: Structure of the thesis

The diagram shows the work flow of this thesis. As can be seen, some basic concepts related to portfolio will be mentioned in the second chapter and third chapter. Risks and return in investment are introduced in chapter two. These actors take place in the view of economics. Risks contain systematic risk and specific risk that investors need to consider. On the other hand, returns comprise of required return, expected return and actual return. Chapter 3 presents the

portfolio concept. All actors related to portfolio will be discussed. The author then will analyse the differences between one stock portfolio and multiple stocks portfolio for the purpose of proving the importance of diversification.

Chapter 4 is reserved for CAPM in detail. The idea and formula will be studied. Afterward, two key relationships of CAPM, security market line and capital market line, are interpreted. These components with the contribution of efficient frontier are the most important factors which support the process of finding out the optimal portfolio. Then, few assumptions and restrictions of the model are also considered.

The empirical part, chapter 5, will apply the information of chapter 3 and chapter 4 into chosen stocks. By doing this, it will clarify the abilities of the model. Furthermore, the result will give the readers how to divide the portfolio into appropriate propotion for each stock. Following that is chapter 6 which concludes the result and summarizes the thesis with further research suggestions recommended by the author.

2 RISKS AND RETURNS IN INVESTMENT

The important factors need to be considered in investment finance are: risks and returns. Without the acknowledgement about these components, an investor will not define the goals and objectives of their investment. Hence, they simply just throw their money away. Investing in a risky asset is not the same as gambling. An investor is able to estimate the risks and returns in his investment, but with gambling it is nothing or double.

Identifying risks and returns is the fundamental step in modern portfolio theory and CAPM. To use CAPM, three factors are required: risk-free rate of the market, stock's beta and risk premium. These terms will be introduced in fourth chapter with the formula.

2.1 Risks

There are several types of risk in businesses, industries or even globe. But in general there are only two risks that deal with investment: systematic risks and unsystematic risks. In order to recognize the difference, the author will first clarify following terms: Certainty vs. risks and uncertainty.

According to Pike et al. (2009), certainty is known as result arises when expectations are single-valued. It means the particular outcome will arise rather than a range of outcomes. Certainly, it is impossible in stock investment, but it can appear when the instruments are risk-free such as bonds, treasure bills provided from government with precise redemption yield. On the other hand, uncertainty and risks have opposite meaning compared to certainty. Even though they are synonyms, these terms are not the same. (Pike, et al. 2009, 160)

Conerly has mentioned that risks and uncertainty are two ends of a single spectrum. If we know the probabilities or the distribution of range of outcomes, we know that we are dealing with risks. But uncertainty is maybe considered as the "unknown unknowns". (Conerly 2013) In another study presented by Stott, he also pointed out that risk involves with possible and potential quantity of outcomes. Nevertheless, uncertainty is potential facts that we are not aware of.

Follow his presentation, risk is known as “known unknowns” while uncertainty is “unknown unknowns”. (Stott 2012)

In the book Modern Financial Management by Ross et al. (2008), risk refers to the unanticipated part of return, the result from surprises which cannot be ignored from investment. Though, there are various sources of risk, but the main portion are: systematic and unsystematic. He also mentioned the definition for these terms.

- A systematic risk is risk that has great impacts to a large number of assets
- An unsystematic risk only specifically affects a single asset

(Ross, et al. 2008)

Brigham et al. (2007) also discussed about diversifiable risks and market risks. Diversifiable risks are specific to the firms which can be labor strikes, unsuccessful marketing programs or other events that are unique. Theses losses from one firm can be offset by other firm’s gains. A diversificable portfolio minimizes the spread of risks and eliminates the unexpected occurs. On the other hand, market risks affect all firms regardless their businesses, therefore it cannot be diversified (Brigham, et al. 2007).

2.1.1 Systematic risks

Systematic risks are defined as market or undiversified risks. The reason behind this statement is that systematic risks appear in macroeconomic point of view. They reflect the degree of risk in certain industries or markets. Because of systematic risks, investors can make profits or losses from the volatility of the market. (Investopedia 2013) These risks can be considered as systematic risks: Interest rates, recession…

First, interest rate is crucial to stocks. Indeed, they have total negative relationship with stocks. It is because of the compound interest. If the interest rate increases, investors would likely put their money into banks and make profit with almost zero risks when inflation is taken into consideration. In constrast, if interest rate is low, investors would prefer to invest in stocks because the returns are higher. The

basic idea is: A same amount of capital is preferred to put into where return is the highest. It is all about demand and supply. If investors prefer to invest into stocks, consequently it will push the price up as more buyers enter the market. (Rand 2013)

Rising interest rate also means that money is more expensive to borrow. The higher the interest, the more you have to pay. Due to this problem, many firms will not probably borrow money from banks to expand the operations. Hence, stock price would not likely to rise in future. And as the result, investors would avoid the stock. (Patton 2014)

A good example for the effect of interest rate is that following the news on September 17th, 2014, the Federal Reserve Bank of United States decided to keep the interest rates at a low rate, 0.25%, for considerable time (Flaherty 2014). After the news released, *"The Dow Jones industrial average (DJI) closed up 109.14 points, or 0.64 percent, to 17,265.99, the S&P 500 (SPX) added 9.79 points, or 0.49 percent, to 2,011.36, and the Nasdaq Composite (IXIC) gained 31.24 points, or 0.68 percent, to 4,593.43"* (Mikolajczak 2014)

Second, recession plays an important role in the stock market. Even so, it does not happen all the time, but every economy has a cycle: Booming, recession, recovery. Riley has defined a recession is a period of time that show a significant decline in economic activities which is visible in gross domestic product (GDP), income, employment or industrial production (Riley 2012). As recession affects the whole economy of a country which means the stock market is also influenced. The major cause of recession is inflation. When inflation happens, the price of goods and products increase. At the same time, we have to spend more to purchase same product. Therefore, people tend to save and cut off spending lead to decrease in GDP. This also applies to businesses as they have to reduce expenses. And one of the options is to lay off employees. Thus, unemployment rate will rise (Morah 2014).

To conclude this chapter, systematic risks change the variability in return of stocks regardless its business, due to factors that influence the return on all securities traded in the market. Systematic risks refer to impacts created in the

macroeconomy such as fiscal policy, interest rates and economy health (Pike, et al. 2009, 230-231). The relationship between systematic risks with the stock is displayed by beta. This matter will be discussed later.

2.1.2 Unsystematic risks

Regarding the section 2.1, the introduction about risks, unsystematic risks are inside individual firms. They are also known as diversificable or specific risks. Specific risks consist of these types: Business risk and financial risk.

Business risk implies the risk that causes the variability in operating cash flows or profits of a firm. It affects the operations of the firm and also refers to the underlying economic environment within it operates (Pike, et al. 2009, 163). For example, in airline industry, a plane crash might cause the decrease in favor of a stock. The figure 5 below show the stock price of Malaysian Airline which had two disasters during year 2014.

Figure 5: Stock chart of Malaysian Airlines (MAS:MK)

(Yahoo Finance 2014)

As the disaster happened in March, the stock price dramatically fell from 0.30 MYR to 0.25 MYR and continued to fall to 0.15 MYR level in mid May. On the right hand side bottom, the 1-year return fell to -20.31%. However, these disasters do not always happen. Instead, some operation problems may appear regularly in a company. For instance, a strike from labor force can affect the firm's productivity. Unfavorable internal events can hurt the profitability of the firm. Thus, investors are not willing to buy risky stocks.

Another risk within the firm is financial risk. Brigham et al. (2007) defined financial risk as additional risk to common stock holders as the result of using debt. Indeed, most firms use debt for leverage. As the result, this action can cause financial distress for the firm. Using debt for leveraging can be a double-sword to the firm. If the company making loss, plus using debt for such occasion, consequently, they need to cut costs to pay off. This can damage the profitability of the firm. Therefore, investors need to carefully look for the capital structure of the firm and decide if the structure is optimal (Brigham, et al. 2007, 444-449). One of the best way to look at financial management of the firm can be found in financial statement. These information can be found in internet. A comparison between three years statements can give investors how the firm is using its debt-equity structure.

2.2 Returns

As with risks, returns are also divided in many forms such as: dividend, capital gain from stocks, compound interests. Of these returns, only capital gain needs to be considered. The reason is because dividend is paid due to the policy of the firm. They can choose to pay dividend or not. Dividend is mandatory distributions of income to its shareholders (Investopedia 2012). Even though, firm should pay dividend but in most case stockholders do not favor it. In the book "Fundamentals of Financial Management", Brigham et al. (2007) stated that there are two options for shareholders. In some case, they prefer dividend because they are uncertain about the growth of capital gain. On the other hand, some investors want firm to keep its retained earnings and then expand the business (Brigham, et al. 2007, 480-481)

Considering about capital gain, a stock can have three types of return: expected return, required return and actual return.

2.2.1 Expected rate of return

In the book Modern Financial Management by Ross et al. (2008), expected return was defined as *"A return that an individual expects a stock to earn over the next period"*. As it is expected, the result is the average of possible outcomes. The actual return can be either higher or lower. The expectation can be the result from individual's perception or from computer-based calculation or even special information (Ross, et al. 2008, 279). To put it simply, the expected rate of return uses probabilities of possible outcomes of an investment to measure the result. Following is the equation about how to calculate expected return:

$$\mathbf{R_e = \sum_{i=1}^{n} pi \times Ri} \qquad \mathbf{(1)}$$

The formula can be rewritten as:

$$\mathbf{R_e = R_1p_1 + R_2p_2 + \ldots + R_np_n} \qquad \mathbf{(2)}$$

(Investopedia 2013)

A simple example for expected rate of return of a single stock as follow:

Stock A	Probability	Return
	0.5	12%
	0.5	5%

Hence, the expected rate of return for stock A is calculated as:

R_e (A) = 0.5 x 12 + 0.5 x 5 = 8.5%

For investor who hold stock A in their portfolio would expect to gain 8.5% profit.

2.2.2 Required rate of return

Apart from expected rate of return, required rate of return is different to investors. As the author mentioned before, expected return can be calculated through computer-based programs or with special information. But required return of a single stock is crucial to be identified. It is known as the minimum annual percentage that an asset need to achieve in order that investors decide whether to put their money or not (Investopedia 2013). The return of a stock takes all possibilities into consideration which are risk-free rate (bonds, T-bills), inflation and risk premium. For instance, an investor hold a stock which gives 10% in return. Due to inflation of 3%, he only receives back 7%. In order to achieve 10% return, the required return hence need to be 13%. Required return is well-known component in the formula of CAPM. Therefore, the author will introduce it later in chapter 4.

2.2.3 Actual return

An actual return is the real value an investor gained or lost during a given period. In some case, actual return does not include dividend pay from stock. But if the firm agrees to pay dividend to its shareholders, then the actual return also consists of dividend paid (Ross, et al. 2008, 256-257). The total return from stock is displayed as follow:

Total stock return = Actual return (Gain or loss) + Dividend (3)

The formula can be written in another way:

$$\frac{(\boldsymbol{P1} - \boldsymbol{P0}) + \boldsymbol{D}}{\boldsymbol{P0}}$$

For instance, the author took an example from Johnson&Johnson (JNJ) Company to show the total return of the firm's stock during a one-year period from September 2013 to September 2014:

Figure 6: Stock chart of Johnson&Johnson

The information was retrieved from website www.finance.yahoo.com

As can be seen in the figure, the stock price of JNJ on September 27th, 2013 was 86.73 dollars and the current price on September 26th, 2014 is 107.10 dollars. In addition, the company has been paying dividend of 2.8 dollars annually. Altogether, the total return of JNJ stock is calculated as follow:

Total stock return = (107.10 – 86.73) + 2.80 = 23.17 USD

On the right-hand side bottom, we can find the return percentage from JNJ stock which is 23.49% and it does not include dividend paid.

In conclusion to this chapter, the author has introduced two factors that contribute to investor's portfolio: risks and returns. In each category, there are several types of risk and return which need to be identified. Risks consist of systematic risks which refer to impacts in macroeconomic scale while unsystematic risks, also known as specific risks only deal with a single asset. On the other hand, returns include three types: Expected return, required return and actual return. Expected return is usually calculated on computer-based program and reflects the expectation of investors. Required return, in constrast, show the rate of return that a single asset has to provide to investors in order that they willing to put their

capital. Finally, actual return is the real value from investment. It usually combines actual gain or loss from stock with dividend paid from the firm.

3 INVESTMENT PORTFOLIO AND DIVERSIFICATION

3.1 Investment portfolio

An investment portfolio is a collection of variable assets from stocks, bonds, and treasure bills to real estates, mutual funds. Investors hold portfolio in order to achieve their goals and avoid dependence in a single asset. The composition of a portfolio depends on multiple factors but most important are: investor's risk tolerance, time frame for holding it and investment capital. The mixture of assets comes from expected risks and returns that the holder wants to achieve (Investopedia 2013). Investment portfolio can be illustrated in a pie chart where each investment vehicle has a certain propotion:

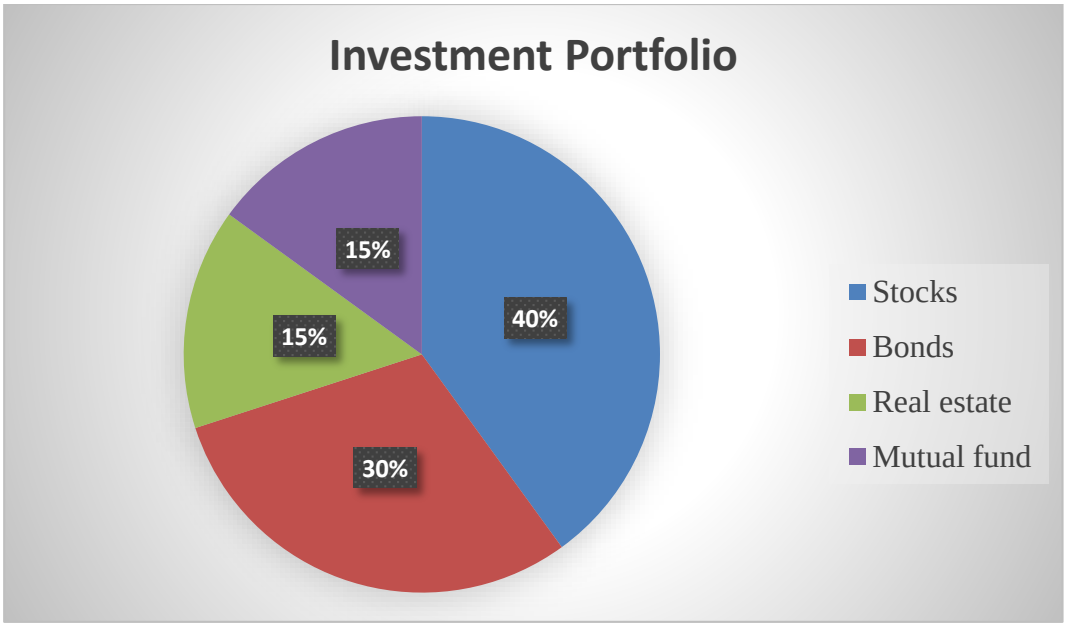


Figure 7: An example of investment portfolio

There are two types of portfolio: aggressive and conservative. A conservative investor may hold only 20% in stocks and 80% in bonds (Wells Fargo Bank). Stocks volatile intraday. It means that the price can go up or down in the same day especially, when some major events happen. Because of this reason, conservative investors only hold 20% of their capital in stocks. Bond is another instrument which is safetier than stocks. Bond is issued by governments. So, the default risk is very low. In history, bond is known as safe-haven instrument because of high yield for long maturity and low default risk. Even though, bond is still affected by

interest rates as mentioned in previous chapter, but a conservative investor would maintain 80% of their capital for bonds (Perry 2013). The opposite type is the aggressive investor. They would hold 80% for stocks in order to achieve higher profit but it also means that they need to bear higher losses than conservative investors.

A study made by Merrill Lynch Corporation has showed how investors should allocate their capital depends on risk bearing ability and their goals. The table 3 below will show the risk categories for different type of investors.

Table 3: Risk categories and asset allocation

Source: (Merrill Lynch Corporation 2005)

Type of Investors	Asset Allocation	Risk Potential	Return Potential
Conservative	Stocks 25% Bonds 50% Cash 25%	+	+
Conservative for growth	Stocks 40% Bonds 45% Cash 15%	++	++
Moderate risk	Stocks 50% Bonds 40% Cash 10%	+++	+++
Growth	Stocks 65% Bonds 25% Cash 10%	++++	++++
Aggressive growth	Stocks 80% Bonds 10% Cash 10%	+++++	+++++

The portfolio is a collection of variable assets because investors need to diversify the specific risks of each asset by combining them together. The idea behind this term will be explained in next section.

3.2 Principle of diversification

In the book “Stocks for the long run” by Siegel (2007), the reason to investing internationally is to diversify the portfolio. A good investment policy must be made within variable of stocks as well as economies. Moreover, investors do not diversify in just their domestic countries but also internationally (Siegel 2007, 168-169). As mentioned before in the first chapter, a combination of more than 60 stocks will reduce 98 percent of specific risks. Indeed, diversification reduces the risks that might occur because the stock prices from different assets can move opposite at the same time. In other word, investors can hedge the dependence on one single stock performance.

Putting all in one stock is too risky. Diversification generates some major strategic advantages: the wider the activities, the wider the spread of risks. A fundamental idea for diversification is to engage in activities that do not correlate to each other. In that manner, they will behave exactly opposite ways (Pike, et al. 2009, 260-261). An investment portfolio is always compared to the market, particularly the return. And risk of a portfolio is measured by the ratio between portfolio’s variance of return to its market return. Therefore, a diversified portfolio will only bear the market risk, in other words, it has same movement with market (Eiteman, et al. 2010). Figure 8 will explain the advantages of diversification principle:

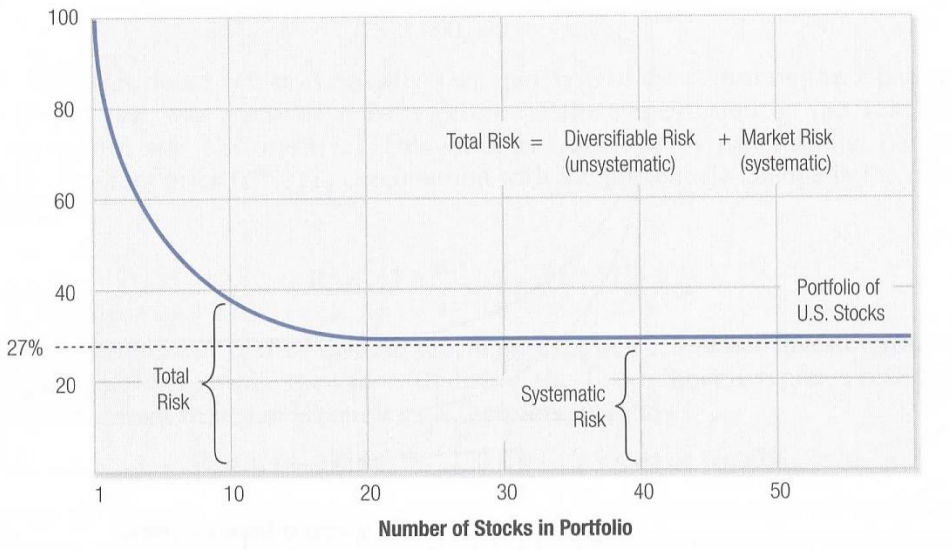


Figure 8: Portfolio risk reduction through diversification

(Eiteman, et al. 2010)

As can be seen from figure 8, as the number of assets increases, the diversificable risks decrease. Instead of holding a one-stock portfolio, investors can buy 10 to 20 stocks to reduce risks. The risk percentage falls dramatically to 27 percent with number of holding stock is 20. Though, the number of stock could grow to 50 but the risk level stays the same. At this level, it assumes that the investor only bear the market risks because all diversificable risks are ignored.

Specific risks are independent to each asset. Therefore, the effect of diversification becomes stronger as more assets are added to the portfolio. A diversified portfolio is known as market portfolio because it has only market risks. In this case, the portfolio moves along with the market (Ross, et al. 2008, 328-332). Moreover, this principle can be applied internationally. The investor could pick up stocks oversea in order to diversify more. Though it sounds interesting but the risks related is much more complicated.

In order to apply this principle in reality, the investor needs to pick up stocks which have low correlation with each other. Considering the case scenario that one stock scales up and one scales down to minimize the risk of losses in diversified portfolio, the correlation must be low or even negative. To understand more about how this mechanism works, the author will explain three terms in the next sections: standard deviation, coefficient of variation and correlation coefficient.

3.2.1 Standard deviation

Measurement of risks is based on past experience and historical analysis. Though we cannot be certain about the future but with little knowledge about past figures, investors are able to find the possible distribution of outcomes. Therefore, standard deviation is one of the most powerful tool to define the degree of risks and measure the distribution of returns as well (Pike, et al. 2009, 164)

In finance, according to Brigham et al. (2007), it stated *"the tigher the probability distribution of expected future returns, the smaller the risk of a given investment"* (Brigham, et al. 2007, 250). In fact, standard deviation gives us a bigger picture about the variability of an investment's outcomes. It is applied to find the average

risks and returns from a particular stock or project, then we can define the volatility. In order to find the standard deviation of a single stock, Brigham et al. 2007 has illustrated the formula as follow:

$$б = \sqrt{\sum_{i=1}^{N}(\boldsymbol{Ri} - \boldsymbol{Re})^2\ \boldsymbol{pi}} \quad \textbf{(4)}$$

(Brigham, et al. 2007)

Follow the formula, the first thing that the investor needs to calculate is the expected rate of return (Re). This return can be discovered by using probability of potential outcomes and actual previous returns of an asset. Second thing is the deviation which is the difference between actual returns versus expected returns. Then, we square the result and multiply with probability of that scenario. For example: Stock A's expected return is 15%, the actual return of three consecutive previous years are: 8%, 20%, 17% and the probability is 0.4, 0.3, and 0.3 respectively. Hence, we can calculate the б as follow:

$б_A = \sqrt{(8-15)^2\ \times 0.4 + \ (20-15)^2 \times\ 0.3 + \ (17-15)^2 \times 0.3}$ = 5.32%

As the result is 5.32 percent, we can understand that from expected return, the actual return could be 5.32 percent higher or lower.

Standard deviation can be applied to compare two stocks or assets with each other. By finding out the dispersion of possible outcomes, investors can choose stock with high or low volatility. For instance, a risk-averse person would choose stock with small standard deviation while a risk tolerated investor would do the opposite (Pike, et al. 2009, 166). Suppose, an investor would buy stock B with the same expected return is 15% but the actual returns from three previous years are: 30%, 8%, and 14% and probabilities are 0.2, 0.4, and 0.4 respectively. Then we can calculate the $б_B$ = 8.06%. As a risk averse, stock A is more favoured than stock B as $б_A < б_B$.

3.2.2 Coefficient of variation

Another useful tool to track the degree of risk is coefficient of variation. Investors can use this tool to measure the dispersion of variability for stocks with different expected return (Pike, et al. 2009, 167). Though the standard deviation gives investors the difference between expected return and actual return could be, it cannot compare two stocks in a meaningful way to determine which one has greater dispersion because they may vary due to their expected returns (UCLA). It is calculated by dividing the standard deviation by the expected return:

$$\textbf{Coefficient of variation} = \sigma/Re \qquad (5)$$

Let's take a look at the previous example where stock A and B give the same expected return of 15%. In different scenario, stock A's expected return is 25%. Hence, A's standard deviation is $\sigma_A = 11.93\%$. Using these results in the formula, we can calculate the CV of A is 0.80 while CV of B is 0.54. The coefficient of variation reveals that stock B actually offers lower degree of risks than stock A. For the different scale of expected return, stock A's risk dispersion is bigger than stock B. In other words, stock A is more volatile than stock B.

3.2.3 Covariance and correlation coefficient

From the last two previous sections, the author has described two risk measurements for investors to choose a single stock. However, a portfolio is one collection of multiple assets. Therefore, investors need to know if these chosen stocks are negative or positive correlated to each other. The covariance and correlation coefficient measure the movement between two stocks (Anke 2010). According to his article, he has showed the correlation range and diversification value to portfolio. Table 4 below will demonstrate that.

Table 4: Correlation range and diversification effect to portfolio

Source: (Anke 2010)

Asset's Correlation Range	Diversification value in portfolio
Negative	Outstanding
0.0 to 0.5	Excellent
0.5 to 0.6	Very good
0.6 to 0.7	Good
0.7 to 0.8	O.K to poor
0.8 to 0.9	Poor
0.9 to 1.0	Worthless

In statistics and finance, both terms are used to measure the relation between two or multiple stocks. If the covariance is positive, both assets move same direction together, if it is negative, they will move in opposite direction. In order to find the correlation coefficient, the investor need to define the covariance between two assets.

$$\textbf{Covariance (X,Y)} = \sum_{i=1}^{n} \frac{(Ri(x) - Expected\ Rx) \times (Ri(y) - Expected\ Ry)}{n\ periods} \qquad \textbf{(6.1)}$$

If the calculation uses historical data, the following formula is applied:

$$\textbf{Covariance (X,Y)} = \sum_{i=1}^{n} \frac{(Ri(x) - Average\ Rx) \times (Ri(y) - Average\ Ry)}{(n-1)\ periods} \qquad \textbf{(7.2)}$$

(Investopedia)

The difference between formula 6.1 and 6.2 is that the first formula is use to calculate the expected covariance while the other used for historical covariance. When covariance is known, correlation coefficient between two stocks will be calculated as follow:

$$\textbf{Correlation (X,Y)} = \rho_{x,y} = \frac{Cov(X,Y)}{6x \times 6y} \qquad \textbf{(8)}$$

(Investopedia)

The correlation is found by dividing covariance between stock X and Y by result of multiplying standard deviation of X and Y. Negative result gives investor an outstanding diversification effect while positive result brings consideration of what degree they will move together.

3.3 One-stock portfolio versus multiple stocks portfolio

3.3.1 One-stock portfolio

When a portfolio consists of only a single asset or stock, the risk of holding it is very high. A stock has its standard deviation which measures the degree of risks, its specific and systematic risks. As mentioned before, through diversification, investors can ignore the specific risk. But when invest in one asset, the investor need to bear both risks and the ability of losing or gaining depends on the nature of the chosen stock. It would be the same as gambling when the chances are 50/50.

Unlike bonds - a financial instrument, which gives a specific rate of return and it is considered as risk-free. Stocks are riskier to investors. However, the rate of return is usually higher than bonds and others but also hard to predict. The expected return from stock can be 20 percent but investors need to recognize the actual rate of return could be in the range of 1000 percent or minus 100 percent (Brigham, et al. 2007, 247).

For example, the investor would choose Johnson&Johnson stock for the portfolio. According to analysis from website Stock Analysis on Net, the standard deviation of JNJ is 4.30% which was computed with the figures during 2009 and 2013. Another statistic to look for is the correlation coefficient of JNJ with its market, in this case is Standard&Poor 500 (S&P 500) is 0.61. Following the previous table of correlation range, it is considered as good (Stock Analysis on Net 2013). Yet, the investor could add extra stocks in order to reduce the standard deviation of the portfolio as well as the correlation coefficient. As the matter of fact, the more

assets added, the less risky the portfolio is. For this reason, the author will demonstrate the effect in next section.

3.3.2 Portfolio with two assets

A portfolio which consists of two stocks is better than a one-stock portfolio as risks are spread among chosen assets. Specific risk of each firm will be diversified as the number of asset increases. However, the investor does not need to bear both risks from one stock. Good news from one stock will cover bad news from other (Berk, et al. 2011, 311). When combine two stocks, the portfolio standard deviation will have less dispersion and hence reduces the degree of risk.

To form a portfolio of two assets, the investor need to consider about these terms: the standard deviation of each stock as well as portfolio, the correlation coefficient, the overall expected return. According to Reilly et al. (2003), the standard deviation of a portfolio is calculated as follow:

$$\text{б}_p = \sqrt{\sum_{i=1}^{n} w_i^2 \text{б}_i^2 + \sum_{i=1}^{n} \sum_{\substack{i=1 \\ i \neq j}}^{n} w_i w_j Cov_{i,j}} \quad \textbf{(9)}$$

When the portfolio has only two assets, the standard deviation formula is:

$$\text{б}_p = \sqrt{w_1^2 \text{б}_1^2 + w_2^2 \text{б}_2^2 + 2 w_1 w_2 Cov_{1,2}} \quad \textbf{(10)}$$

(Reilly, et al. 2003, 220-221)

Also, Pike et al. (2009) came up with the formula for expected return of a portfolio. The return depends on the weights of all assets included. The reason behind this is that some assets deliver greater returns and greater risks while others do the opposite. If the investor is risk-averse, he will put most of his investment to safer stock with low standard deviation. The expected return of a portfolio is demonstrated in the next formula:

$$\mathbf{R_{e(p)}} = \sum_{i=1}^{n} w_i R_i \quad \textbf{(11)}$$

To illustrate this situation, the author picked two stocks which are Apple Inc. (AAPL) and Johnson&Johnson (JNJ). Considering the investor holds 50% of his capital for each asset. So $w_1 = w_2 = 0.5$. Expected return for Apple stock is 14.89% while Johnson&Johnson's is 9.19%. Hence, we can easily calculate the expected return of the portfolio using formula number 10:

$R_{e(p)} = 0.5 \times 14.89 + 0.5 \times 9.19 = 12.04\%$

Also, the author can find the portfolio standard deviation based on information from Stock Analysis on Net. Standard deviation of Apple is 7.87% and JNJ has 4.3% during the chosen period. In order to find the σ_p, the covariance between AAPL and JNJ need to be discovered. Based on figures of 56 periods from 28th February 2009 until 30th September 2013 and formula number 6.2 and 7, the covariance is 0.00049 and their correlation coefficient is 0.144. These numbers tell the author that the combination has excellent diversification effect. By combining these results and apply them to formular number 9, we have:

$$\sigma_p = \sqrt{0.5^2 \times 0.102^2 + 0.5^2 \times 0.043^2 + 2 \times 0.5 \times 0.5 \times 0.00049} = 0.047$$

The overall standard deviation of this portfolio is 4.7% which is much smaller than a portfolio which has only Apple stock and slightly higher than a portfolio which has Johnson&Johnson stock. On the other hand, the expected return is strong with 12.04%.

Through this example, the author has proved the effect of diversification and its advantages though the portfolio has only two assets. The author has explained the idea of an investment portfolio and several types of investor. In a portfolio, the diversification is important as it reduces risks when assets cover losses for each other. Furthermore, a number of formulas is provided in order to pick the suitable stocks. In the end of this chapter, the author also demonstrated the difference between one-stock and two-stock portfolio. The results have clearly explains the theoretical studies introduced in the beginning of the chapter. In the next one, the author will explain the capital asset pricing model to build an optimal portfolio and its key relationships.

4 CAPITAL ASSET PRICING MODEL IN INVESTMENT PORTFOLIO

4.1 The formula

The capital asset pricing model is one of the most basic formulas to analyse an investment. The formula interprets the general idea that an investor need to be compensated in two ways which are: Time value of money and possible risks for the investment. An investment's return must match the required return from the formula. If not, the investment should not be made (Investopedia 2012). On the other hand, the CAPM also provides investors a full understanding how to identify the efficient portfolio which is the same as market portfolio (Berk, et al. 2011, 357). The CAPM formula can be found in many books. Below formulas are taken from several finance books.

$$\mathbf{E(R_i) = RFR + \beta_i(R_M - RFR)} \qquad \mathbf{(12.1)}$$

(Reilly, et al. 2003, 248)

$$\mathbf{R_S = R_F + \beta \times (R_M - R_F)} \qquad \mathbf{(11.2)}$$

(Ross, et al. 2008, 342)

$$\mathbf{E[R_i] = r_i = r_f + \beta_i \times (E[R_{Mkt}] - r_f} \qquad \mathbf{(11.3)}$$

(Berk, et al. 2011, 359)

$E(R_i)$, R_S, $E[R_i]$: Expected return of an asset

RFR, R_F, r_f: Risk-free rate

β: beta of an investment with its market

$(R_M - R_F) = R_{pr}$: the market risk premium.

In these formulas, in order to identify the expected return, it requires risk-free rate of return, beta of the stock with its market and the market risk premium to be known. In order to understand these components, the author will explain each of these in following sections to provide a thorough interpretation.

4.2 The beta (β)

In a well-diversified investment portfolio, the specific risks are ignored. This statement is true and was proved in the previous chapter. Instead of considering the diversificable risks, the investor needs to look out for the market risk. Therefore, the measurement for the relation between a stock and its market is beta. In the book, Investment Analysis: Portfolio Management (2003), Reilly et al. have determined beta as *"A standardized measure of systematic risk"*. Beta is used to estimate the movement of a stock relates to its market. In a broad understanding, it specifies the systematic risk and sensitivity of a security (Reilly, et al. 2003, 248). This value describes how sensitive the firm's underlying revenues and cashflows are to market-wide conditions. According to Berk et al. (2011), for cyclical firms usually have beta higher than 1 because the supply and demand can fluctuate all the times due to stages of its business. In constrast, non-cyclical companies have betas smaller than 1 because their businesses tend to be stable (Berk, et al. 2011, 319). For this reason, the author will provide the general view of 100 US large-cap stocks' betas in the appendice 1.

Certainly, in the business world, when the information is available, the investor can find the beta for each stock he owns. Indeed, the beta can be found in several finance websites nowadays. However, beta also can be calculated based on the covariance of the stock with its market. Below formula show investors how to find beta:

$$\textbf{Beta of security i} = \frac{Cov(R_i, R_M)}{Var(R_M)} = \frac{6_{i,M}}{6_M^2} \qquad \textbf{(13)}$$

(Ross, et al. 2008, 344)

Following this formula, the investor should get a positive result. A result smaller than 1 reflect that the stock is less sensitive to its market. For instance, JNJ has beta of 0.61. It represents that for 1% movement of the market, the stock move 0.61%. On the contrary, Google Inc. (GOOG) has beta of 1.145 so the volatility is much greater than JNJ stock. For every 1% movement of the market, Google stock has 0.145% difference. All information is retrieved from www.finance.yahoo.com.

4.3 Risk-free rate

As described in the second chapter about risks and returns on an investment, the author has explained two type of risks: specific and market risk. Also, the chapter mentioned three possible returns: expected return, required return and actual return. A risk-free stock or investment has a special feature on return: Actual return and expected return are the same (Damodaran 2008). The reason is that risk-free asset theoretically contains no risk, including default risk. In most markets, bonds, treasury bills are risk-free assets. They are issued by governments with certain yield rate and redemption period. When investing in these instruments, investors need to look for the credit rating for certain countries. According to Standard&Poor 500, credit rating is the future opinion about credit risk. It represents the ability and willingness of an issuer to meet the financial obligations on time. Also, it shows the credit quality of the debt of an individual debt issue (Standard&Poor Ratings Services). In the US market, two typical ratings services are Moody's and Standard&Poor. The rating scales can be found from these two rating services' websites.

Even though these financial instruments are issued by governments, they do not mean that there is surely no risk. Civil unrest, political issues, rising interest rates or unbalanced accounts can lead to default risk. Recently, an article from Bloomberg has pointed out that Finland's credit rating was downgraded to AA+ from AAA due to the stagnation with aging population and the fiscal policy (Pohjanpalo 2014).

Risk-free rate is usually the bond's yield or treasury bills rate. These information can be easily retrieved. Despite the fact that risk-free asset is not practical in reality because it still carries a small amount of risk, the risk-free rate is still considered applicable in invesment. The 10-year US government bond yield is often used as the risk-free rate. Investors can use other rates also considering the investment horizontal period. The 10-year bond's recent rate was decided on 8th October 2014 which was 2.327% (Zeng 2014) . Hence, this rate will be also used in the empirical study later.

4.4 Market risk premium

In the section 4.1 when the author described the formula, the market risk premium is the result of the subtraction between return on market and risk-free rate. It shows the compensation that the stock need to offer to investors for bearing the possible risks in future. The risk premium in CAPM formula is always positive because investors expected a compensation from the stock. However, the market risk premium varies from countries to countries due to the economic situation differences (Pike, et al. 2009, 240). An appendice is included in this paper with market risk premium from 40 countries all over the world in 2014. The higher the figure, the riskier the market.

One way to discover the market risk premium is by taking expected market return, and subtract risk-free rate (usually 10-year bond yield). The benchmark for expected return on market in US is based on S&P 500 index. S&P 500 represents 500 large-cap companies in US and therefore, it reflects the risk/return characteristics of US equities (Investopedia 2013). Investors can easily find the expected return of S&P 500 from website www.moneychimp.com. The author found the annualized return of S&P during 10-year period from January 2004 to December 2013 was 7.36%. Hence, we can calculate the market risk premium by equation (7.36% – 2.33%) equal approximately 5.03% which is quite similar from result from the survey in appendice 2 which is 5.4%.

4.5 Security market line

The security market line demonstrates expected return of each security based on its own beta with the market. It assumes that the market portfolio is efficient and all securities are correctly price. Therefore, all stocks and portfolio should be on the security market line (Pike, et al. 2009, 238). Furthermore, it reflects the relationship between risk and return of an asset. On the other hand, the SML also defines if an asset is being overvalued or undervalued (Reilly, et al. 2003, 250). In reality, we can position the returns of certain stocks in graphic of security market line to find out if it is correctly priced. An example is taken for demonstration as below.

Assume that the investor is looking to invest in stock A and B. According to the US market at current condition, the risk free rate, which is also the 10-year bond's yield, is at 2.3% and the risk premium is 5.4%. Stock A has beta of 1.2 and stock B has beta of 0.8. Insert these datas into the capital asset pricing model, we get the results as pointed out in following table.

Table 5: Expected returns on example stocks

	β	Risk free	Risk premium	E(R)
Stock A	1.2	2.3%	5.4%	8.78%
Stock B	0.8	2.3%	5.4%	6.62%
10-year bonds	0	2.3%	5.4%	2.30%
Market	1.0	2.3%	5.4%	7.70%

Based on this table, the author will show it in graphic below:

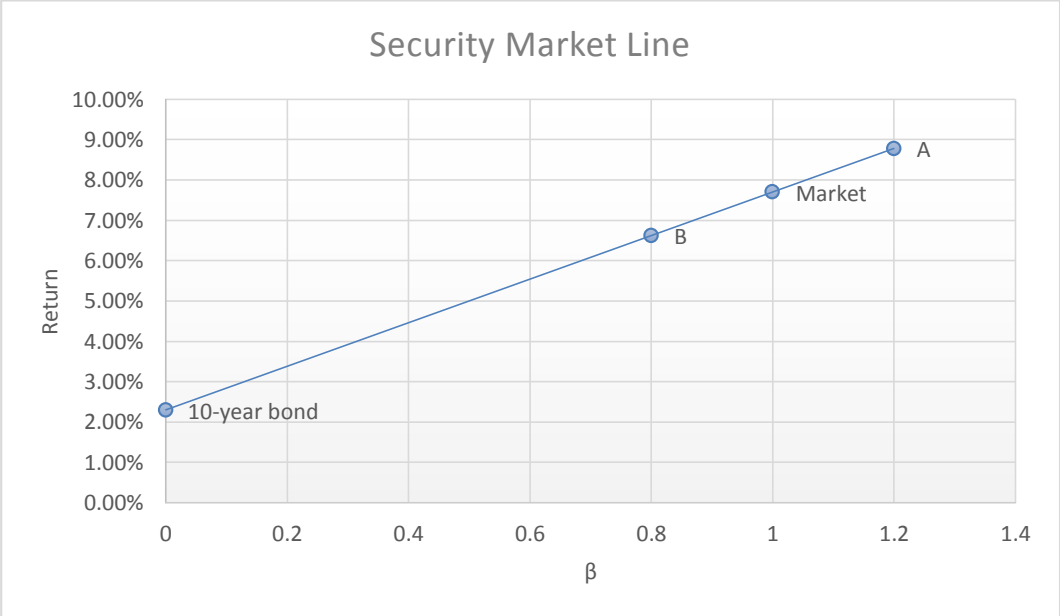


Figure 9: Security market line of example stocks

As can be seen from the graphic, if stock A and B are correctly valued, they should deliver to the investor the calculated expected return in table 5. However, in reality, some stocks might give higher or lower returns compare to expected return. In other case scenario, stock X's expected return is plotted above the SML

while stock Y's return is plotted under the SML. As the meaning of security market line, stock X is being undervalued because for the same amount of risk which is represented by beta, stock X delivers higher return than expectation. Meanwhile, stock Y is overvalued because it delivers lower return. Figure 10 below shows the expected return of X and Y in comparison with the security market line.

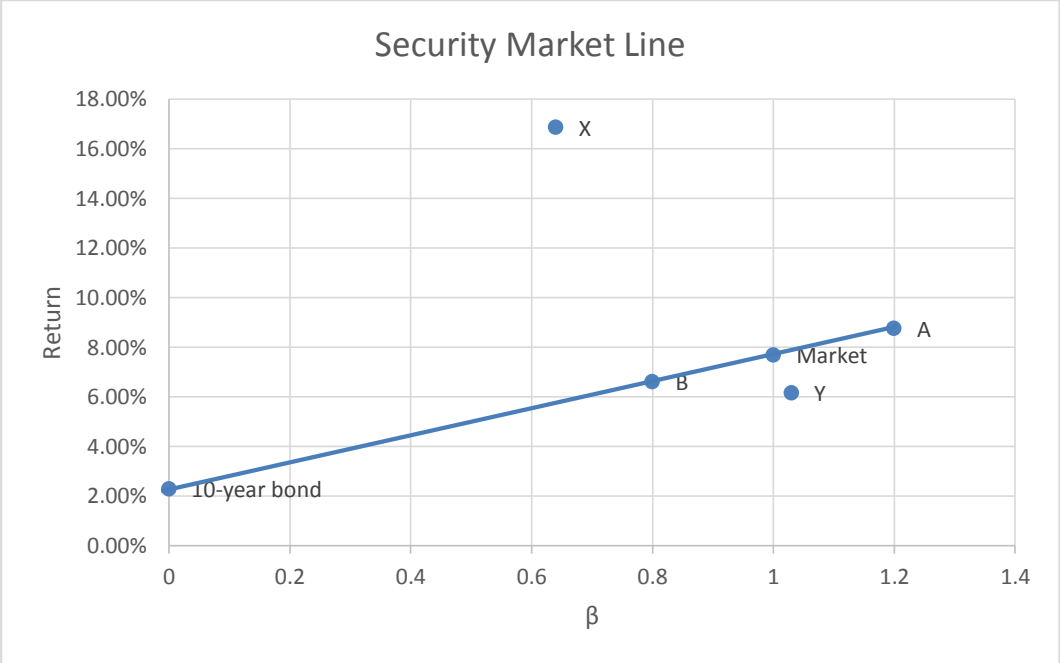


Figure 10: Undervalued and overvalued stocks with security market line

If a stock delivers return which is not plotted in the security market line, then that stock is not correctly priced. In reality, it is hard to find any stock that has fair value. The reason is that a market is the combination between bulls and bears (terms that describe a group of investors who believe that stock market will rise or decline). No individual can control the market, hence stocks are not fairly priced.

On the other hand, the security market line only gives a quick look on the stock. It is not a tool for thorough analysis. Thus, to discover the intrinsic value of an asset, investors are required to have variety of security analysis knowledge.

4.6 Optimal portfolio

In order to find the optimal portfolio in CAPM, the author hereby introduces the following concepts: The efficient frontier and capital market line.

4.6.1 The efficient frontier

If we look back at the example in section 3.3.2 when the author described a two-asset portfolio, we can see that the weight for each asset equals 0.5. In fact, these weights could be adjusted depends on type of investors. For a conservative investor, the weight of Apple Inc. stock could be decreased since it has higher standard deviation than Johnson&Johnson stock. Hence, investors have plenty of options to adjust their investments. However, every combination has its own risks. For that reason, the investor need to identify the portfolio which delivers the highest possible return or lowest level of risk and it should be positioned in the efficient frontier. According to Reilly et al. (2003), *"the efficient frontier represents that set of portfolios that has the maximum rate of return for every given level of risk, or the minimum risk for every level of return"* (Reilly, et al. 2003, 228). The figure below will illustrate the concept.

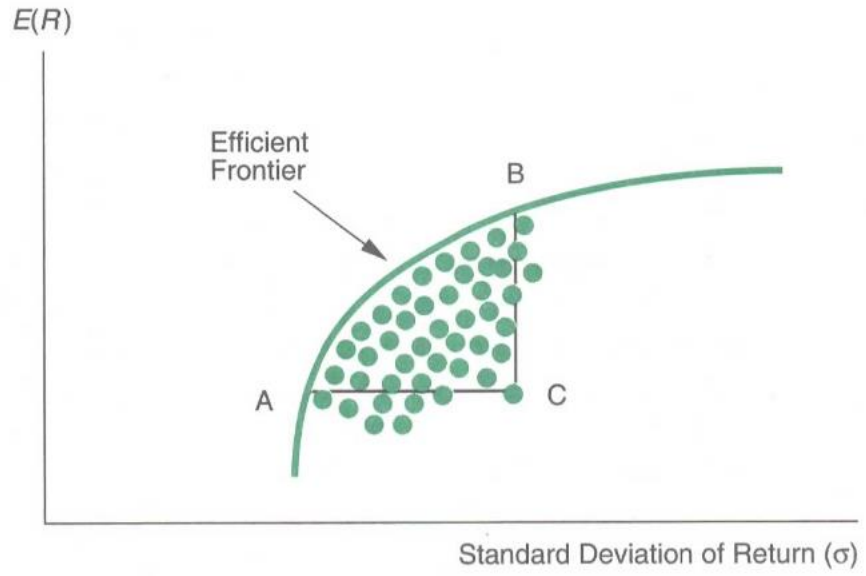


Figure 11: The efficient frontier

(Reilly, et al. 2003, 229)

As shown in figure 11, the triangle ACB is the collection of all possibilities of portfolio combining two assets. These options have different weights for each asset. Nevertheless, all combinations from A to B will give investors either maximum return for given level of risk or minimum risk for level of return. It is so-called the efficient frontier.

Furthermore, investors can define which combination is inefficient and efficient by looking at the figure. For inefficient ones, the more to the right, the less efficient the portfolio is because it can be replaced by other combinations with higher return for same level of risk. It can be seen that at point A deliver the best portfolio with lowest standard deviation. There is no other portfolio that offer the same return and less risk. (Berk, et al. 2011, 343)

4.6.2 Capital market line

Unlike the security market line which evaluates value of an asset, the capital market line represents the portfolio as a whole. It illustrates the relation between rates of return for efficient portfolio includes risk-free asset and measures standard deviation of a particular portfolio. It is considered superior to the efficient frontier because it combines risky and risk-free asset. (Investopedia). From previous chapter, the author has mentioned how to adjust the weights of chosen assets in a portfolio. The missing component in those examples is the risk-free asset. Consider the principle of diversification which emphasizes that investors need to spread their capital among financial instruments, the possibility of investing in such asset, the range of opportunities widens further (Pike, et al. 2009, 246-247). Not only the number of asset increases but also, the investor can borrow on risk-free asset and invest more in stocks.

Because the capital market line is superior, it represents all the efficient combinations. Hence, optimal portfolio should be on it. In fact, it is the intersection between the efficient frontier and capital market line. And it is called the tangency portfolio. Though we can only identify the efficient frontier through computer-based program by calculating all possible combinations, but investors are able to illustrate the capital market line using following formula.

$$\mathbf{ER_p = R_f + [\frac{ER_m - R_f}{6_m}] \times 6_p} \qquad \mathbf{(14)}$$

(Pike, et al. 2009, 248-249)

As can be seen, the capital market line starts from risk-free rate of return and increase as well as the standard deviation of the portfolio. The higher the 6_p, the higher the expected return on portfolio. The idea behind the optimal portfolio is to

maximize risk and return trade-off. The best combination is when the efficient frontier and the capital market line coincide. When all investors hold homogenous expectations, this intersection represents the efficient portfolio also equals to market portfolio (Berk, et al. 2011, 357-359). The example below will demonstrate the concept.

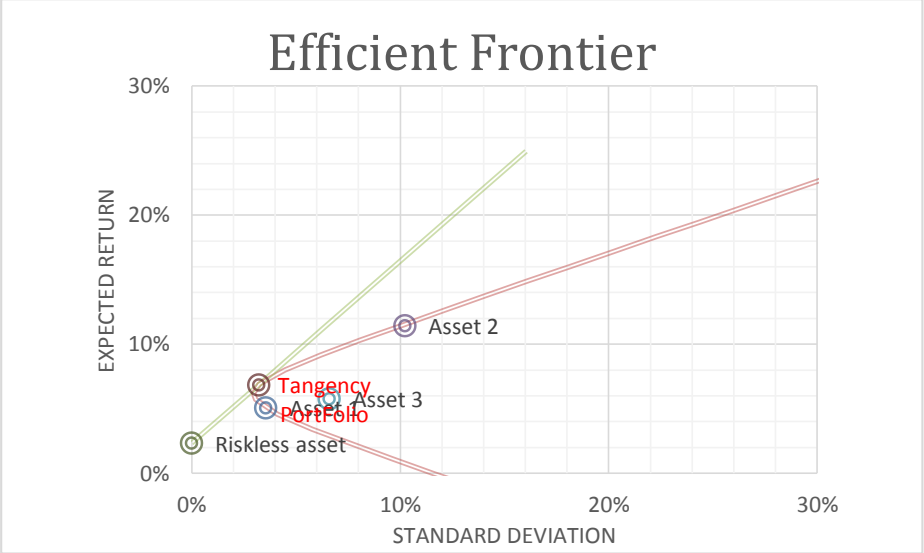


Figure 12: Tangency portfolio of 3 assets with riskless asset

The above example was conducted by the author and the three chosen assets are The Coca-Cola Company, General Motors and Nike Inc. As it is shown in the figure, we can find the expected return of the portfolio as well as the standard deviation. From the tangent point, investors can either borrow or lend riskless asset depends on their risk bearing ability. From this, investors can trace back the weight of each asset and thus, invest in certain amount from the calculation. This idea will be tested in empirical study where the author allocated chosen stocks.

4.7 Assumptions behind the Capital Asset Pricing Model

The CAPM is widely used though it still holds some assumptions which are not practical in reality. However, this study still needs to explain those assumptions in order to guide investors to consider and adjust their decisions. Assumptions behind the CAPM are discussed extensively in all finance materials. But the author decided to mention only few simple and main assumptions.

Firstly, investors are able to trade securities with their fair price and borrow and lend risk-less asset unlimitedly (Berk, et al. 2011, 357). In stock market, assets are usually either overvalued or undervalued. The main reason is that investors sometimes overreact to good news and bad news from economy (Incademy). In addition, market combines bulls and bears, thus the volatility of a stock could go up and down in a short-term horizon. Also, risk-less asset is impossible in real life because it still contains minor risk such as default risk, interest rates.

Secondly, all investors are rational and risk-averse. They aim at maximize return and minimize risk (Pike, et al. 2009, 245-246). As mentioned before, investors can be aggressively invest all in stocks or conservative by dividing the capital in certain amount. But the CAPM only consider risk aversion investors and thus is not suitable for aggressive ones.

Lastly, calculated return mentioned is expected. There might be loss or profit depends on how the market behaves. Furthermore, the CAPM assumes that all investor hold homogeneous expectations and agree about returns of all assets (Solnik, et al. 2009, 121). This assumption in fact is not true. In the first assumption, the author has explained that a stock market consists of bulls and bears. For that reason, it is not correct to assume that all investors hold the same expectations.

To conclude this chapter, the author had introduced the capital asset pricing model formula. The most important component is beta. It measures the movement of the asset with its market. By using the formula, an asset can be evaluated through the security market line. If the expected return is lower than required return, it is considered to be overvalued while undervalued asset is just the opposite. Following that is the capital market line which shows all efficient combinations for different degree of risk. The intersection between efficient frontier and capital market line is the optimal portfolio which gives the best return for any level of volatility. The author had briefly explained all concepts in order to help readers to understand the conducted empirical study in the next chapter.

5 CASE ANALYSIS

To demonstrate the theoretical framework in previous chapters, the author attempted to prove two main points which are: Diversification principle and positioning assets in optimal portfolio using CAPM. In order to do that, the author has randomly chosen these following stocks:

- The first portfolio is comprised of three stocks in same industry: Apple Inc. (AAPL), Microsoft Corp. (MSFT) and Intel Corp. (INTC). These are all in technology industry.
- The second portfolio consists of following stocks: The Coca-Cola Company (KO), Johnson & Johnson (JNJ) and Nike Inc. (NKE). They are from totally different industries which are beverage and food, heath care and clothing respectively.

The applied research method is deductive method which starts from theory and leads to hypotheses. Therefore, the author also came up with some hypotheses.

5.1 Sub-case 1

The first sub-case was made to prove the effect of diversification. Two portfolios have same amount of holding stocks which is 1000. This amount is divided equally to three chosen stocks with the number of 333 shares. To clarify the diversification effect, the writer proposed to establish hypotheses as follow:

H_0: A portfolio consists of three stocks from different industries (portfolio number 2) gives higher return and lower standard deviation.

H_1: A portfolio consists of three stocks from different industries (portfolio number 2) gives lower return and higher standard deviation.

The table 6 below will demonstrate the idea:

Table 6: Weights of chosen stocks for sub-case 1

Portfolio number 1		Portfolio number 2	
Apple Inc. (AAPL)	333 shares	The Coca-Cola Company (KO)	333 shares
Microsoft Corp. (MSFT)	333 shares	Johnson & Johnson (JNJ)	333 shares
Intel Corp. (INTC)	333 shares	Nike Inc. (NKE)	333 shares

5.1.1 Result from calculation

Firstly, the author needed to find out the standard deviation and correlation coefficient between these chosen stocks. In order to do that, the author has collected historical prices. Datas were collected through website www.finance.yahoo.com from each stock monthly for 31 periods during January 2011 until July 2013. An appendice is enclosed for the information. Table 7 below will show the result for portfolio 1.

Table 7: Descriptive analysis and correlations between stocks in portfoio 1

Descriptive Statistics

	Mean	Std. Deviation	N
Apple	.008068	.0577127	31
Microsoft	.014629	.0789298	31
Intel	.008139	.0616082	31

Correlations

		AAPl	MSFT	INTC
Apple	Pearson Correlation	1	.308	.619**
	Sig. (2-tailed)		.092	.000
	N	31	31	31
Microsoft	Pearson Correlation	.308	1	.136
	Sig. (2-tailed)	.092		.467
	N	31	31	31
Intel	Pearson Correlation	.619**	.136	1
	Sig. (2-tailed)	.000	.467	
	N	31	31	31

As can be seen, since three chosen stocks are from same industry, the correlation coefficients between them are quite high range from 0.136 to 0.619.

Following is table 8 which shows results from portfolio 2.

Table 8: Descriptive analysis and correlations between stocks in portfolio 2

Descriptive Statistics

	Mean	Std. Deviation	N
Coca-Cola	.009139	.0355956	31
Johnson&Johnson	.014629	.0789298	31
Nike	.015719	.0659341	31

Correlations

		KO	JNJ	NKE
Coca-Cola	Pearson Correlation	1	.007	-.066
	Sig. (2-tailed)		.972	.723
	N	31	31	31
Johnson&Johnson	Pearson Correlation	.007	1	.067
	Sig. (2-tailed)	.972		.720
	N	31	31	31
Nike	Pearson Correlation	-.066	.067	1
	Sig. (2-tailed)	.723	.720	
	N	31	31	31

The result from computed calculation showed that these stocks have outstanding correlation effect because they are ranged from -0.066 to 0.067 which are also lower than results from portfolio 1.

Secondly, expected return of each stock needs to be identified by using the formula of capital asset pricing model. These expected returns will be used in order to find expected return of the whole portfolio.

Table 9: Expected returns of chosen stocks using CAPM formula

Source: www.finance.yahoo.com

	Apple Inc.	Microsoft Corp.	Intel Inc.	The Coca-Cola Company	Johnson&Johnson	Nike Inc.
Beta	1.03	0.69	1.03	0.51	0.61	0.64
R_e	7.90%	6.06%	7.90%	5.08%	5.62%	5.80%

Finally, the author need to calculate portfolio's standard deviation, expected return and coefficient of variation. Table 10 will summarise the results from both portfolio.

Table 10: Summaries of both portfolios

	Portfolio 1	Portfolio 2
Standard deviation	4.93%	3.69%
Expected return	7.28%	5.49%
Coefficient of variation	0.68	0.67

By comparing the correlation coefficient tables of both portfolios and the coefficient of variation, we can see that portfolio 2 gives higher return and lower standard deviation. Furthermore, stocks from portfolio 2 have outstanding correlation effect which is less risky than portfolio 1. The next section is the results from these two portfolios in real life investments.

5.1.2 Result from observation

The author planned to observe these portfolios in five days. For the first sub-case which observed the diversification effect, the author has implemented the plan during week 42 from 13th – 17th October. Following is the results from both portfolios.

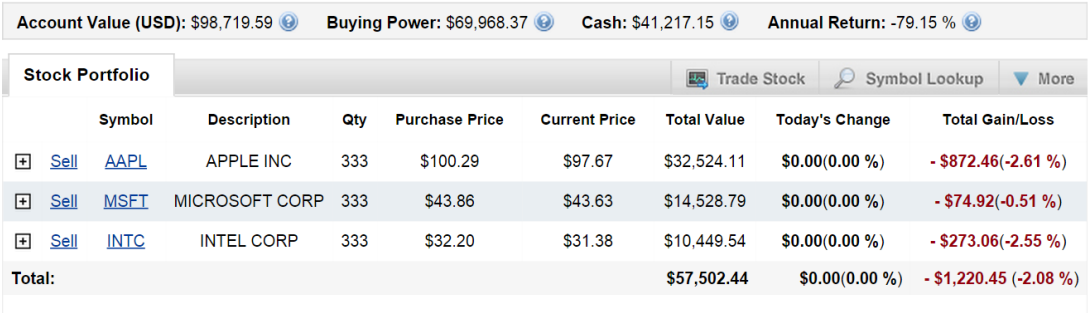
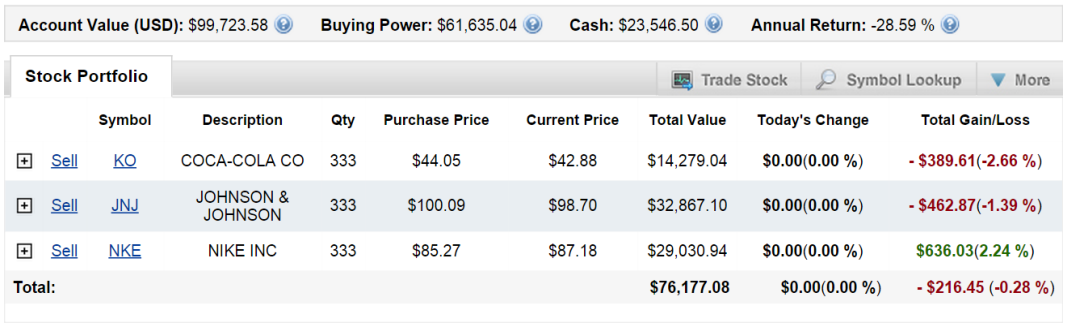


Figure 13: Stock observation for portfolio 1 (sub-case 1)



Account Value (USD): $99,723.58 **Buying Power:** $61,635.04 **Cash:** $23,546.50 **Annual Return:** -28.59 %

Stock Portfolio | Trade Stock | Symbol Lookup | More

		Symbol	Description	Qty	Purchase Price	Current Price	Total Value	Today's Change	Total Gain/Loss
⊞	Sell	KO	COCA-COLA CO	333	$44.05	$42.88	$14,279.04	$0.00(0.00 %)	- $389.61(-2.66 %)
⊞	Sell	JNJ	JOHNSON & JOHNSON	333	$100.09	$98.70	$32,867.10	$0.00(0.00 %)	- $462.87(-1.39 %)
⊞	Sell	NKE	NIKE INC	333	$85.27	$87.18	$29,030.94	$0.00(0.00 %)	$636.03(2.24 %)
Total:							$76,177.08	$0.00(0.00 %)	- $216.45 (-0.28 %)

Figure 14: Stock observation for portfolio 2 (sub-case 1)

Through these observations, though both portfolios delivered losses to investors but we can see that value of portfolio 2 decreased less than portfolio 1. In other words, portfolio 2 is more diversified than portfolio 1. Thus, investor who bought portfolio 2 has better chance avoiding the mass destruction from same industry. The more diversified your portfolio, the better return you will get. Hence, hypothesis H_0 is accepted.

5.2 Sub-case 2

In this case, the author has implemented the efficient frontier and capital market line in order to find the optimal combinations for two portfolios above. The approach to this matter was by using excel functions to calculate and position chosen stocks. The results from this case will be compared to the first case by showing the expected return, standard deviation and coefficient of variation. Also, the returns from reality portfolios will be compared. The observations were made during week 43 from 20^{th} -24^{th} October 2014. For that reason, the author will propose these hypotheses as follow:

H_0: Portfolios from case 2 give higher return and lower standard deviation than porfolios from case 1

H_1: Portfolios from case 2 give lower return and higher standard deviation than portfolios from case 1

5.2.1 Result from calculation (portfolio 1)

Combination 1: Apple Inc. (AAPL), Microsoft Corp. (MSFT) and Interl Corp. (INTC). Total share: 1000 shares

The author has discovered the tangency point of the first portfolio. An appendice was enclosed that showed all possible combinations. Figure 15 will demonstrate the best combination.

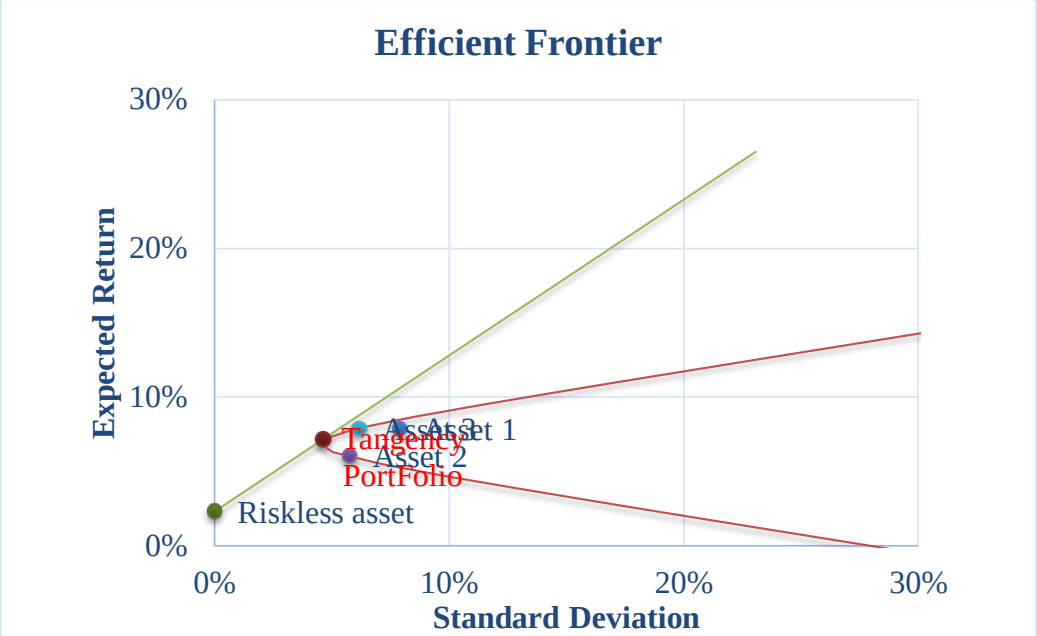


Figure 15: Tangency point of portfolio 1

As the optimal point is identified, the author was able to measure the weights for each asset. The results are shown in table 11 below.

Table 11: Result for optimal portfolio 1

Tangency Portfolio		
Expected Return		7.2%
Standard Deviation		4.6%
Weight	Apple Inc.	2.6%
	Microsoft Copr.	39.9%
	Intel Corp.	57.5%
	Total	100.0%

The comparison for both case of portfolio 1 is made in the next table.

Table 12: Comparison of first combination between 2 cases

	Case 1 (portfolio 1)	Case 2 (portfolio 1)
Standard deviation	4.93%	4.6%
Expected return	7.28%	7.2%
Coefficient of variation	0.68	0.64

As the result, the combination from case 2 give same amount of return but lower standard deviation than case 1. We can look at the coefficient of variation and see that the degree of risk in case 2 is lower than case 1.

5.2.2 Result from observation (portfolio 1)

To construct this more concrete, the author will demonstrate the return from real life investment.

Figure 16: Stock observation for portfolio 1 (sub-case 2)

As can be seen, the combination in case 2 delivered better return with more than 2,600 dollars profit while in other case, the combination gave a loss of more than thousand dollars.

5.2.3 Result from calculation (portfolio 2)

Combination 2: The Coca-Cola Company (KO), Johnson&Johnson (JNJ) and Nike Inc. (NKE). Total share: 1000 shares

By applying the same approach, the author was able to find the tangency point for portfolio 2. An appendice was attached to show all possible combinations. Figure 17 below show the tangent point of second portfolio.

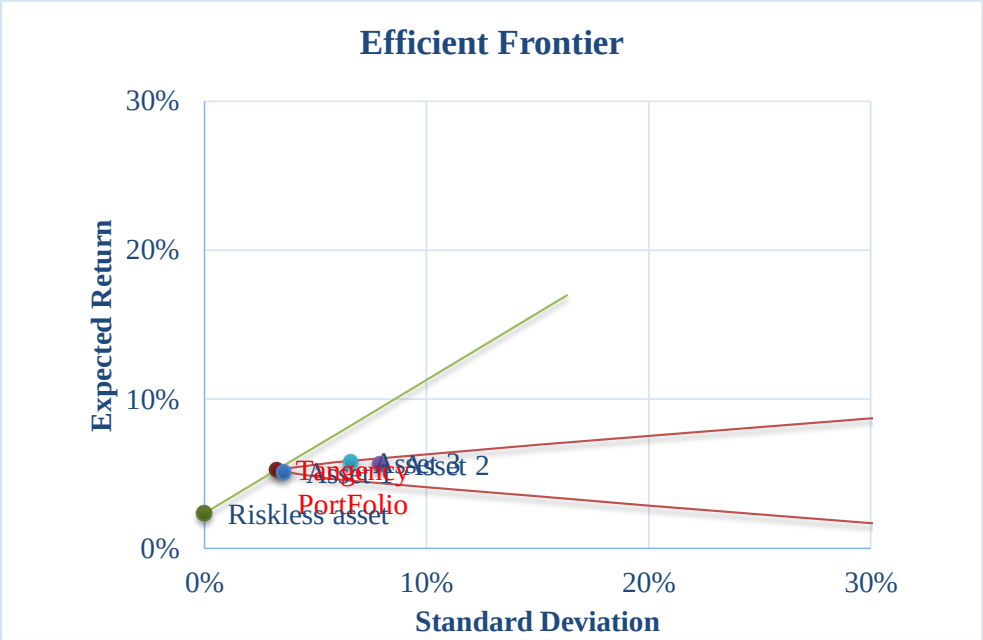


Figure 17: Tangency point of portfolio 2

With the same method, the weights for each asset were also identified as follows

Table 13: Result for optimal portfolio 2

Tangency Portfolio		
Expected Return		5.3%
Standard Deviation		3.3%
Weight	The Coca-Cola Company	71.2%
	Johnson&Johnson	17.3%
	Nike Inc.	11.5%
	Total	100.0%

A comparison table was made in order to demonstrate the differences

Table 14: Comparison of second combination between 2 cases

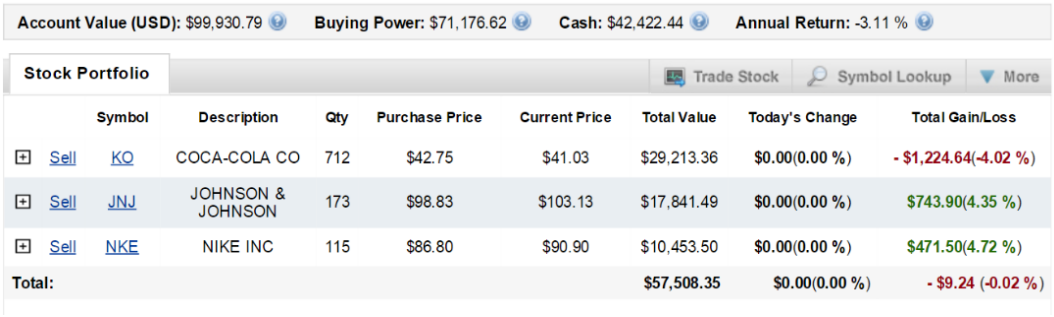
	Case 1 (portfolio 2)	Case 2 (portfolio 2)
Standard deviation	3.69%	3.3%

Expected return	5.49%	5.3%
Coefficient of variation	0.67	0.62

Once again, though in this case, the combination in case 2 gave a lower return but the CV is still lower than the case 1. By this, it means that case 1 is riskier than case 2.

5.2.4 Result from observation (portfolio 2)

In this section, the author also showed the real life portfolio and compared the actual return of 2 cases.



Account Value (USD): $99,930.79 **Buying Power:** $71,176.62 **Cash:** $42,422.44 **Annual Return:** -3.11 %

Stock Portfolio — Trade Stock | Symbol Lookup | More

	Symbol	Description	Qty	Purchase Price	Current Price	Total Value	Today's Change	Total Gain/Loss
Sell	KO	COCA-COLA CO	712	$42.75	$41.03	$29,213.36	$0.00(0.00 %)	- $1,224.64(-4.02 %)
Sell	JNJ	JOHNSON & JOHNSON	173	$98.83	$103.13	$17,841.49	$0.00(0.00 %)	$743.90(4.35 %)
Sell	NKE	NIKE INC	115	$86.80	$90.90	$10,453.50	$0.00(0.00 %)	$471.50(4.72 %)
Total:						$57,508.35	$0.00(0.00 %)	- $9.24 (-0.02 %)

Figure 18: Stock observation for portfolio 2 (sub-case 2)

Even though this combination delivered loss of 9 dollars but it is still better than the combination in case 1 where the investor divided the total shares by 3 and total loss of 216 dollars.

By combining results from previous section from 5.2.1 to 5.2.4, the author confirms that by using the efficient frontier and capital market line in CAPM, investors are able to find the optimal portfolio where it delivers the highest return for lowest volatility. However, this observation need to be longer as the risk-free rate is 10-year government bond. Thus the horizontal investment should be 10 years. The author did not have enough time to observe but the results came as expected.

6 CONCLUSIONS

In this chapter, the author will hereby conclude the thesis and summarize it. Also, he decided to put his thoughts and all obstables he had faced during this study. On the other hand, some recommendations for further researchs will be included.

The practical aim of this thesis is to aid readers understand the portfolio theory, which mostly focused on diversification principle and the approach to trading stock – the CAPM. Moreover, the basic factors of any investment are also examined: risks and returns. After that, the author combined these matters together in the application of capital asset pricing model. Theoritically, the whole process from chapter 2 to chapter 4 is one of the frameworks for any investor who wants to start trading. Though the results from practices were different from theoretical estimations, the author wanted to emphasize on theses following considerations and make sure that he has answered all research questions.

- **What are the risks and returns of an investment for investors?**

First of all, the risks and returns of an investment are foremost to any investor. They need to be identified in order to set the goals and objectives. Because the importance of investing is to create the second source of earning. Therefore, if an investment's return does not meet the criterias which were set by investor or compensate the risk, it is not sufficient enough to put capital in it. The author had mentioned two most considered terms: Systematic and specific risk. The most important systematic risks are interest rates and recession. On the other hand, specific risks are business and financial risk. However, due to the nature of this thesis, he was not able to conclude all types of risk.

- **What is diversification and its advantages?**

The second matter is the diversification principle that was studied in chapter 3. As we all know, the more assets added the more diversified the portfolio. A diversified portfolio only deals with market risks because specific risks are ignored. With the number of stocks more than 500, 99 percent of unsystematic risks is reduced. That is the advantage of diversification. However, portfolio is a combination of different investments with different weights. Investors need to

consider their risk bearing ability in order to adjust the components. For risk-averse investor, he or she will put more money in bonds and other safetier financial instruments while the risk-tolerated ones would spend in stocks aggressively. This is just a reminder for investors when they have identified the risks and returns, hence modify their adjustments.

- **How can investors position assets in a portfolio using CAPM?**

The CAPM is the last topic that need to be considered in this section. Capital asset pricing model is one of the simplest methods to measure a security's required return. By defining the risk-free rate and return on market, investors then can find the required return for each asset with its beta respectively. In addition, combining the effect of efficient frontier and capital market line, the optimal portfolio is found. Results came with different weights for assets. Based on that, investor can maximize the return for any level of risks, because the optimal portfolio is also considered as market portfolio.

Nonetheless, it does not cover the whole big picture, because the stock market is affected by many factors from governments, supply and demand to company's business such as financial, operations and so on. Also, it holds several important assumptions which do not exist in reality. For that reason, this study only gives readers a brief look on investing as well as concerned factors.

6.1 Validity and reliability

Validity and reliability are important to a study using quantitative method because they help readers understand the use of the results and also consider the further studies.

About the validity aspect, the author followed the process of deductive method. The study started with theories from risks and returns, diversification principle to the capital asset pricing model method. This approach is consistent and logical that give readers a comprehensive structure. Definitions and examples were given in order to illustrate the ideas each chapter. Theories were collected through multiple trustworthy sources such as books, well-known websites and published universities' studies. The emprirical study was based on datas collected from

Yahoo Finance which is considered accurate and up-to-date information. Also, the calculation was done through SPSS program and Excel. Thus, the thesis is considered highly valid.

Regarding the reliability of the study, the datas were collected during 2-year period from 2011 to 2013 with monthly returns from chosen companies. The author believed that if under current situation without any sudden occurs in macroeconomic aspect, the result would probably give the same answer. However, the author wants to remind that these occurs are unpredictable. Hence, investors need to carefully update the news. In general, this thesis is reliable.

6.2 Recommendations for further studies

As mentioned in chapter 4 with the definition of security market line, investor only can find the required return of an asset and estimate whether it is overvalued or undervalued. It does not give a thorough analysis on asset because in reality, price of stock mostly changes due to its business. For that reason, the author recommend that researchers should consider a more comprehensive approach for better analysis.

On the other hand, the CAPM has many branches as it was developed to fit to real life investment. The author also encourage readers to study about others to acquire themselves with full knowledge of capital asset pricing model. Moreover, there were several other models which were tested to be effective to analyze an assets. This is considered as an opportunity for other researchers to start examining those models.

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APPENDICES

Appendice 1: Beta of 100 US large-cap stock (long term and current time)

Ticker	**Company**	**Beta Estimate (long-term average)**	**Beta Estimate (current time-varying estimate)**
AAPL	Apple Inc	0.97	0.71
ABT	Abbott Laboratories	0.43	1.01
ACN	Accenture Ltd	0.86	1.14
AEP	American Electric Power	0.48	0.61
AIG	American International Group	2.12	1.61
ALL	Allstate Corporation	1.14	1.11
AMGN	Amgen Inc	0.56	0.66
AMZN	Amazon.Com Inc	1.16	1.28
APA	Apache Corp	1.45	1.21
APC	Anadarko Petroleum Corp	1.41	1.28
AXP	American Express Co	1.60	1.08
BA	Boeing Co	1.19	1.03
BAC	Bank Of America Corp	2.56	1.72
BAX	Baxter International Inc	0.53	0.93
BK	The Bank of New York Mellon Corporation	1.49	1.36
BMY	Bristol-Myers Squibb Co	0.50	0.88
BRKB	Berkshire Hathaway Cl B	0.84	0.85
C	Citigroup	2.72	1.60
CAT	Caterpillar Inc	1.58	1.43
CL	Colgate-Palmolive Co	0.43	0.64
CMCSA	Comcast Corp Cl A	1.12	1.13
COF	Capital One Financial Cp	2.07	1.40
COP	ConocoPhillips	1.04	0.95
COST	Costco Wholesale Corp	0.65	0.66
CSCO	Cisco Systems Inc	1.09	1.09
CVS	Cvs Caremark Corp	0.78	0.83

CVX	Chevron Corp	0.96	1.01
DD	E. I. du Pont de Nemours and Co	1.35	1.23
DIS	The Walt Disney Company	1.15	1.20
DOW	Dow Chemical Co	1.82	1.50
DVN	Devon Energy Corp	1.27	1.31
EBAY	Ebay Inc	1.26	0.96
EMC	Emc Corp	1.11	0.91
EMR	Emerson Electric Co	1.19	1.25
EXC	Exelon Corporation	0.51	0.27
F	Ford Motor Co	1.80	1.43
FCX	Freeport Mcmoran C&G B	1.73	1.93
FDX	Fedex Corp	1.34	1.24
GD	General Dynamics Corp	1.09	1.06
GE	General Electric Co	1.60	1.25
GILD	Gilead Sciences Inc	0.68	1.09
GOOG	Google	0.96	1.06
GS	Goldman Sachs Group Inc	1.44	1.51
HAL	Halliburton Co	1.44	1.45
HD	Home Depot Inc	1.01	0.86
HON	Honeywell International	1.27	1.28
HPQ	Hewlett-Packard Co	1.14	1.14
IBM	International Business Machines Corporation	0.74	0.74
INTC	Intel Corp	1.09	1.16
JNJ	Johnson & Johnson	0.48	0.73
JPM	JPMorgan Chase and Co	1.77	1.45
KO	Coca-Cola Co	0.47	0.53
LLY	Eli Lilly & Company	0.59	0.68
LMT	Lockheed Martin Corp	0.65	0.68
LOW	Lowe's Companies Inc	1.17	1.18
MA	MasterCard Inc	1.01	1.01

MCD	McDonalds Corp	0.37	0.38
MDLZ	Mondelez International Inc	0.48	1.07
MDT	Medtronic Inc	0.91	0.95
MET	Metlife Inc	2.10	1.86
MMM	3M Company	1.01	1.02
MO	Altria Group Inc	0.28	0.56
MON	Monsanto Co	1.10	1.05
MRK	Merck & Co	0.68	0.58
MS	Morgan Stanley	2.00	1.96
MSFT	Microsoft Corp	0.95	1.00
NKE	Nike Inc Cl B	0.89	0.86
NOV	National Oilwell Varco Inc	1.49	1.22
NSC	Norfolk Southern Corp	1.33	1.16
ORCL	Oracle Corporation	1.05	1.10
OXY	Occidental Petro Cp	1.14	0.88
PEP	Pepsico Inc	0.43	0.68
PFE	Pfizer Inc	0.59	0.66
PG	Procter & Gamble Co	0.41	0.64
PM	Philip Morris International	0.57	0.66
QCOM	Qualcomm Inc	0.83	0.88
RTN	Raytheon Co	0.74	0.76
SBUX	Starbucks Corporation	1.24	1.04
SLB	Schlumberger Ltd	1.31	1.13
SO	Southern Company The	0.27	0.27
SPG	Simon Property Group	1.44	0.86
T	AT&T Inc	0.56	0.59
TGT	Target Corporation	0.78	0.57
TWX	Time Warner Inc	1.09	1.08
TXN	Texas Instruments Inc	1.00	1.11
UNH	UnitedHealth Group Inc.	0.86	0.75
UNP	Union Pacific Corp	1.29	1.00
UPS	United Parcel Service B	0.95	0.89

USB	US Bancorp	1.70	1.02
UTX	United Technologies Corp	1.04	1.12
V	Visa Inc	0.93	0.90
VZ	Verizon Communications	0.50	0.50
WAG	Walgreen Co	0.72	0.96
WFC	Wells Fargo & Company	1.95	1.17
WMT	Wal-Mart Stores Inc	0.36	0.41
XOM	Exxon Mobil Corporation	0.79	0.84

(ABG Analytics 2013)

Appendice 2: Market risk premium of 40 countries in 2014

1 USA	5.40%	21 Norway	5.80%
2 Spain	6.20%	22 Argentina	11.80%
3 Germany	5.40%	23 Colombia	8.10%
4 UK	5.10%	24 Portugal	8.50%
5 Italy	5.60%	25 Denmark	5.10%
6 Canada	5.30%	26 Japan	5.30%
7 Mexico	7.40%	27 Poland	6.30%
8 Brazil	7.80%	28 Greece	15.00%
9 France	5.80%	29 Finland	5.60%
10 South Africa	6.30%	30 New Zealand	5.60%
11 China	8.10%	31 Peru	7.80%
12 Australia	5.90%	32 Luxembourg	4.90%
13 Netherlands	5.20%	33 Turkey	7.90%
14 Switzerland	5.20%	34 Czech Republic	6.50%
15 Russia	7.90%	35 Israel	5.80%
16 India	8.00%	36 Indonesia	7.90%
17 Sweden	5.30%	37 Korea	6.30%
18 Chile	6.00%	38 Taiwan	7.50%
19 Austria	5.50%	39 Ireland	6.80%
20 Belgium	5.60%	40 Singapore	5.70%

(Fernandez, et al. 2014)

Appendice 3: All possible combination of portfolio 1 (32 combinations in total)

	RANK	Unsorted E(R)	Col_Index	**Sorted E(R)**	**Standard Deviation**	Weight			Total
						Asset 1	Asset 2	Asset 3	
Tangency Port	12	7.2%	1	**15.8%**	**36.0%**	203%	-430%	327%	100%
Minimum Var	14	6.9%	2	**15.0%**	**32.9%**	184%	-387%	302%	100%
0	1	15.8%	3	**14.2%**	**29.7%**	166%	-344%	278%	100%
1	2	15.0%	4	**13.4%**	**26.6%**	148%	-301%	253%	100%
2	3	14.2%	5	**12.6%**	**23.5%**	129%	-258%	228%	100%
3	4	13.4%	6	**11.8%**	**20.4%**	111%	-215%	204%	100%
4	5	12.6%	7	**11.0%**	**17.3%**	93%	-172%	179%	100%
5	6	11.8%	8	**10.3%**	**14.3%**	75%	-129%	154%	100%
6	7	11.0%	9	**9.5%**	**11.3%**	56%	-86%	130%	100%
7	8	10.3%	10	**8.7%**	**8.5%**	38%	-43%	105%	100%
8	9	9.5%	11	**7.9%**	**6.0%**	20%	0%	80%	100%
9	10	8.7%	**12**	**7.2%**	**4.6%**	3%	40%	57%	100%
10	11	7.9%	13	**7.1%**	**4.6%**	1%	43%	56%	100%
11	13	7.1%	14	**6.9%**	**4.5%**	-4%	55%	49%	100%
12	15	6.3%	15	**6.3%**	**5.0%**	-17%	86%	31%	100%
13	16	5.5%	16	**5.5%**	**7.1%**	-35%	129%	6%	100%
14	17	4.7%	17	**4.7%**	**9.7%**	-54%	172%	-18%	100%
15	18	3.9%	18	**3.9%**	**12.6%**	-72%	215%	-43%	100%
16	19	3.2%	19	**3.2%**	**15.6%**	-90%	258%	-68%	100%
17	20	2.4%	20	**2.4%**	**18.7%**	-109%	301%	-92%	100%
18	21	1.6%	21	**1.6%**	**21.8%**	-127%	344%	-117%	100%
19	22	0.8%	22	**0.8%**	**24.9%**	-145%	387%	-142%	100%
20	23	0.0%	23	**0.0%**	**28.0%**	-163%	430%	-166%	100%
21	24	-0.8%	24	**-0.8%**	**31.1%**	-182%	473%	-191%	100%
22	25	-1.6%	25	**-1.6%**	**34.3%**	-200%	516%	-216%	100%
23	26	-2.4%	26	**-2.4%**	**37.4%**	-218%	559%	-240%	100%
24	27	-3.2%	27	**-3.2%**	**40.6%**	-237%	602%	-265%	100%
25	28	-3.9%	28	**-3.9%**	**43.7%**	-255%	645%	-290%	100%
26	29	-4.7%	29	**-4.7%**	**46.9%**	-273%	688%	-314%	100%
27	30	-5.5%	30	**-5.5%**	**50.0%**	-292%	731%	-339%	100%
28	31	-6.3%	31	**-6.3%**	**53.2%**	-310%	774%	-364%	100%
29	32	-7.9%	32	**-7.9%**	**59.5%**	-347%	860%	-413%	100%

Calculation form was retrieved from Phd. Francis Clark

(Francis 2012)

Appendice 4: All possible combination for portfolio 2 (32 combinations in total)

	RANK	Unsorted E(R)	Col_Index	**Sorted E(R)**	**Standard Deviation**	Weight			Total
						Asset 1	Asset 2	Asset 3	
Tangency Port	**12**	**5.3%**	1	**11.6%**	**54.1%**	-874%	215%	759%	100%
Minimum Var	13	5.2%	2	**11.0%**	**49.2%**	-787%	196%	691%	100%
0	1	11.6%	3	**10.4%**	**44.3%**	-701%	178%	622%	100%
1	2	11.0%	4	**9.8%**	**39.4%**	-614%	160%	554%	100%
2	3	10.4%	5	**9.3%**	**34.5%**	-527%	142%	485%	100%
3	4	9.8%	6	**8.7%**	**29.6%**	-441%	124%	417%	100%
4	5	9.3%	7	**8.1%**	**24.8%**	-354%	106%	348%	100%
5	6	8.7%	8	**7.5%**	**19.9%**	-268%	88%	280%	100%
6	7	8.1%	9	**6.9%**	**15.1%**	-181%	70%	211%	100%
7	8	7.5%	10	**6.4%**	**10.3%**	-94%	52%	142%	100%
8	9	6.9%	11	**5.8%**	**5.9%**	-8%	34%	74%	100%
9	10	6.4%	**12**	**5.3%**	**3.3%**	71%	17%	11%	100%
10	11	5.8%	13	**5.2%**	**3.2%**	79%	16%	5%	100%
11	14	5.2%	14	**5.2%**	**3.2%**	79%	16%	5%	100%
12	15	4.6%	15	**4.6%**	**5.9%**	165%	-2%	-63%	100%
13	16	4.1%	16	**4.1%**	**10.3%**	252%	-20%	-132%	100%
14	17	3.5%	17	**3.5%**	**15.1%**	339%	-38%	-200%	100%
15	18	2.9%	18	**2.9%**	**19.9%**	425%	-57%	-269%	100%
16	19	2.3%	19	**2.3%**	**24.8%**	512%	-75%	-337%	100%
17	20	1.7%	20	**1.7%**	**29.6%**	598%	-93%	-406%	100%
18	21	1.2%	21	**1.2%**	**34.5%**	685%	-111%	-474%	100%
19	22	0.6%	22	**0.6%**	**39.4%**	772%	-129%	-543%	100%
20	23	0.0%	23	**0.0%**	**44.3%**	858%	-147%	-611%	100%
21	24	-0.6%	24	**-0.6%**	**49.2%**	945%	-165%	-680%	100%
22	25	-1.2%	25	**-1.2%**	**54.1%**	1031%	-183%	-748%	100%
23	26	-1.7%	26	**-1.7%**	**59.0%**	1118%	-201%	-817%	100%
24	27	-2.3%	27	**-2.3%**	**63.9%**	1204%	-219%	-885%	100%
25	28	-2.9%	28	**-2.9%**	**68.8%**	1291%	-237%	-954%	100%
26	29	-3.5%	29	**-3.5%**	**73.7%**	1378%	-255%	-1022%	100%
27	30	-4.1%	30	**-4.1%**	**78.6%**	1464%	-273%	-1091%	100%
28	31	-4.6%	31	**-4.6%**	**83.5%**	1551%	-291%	-1159%	100%
29	32	-5.8%	32	**-5.8%**	**93.3%**	1724%	-328%	-1296%	100%

Calculation form was retrieved from Phd. Francis Clark

(Francis 2012)