



## Portfolio Selection Strategies in Bursa Malaysia Based on Quadratic Programming

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### Abstract

The study aims to select the efficient portfolio on stock listed in Bursa Malaysia by using the quadratic programming method. It can help the investors to gain expected returns from the diversification portfolio. However, there are some problems that should be considered such as the measurement of inputs for Mean-Variance Models (MVM), use of portfolio models through time and consistency with management objectives in the portfolio. These problems will affect the performance of selected portfolio and cause the loss problem. Therefore, this study implements a quadratic programming approach to select an efficient portfolio on stocks listed in Bursa Malaysia. The study will choose 15 potential companies which have the best performance in the Bursa Malaysia. Quadratic programming (QP) model can solve any type of mathematical optimisation problem in the study. Therefore, investors can optimise the investment portfolio returns by using QP methods. However, we can observe the efficient frontier which is a graph that representing a list of portfolios that optimising expected return for a different level of portfolio risk so can help the investors make a good decision. The findings of this study will give important inputs, especially to the investors to maximise their portfolio return at different level of risks.



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### 1. Introduction

In this advanced era, investment is a common way for us to earn money. Investors always concern about how much they will allocate or how much they will gain the money from their investment and the risk that they will face in the investment. The concept of investment refers to the process of funds allocation to hold assets for a future period [1]. An efficient portfolio refers to a portfolio that yields the highest possible return given a certain level of risk that the investor is willing to take [2]. Therefore, investors should understand how much risk they willing to take to receive the expected return. They should understand the portfolio optimisation, which is a risk management, and know how to obtain the optimal solution of portfolio allocation. The different portfolio allocation will bring a different amount

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of profit to investors. The investment by this meaning focuses much on the hypothesis of the Portfolio Selection [3]–[6]. Therefore, investors should implement some investment strategies to help them make the right decision for investment. Process of selection in a portfolio is one of the strategies in investment. According to Markowitz, the model of portfolio selection is as follows:

- (a)  $n$  securities
- (b) an initial sum of money to be invested
- (c) the beginning of a holding period
- (d) the end of the holding period

Quadratic programming (QP) is a type of mathematical programming in which the objective function represented by quadratic function aims to minimise (maximise) subject to a linear function as a constraint. In the functional management areas, The QP model of Markowitz can be considered as one of the most established mathematical programming methods to solve the portfolio management problem [7].

Recently, a new virus occurs which is coronavirus (Covid-19) and first emerged in the Chinese city of Wuhan last December [8]. Based on the statistical data, China is the world's second-largest economy developed country and confirmed cases are more than 80,000 infections have been reported since Covid-19. Consequently, it will slow down the global economic and financial market. Unarguable fact is this Covid-19 pandemic also gives a huge effect to the global economy. This will cause the major institutions and banks who have rich experience and knowledge in the economy field also cannot forecast for the circumstance of the economy in the future. Thus, this is a threat to the development of modern economy and investors today [9].

However, Bank Negara Malaysia (BNM) and Securities Commission Malaysia (SC) think some strategies to control this situation. In Malaysia, we are being hit by two shocks which are the spread of COVID-19 and the sharp decline in oil prices. For example, Bank Negara Malaysia (BNM) lowered the Overnight Policy Rate (OPR) by 25 basis points to 2.50%, citing market disruptions, greater risk aversion and financial market volatility, and tighter financial conditions due to COVID-19. SC and Bursa Malaysia suspended short selling until April 30, but the suspension was extended through June 30. SC also waived annual licensing fees for capital market licensed entities. These policies aim to protect our economic market and minimise the loss due to the pandemic of COVID-19 and the sharp decline in oil prices [10].

Investors should be focused on the investment strategy that can help them to earn more money with the less risk they faced in the diversification of their portfolio. Based on [11], Markowitz's modern portfolio theory, which won the Nobel Memorial Prize for the economic sciences in 1990, the function of this theory was it can examine the elements such like asset returns, risks, correlation, and diversification affect investment portfolio returns. It can identify the information and help the investors can acquire the return which they expected with the acceptable risk in the portfolio selected.

Apart from that, quadratic programming (QP) was designed to optimise the usage of limited resources and it also can solve portfolio selection problems. Based on the [12], the quadratic programming problem is concerned with the nonlinear objective function and linear constraints. This is because the quadratic programming method can calculate a quantitative problem when the model has been formulated. Based on the [13], QP methods solved the problems which it was a set of linear equality and inequality constraints and each subproblem of reducing energy shortage with a quadratic objective. Based on [14]–[16], they introduced the several method and algorithms for solving the QP problem. There are some QP problems such as [17] studied the unconstrained binary quadratic programming problem.

There are some problems in existing portfolio selection approaches. Firstly, one of the major problems is the measurement of inputs for Mean-Variance Models (MVM) [18]. For instance, analysts have limited ability to forecast the price changes of stocks since all the information would be incorporated in the stock prices in an efficient market. This incident indicates that the portfolio selection models would have very limited usefulness due to the stock trading should only be undertaken to sustain a diversified position and possibly to sustain some targeted level of systematic risk. If analysts could forecast the returns on individual stocks very accurately then portfolio selection models would again be redundant.

Moreover, another problem of portfolio selection approach is using portfolio models through time [19]. Generally, an investor would like to prefer some form of multi-period portfolio selection approach rather than a single horizon one. This can avail an investor formulate a proper basis for comparison of investments which are expected to need different lengths of time to receive the investment cost and start earning extra funds as return. Both single and multi-period portfolio selection models are likely to

be inefficient if there is any flexible variable changing the forecasts through the time being and causing additional changes in the models. Thus, the investor able to manipulate the input variable to formulate the most suitable quadratic programming model for the time being.

Apart from that, the last problem is consistency with management objectives in the portfolio [19]. If management is willing to accept the portfolios selected by a model, then its objectives should be consistent with those of management. The issue is really whether the objectives of management are to select portfolios which are efficient in nominal terms. Therefore, suitable approach like quadratic programming should be used in the portfolio so it can help to achieve the management objectives which is to obtain the expected highest return from the portfolios.

This article will be significant for student and academic investors because this article describes the important data needed before investing, the process of collecting the specific data, characteristics of the share market, and analyzing the data collected. Therefore, they can be able to calculate the expected return of each optimal portfolio selected and can identify which portfolio promising the high return. Besides that, this article also significance on the ever-changing economic market can affect the company or investors performance. Investors cannot predict the ever-changing economic market, but it will give a huge effect to investment or companies performance. In this article, portfolio selection can analyze the portfolio that face some fluctuations in the stock market happen due to macroeconomic events such as economics issues, political decision, announcements, and other aspects. The complication situation regarding investment decisions leads to improve and construct decision models that may help an investor to decide and have a better understanding of the problem.

Moreover, this article also significance on the investor's decision making on portfolio selection as the investment. Investors should be searching information about the portfolio's performance and may listen to some professionals 'advice so they can make the best decision before make investment. It can reduce the unexpected risk and gain profits. In this article, they should learn how to identify the data and calculate the expected return of each portfolio selected by using quadratic programming. This is very useful for the investors because it can help the investors clearly to know about how much that the expected return, they will gain for the certainty investment risk.

## 2. Literature Review

### 2.1. History of portofolio theory

In last century, generally financial investors evaluated individual stocks' price based on the model which was present value model published by an American economist, John Burr Williams in early 1900s. This condition happened until a model published by another American economist known as Harry M. Markowitz in 1952.

$$E(R), \text{ of Portfolio with } n \text{ assets} = w_1R_1 + w_2R_2 + \dots + w_nR_n \quad (1)$$

$$E(r) = w_1r_1 + w_2r_2 + \dots + w_nr_n, \quad (2)$$

$$\sigma_p^2 = w_1^2\sigma_1^2 + w_2^2\sigma_2^2 + 2w_1w_2Cov_{1,2}, \quad (3)$$

N is the number of assets, E(r) is a future expected return with n assets, w is the weight of the investment, R is an expected return and  $\sigma^2$  is the variance of high-risk as set.

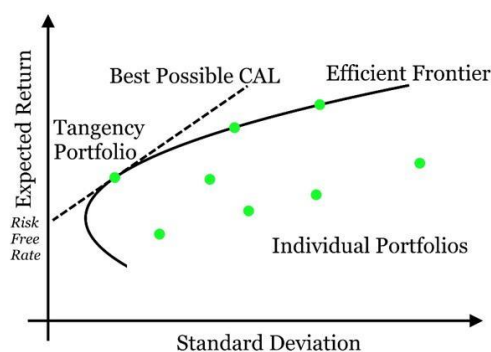


Figure 1. The efficient frontier

Therefore, Harry M. Markowitz in 1952 made his decision to do some research on this subject and succeed developed some new knowledges. He did publish his results in a seminal paper called Portfolio Selection. In his seminal paper, he developed a new model which was Mean - Variance model. By using justifiable logic which including statistics, graph, and mathematical formulas, he introduced Mean – Variance model which uses risk and mean of past investment return to calculate the variance of past investment return and use it as an indicator of expected return. Below were two equations made by Harry M. Markowitz. Furthermore, he also introduced the concept of efficient portfolios which were the higher the risk, the greater the return. He pointed out the advantages of diversification rather than “put all eggs in one basket”. After few years, he wrote a book named as “Portfolio Selection: Efficient Diversification of Investments” and this book was published in 1959. Till today, the paper and the book together became well known as Modern Portfolio Theory (MPT) and widely used in some industries, especially the financial industry.

Markowitz continued introduced and further explained the theory made in his previous paper with lots of useful ideas and practical applications for financial investment in real world. There was still no concept of demonstrating software such as Microsoft excel that we have today and not even close to the concept of computing devices like a personal computer while he wrote this book. Inside this book, majority parts of it explained beginner knowledge for regular financial investors who did not expert in statistics and finance. For example, geometric average, laws of a large number, standard deviation, and variance.

## 2.2. The efficient frontier

According to [20], he defined that the efficient frontier is a graph that representing a list of portfolios that optimising expected return for different level of portfolio risk from lowest risk till highest risk. To plot a complete efficient frontier, future expected returns and standard deviation of each portfolio asset and correlation coefficients between each pair of portfolio assets must be calculated to plot it. The shape of a complete efficient frontier will look like a curve. Based on Figure 1, we can observe that the left-most point on the curve illustrates the lowest possible value of variance among all portfolio also known as Minimum-Variance portfolio. For those investors whom willing take a lower amount of risks, they can choose any portfolio within the bottom part of the curve. Furthermore, the upper part of the curve which named as efficient frontier will contain the portfolios that able to provide higher expected return according to their risks. The efficient frontier will shift according to the diversification of portfolios. For example, the more the diversification, the efficient frontier will shift more to the left-hand side. Hudson-Wilson gave his explanation about the efficient frontier in 1995 [21].

## 2.3. Quadratic programming problem

### 2.3.1. Quadratic programming problem

A problem of Quadratic programming can define as an issue where the goal is a quadratic function of the variables of judgment with linear functions of the variables as the constraints of the problem. Without loss of generality, the definition of a QP problem is given as follows:

$$\text{Min } z = \frac{1}{2} x^T Qx + c^T x, \quad (4)$$

subject to

$$A^T x \leq b \quad (5)$$

and

$$x \geq 0 \quad (6)$$

where  $x = (x_1, \dots, x_n)^T \in \mathbb{R}^n$ ;  $Q$  is a positive definite matrix,  $c$  is a constant,  $A$  is the coefficient matrix of the constraints, and  $T$  is a transpose.

The matrix  $Q$  is a positive semidefinite matrix, then the quadratic programming problem is a convex function of  $x$ , which is true for portfolio optimisation problems. The QP problems have only one feasible region but the optimal solution may be found anywhere within the region [22]. In terms of the financial area, the Quadratic programming problem always linked to Markowitz mean-variance portfolio optimisation model. Therefore, the portfolio variance is the main goal of the quadratic function and at the same time the linear constraints indicated a lower boundary for portfolio return. Fernando also pointed out there are different formulae in portfolio optimisation problem [23]. To solve different

scenarios, there may require different mathematical methods because some scenarios consist of some linear or nonlinear constraints, equality, and non-equality constraints, and so on.

### 2.3.2. Quadratic programming model

Gerard (2005) the quadratic model allows the objective function to be quadratic. Today, there is not difficult to realise an investor has  $n$  different assets at the same time and he was expected different assets have a different expected return value. Let say the rate of return on each asset,  $i$  and  $i = 1, 2, 3, \dots, n$ , is a random variable with anticipated value  $m_i$ . Therefore, the main problem of the investor is to calculate how to align the percentage of total funds,  $x_i$  to invest in each asset  $i$  regarding minimizing risk for achieving a given minimum specified rate of return.

$$\min \frac{1}{2} * x^T * H * x + f^T * x \quad (7)$$

$$\text{s.t. } LB \leq x \leq UB \quad (8)$$

$$A_{eq}x = b_{eq} \quad (9)$$

$$Ax \leq b \quad (10)$$

$$x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \quad (11)$$

$$H = \begin{bmatrix} h_{11} & h_{12} \\ h_{21} & h_{22} \end{bmatrix} \quad (12)$$

$$f = \begin{bmatrix} f_1 \\ f_2 \end{bmatrix} \quad (13)$$

$A_{eq}$ : matrix ( $n_{eq} \times n$ ),  $b_{eq}$ : vector ( $n_{eq} \times 1$ ),  $A$ : matrix ( $n_{ineq} \times n$ ),  $b$ : vector ( $n_{ineq} \times 1$ ), and  $n$  is the number of decision variables. In this case,  $n_{eq}$  is the number of equality constraints and  $n_{ineq}$  is the number of inequality constraints.

### 2.3.3. Basic Concept of Portofolio Optimisation

Ralf Korn gave his explanation about the portfolio in 2005. A portfolio can define as the allocation of a certain portions of funds from total funds to invest over different investment choices [24].

The formula of calculating the stocks returns as follow:

$$R_i = \frac{P_t - P_{t-1} + D_t}{P_{t-1}} \quad (14)$$

Modern Portfolio Optimisation (MPT) is a theory of investment which tries to minimise risk (standard deviation of the returns) for a given level of expected return, by carefully choosing the proportions (weights) of various assets available. Therefore, the model can be written as QP problem by replacing  $Q$  in (4) with  $\sigma_{ij}$  such that the model becomes,

$$\text{Min}z = \sum_{i=1}^n \sum_{j=1}^n x_i \sigma_{ij} x_j \quad (15)$$

subject to

$$\sum_{i=1}^n x_i \mu_i = \mu_p \quad (16)$$

And

$$\sum_{i=1}^n x_i = 1 \quad (17)$$

That is, given the target expected rate of return of the portfolio  $\mu_p$ , find the portfolio strategy that minimises the portfolio variance in returns  $\sigma_p^2$ .

In general:

(i) Expected return

$$E(R_p) = \sum_i W_i E(R_i) \quad (18)$$

where  $R_p$  is return on the portfolio,  $R_i$  is return on asset  $i$  and  $W_i$  is weighting of component asset  $i$ .

(ii) Portfolios return variance

$$\sigma_p^2 = \sum_i W_i^2 \sigma_i^2 + \sum_i \sum_{j \neq i} W_i W_j \sigma_i \sigma_j P_{ij} \quad (19)$$

where  $\sigma$  is standard deviation of the periodic returns on an asset,  $P_{ij}$  is correlation coefficient between the returns on assets  $i$  and  $j$ . Alternatively, the expression can be written as:

$$\sigma_p^2 = \sum_i \sum_{j \neq i} W_i W_j \sigma_i \sigma_j P_{ij} \quad (20)$$

$P_{ij} = 1$  for  $i=j$ , or

$$\sigma_p^2 = \sum_i \sum_{j \neq i} W_i W_j \sigma_{ij} \quad (21)$$

Where

$\sigma_{ij} = \sigma_i \sigma_j P_{ij}$  = The covariance of the periodic returns on the two assets.

Or alternatively denoted as  $\sigma(i, j)$ ,  $cov(i, j)$

(iii) Portfolios return volatility (standard deviation)

$$\sigma_p = \sqrt{\sigma_p^2} \quad (22)$$

For a two-asset portfolio:

(i) Portfolio return

$$E(R_p) = W_A E(R_A) + W_B E(R_B) = W_A E(R_A) + (1 - W_A) E(R_B) \quad (23)$$

(ii) Portfolio variance

$$\sigma_p^2 = W_A^2 \sigma_A^2 + W_B^2 \sigma_B^2 + 2W_A W_B \sigma_A \sigma_B \rho_{AB} \quad (24)$$

For a three-asset portfolio:

(i) Portfolio return

$$E(R_p) = W_A E(R_A) + W_B E(R_B) + W_C E(R_C) \quad (25)$$

(ii) Portfolio variance

$$\sigma_p^2 = W_A^2 \sigma_A^2 + W_B^2 \sigma_B^2 + W_C^2 \sigma_C^2 + 2W_A W_B \sigma_A \sigma_B \rho_{AB} + 2W_A W_C \sigma_A \sigma_C \rho_{AC} + 2W_B W_C \sigma_B \sigma_C \rho_{BC} \quad (26)$$

### 3. Method

Research methodology is a method that consists of data collection and data analysis in an effective and efficient way and to ensure that way able to achieve the research objectives that set earlier before. Researcher must decide which research methods will apply in this research. This chapter was beginning with the research framework, follow by research design, population and research sample, data collection, research instrument, reliability and validity analysis, data analysis, and conclusion, respectively.

The research design will present the general idea of how the researcher conduct the research to answer the research question [25]. These research methodologies including quantitative research method, qualitative research method, and a research method which mix quantitative method and qualitative method [26]. Researcher will use quantitative research method to collect existing data from official websites such Wall Street Journal and Bursa Malaysia and conduct mathematical analysis method such as linear programming method to evaluate best portfolio.

### 3.1. Population and research sample

A target population must be identified prior before determined a small-scale of sample size. For instance, small-scale respondents from which a population was determined is called the sample. The reason that a researcher choose small-scale sample out from whole population is because it is considering impossible to amass data from all respondent in whole population due to limited resources, heavy time consuming and massive cost. Therefore, sampling method avails researcher to collect data from small-scale sample to represent whole population as accurate as possible.

#### 3.1.1. Population

A target population can define as a complete set of person or case who fulfil the requirement of targets respondent to whom the research applies. Therefore, a target population was selected based on certain characteristics and must be very specific. The specific characteristic is minimum years of establishment and their market performance. It must be subjecting to the research objectives of the study to address the problem accurately. This study is focuses on portfolio management thus, the targeted population would be the companies which has minimum 10 years history of establishment and its yearly return above average market return.

#### 3.1.2. Research sample

After determined the targeted population, the following step was identified research sample and sample size. In this study, researcher will choose 15 companies which are Xidelang Holdings Ltd, Vortex Consolidated Berhad , Inari Amertron Berhad, Xox Bhd, Supermax Corporation Berhad, Sanichi Technology Berhad, Hartalega Holdings Berhad, Ta Global Berhad, Yong Tai Berhad, Kanger International Berhad, Cimb Group Holdings Berhad, Notion Vtec Berhad, Focus Dynamics Group Berhad, Careplus Group Berhad and Oceancash Pacific Berhad and collect their existing data through official website. The reason that this research use 15 companies is to improve research accuracy and budget consideration.

The roles of secondary data in this research are to provide definition and formula of Mean-Variance Model (MVM) published by Harry Markowitz. Furthermore, secondary data also provide formula of quadratic programming model in this research. To obtain secondary data, researcher review some different sources such as previous studies, books, and others through internet. In this study, researcher will use the Bursa Malaysia which is the official stock exchange of Malaysia as collecting data and its website provide daily asset value and related information such as annual report and economic news for users. This study will use daily stock price of the selected companies sourced from Bursa Malaysia covering a period from 2014 to 2020 and the return is calculated by using Equation (1).

Data analysis is a critical part in a research because it is about to indicate whether the research was succeeded to meet research objectives or not. In data analysis phase, researcher will analyse all data from data collection phase and rearranging the data into organized way. In this research, data analysis phase was separated into two parts. First part was built efficient frontier by using data collected. In this part, researcher build an efficient frontier through Microsoft Excel. In second part which was portfolio optimisation, researcher was used quadratic programming method to calculate a portfolio which can maximise profit while minimise its risk.

## 4. Results and Discussion

This chapter shows the findings and discussions on the results obtained from the secondary data that collected from Wall Street Journal. Researcher calculates the secondary data that using by Mean-Variance Model (MVM). Data analysis is a step which is carried out after the process of data collection. Researcher uses the analysis methods is quadratic programming (QP) model to calculate the expected return for each efficient portfolio when their unexpected risk is high or low. The results of the calculation obtained are discussed and explanations in the section below.

### 4.1. Mathematical model of portfolio

#### 4.1.1. Value of stock

Researcher will collect the data such as unit price of each stock from Wall Street Journal. Researcher will select 15 companies which is Xidelang Holdings Ltd, Vortex Consolidated Berhad, Inari Amertron Berhad, Xox Bhd, Supermax Corporation Berhad, Sanichi Technology Berhad, Hartalega Holdings Berhad, Ta Global Berhad, Yong Tai Berhad, Kanger International Berhad, Cimb Group Holdings Berhad,

Notion Vtec Berhad, Focus Dynamics Group Berhad, Careplus Group Berhad and Oceancash Pacific Berhad from Bursa Malaysia and separate them in 7 different groups. The companies have the most active performance and can gain the profits for investors. The data will be collected from 2014 until 2020. Therefore, researcher will summarize it from 2 January 2014 until 30 June 2014 in the table. Researcher also separates the companies into 7 different groups based on their core business such as sports shoes, consumer bank, entertainment, and food beverage (F&B), property, latex glove, electronic and electrical and raw materials.

#### 4.1.2. Return

To calculate the return that given by the companies, researcher will take the present price minus previous price and divide by previous price. Researcher will calculate the return from 2014 until 2020. Therefore, researcher will summarize it from 2 January 2014 until 31 March 2014.

#### 4.1.3. Mean of each stock

To calculate average price of every stock, researcher did sum all the corresponding's stock value and divide with number of days. Next step, to understand how one stock's behaviour is related to that of another's, researcher did establish a common base which is average mean for all stock. To do that, research did sum the mean of every stock then divide it by number of stocks selected.

#### 4.1.4. Variance covariance matrix

To analysis relationship between the stock with other stocks, researcher selected the stocks which has the highest mean of return and made a variance covariance matrix to indicate how a change of stock value affect other stock. Variance covariance matrix was calculated through using Excel Solver.

#### 4.1.5. Portofolio variance and portofolio mean

Portfolio variance must be calculated in every portfolio to measure the dispersion of return of the corresponding portfolio. To calculate portfolio variance, researcher used the standard deviation of each stock in the portfolio and the variance covariance matrix among these stocks. For portfolio mean, researcher did sum together after multiple weight of each stock by its expected return which is stock mean. However, before calculate portfolio variance and portfolio mean, researcher must set weight for each stock in the portfolio. In this case, researcher divided equally into each stock which mean 20 percent in every stock.

#### 4.1.6. Random portofolio

To illustrate the efficient frontier and different portfolio might be choose based on different condition, researcher divided weight randomly into every stock in different portfolio. In addition, portfolio variance, portfolio standard deviation and portfolio mean calculated for every portfolio.

#### 4.1.7. Value of stock

The efficient frontier's function to illustrate a set of optimal portfolios that offer the highest expected return with defined risk level or the lowest risk along with defined level of expected return. Generally, portfolio that locate below the efficient frontier will not be choose because they are sub-optimal which mean do not provide high enough expected return according to their risk level. The figure below shows the few portfolios calculated in previous step and presents in the efficient frontier. Based on the efficient frontier, the fourth portfolio is the portfolio which provide the highest return with the lowest risk level.



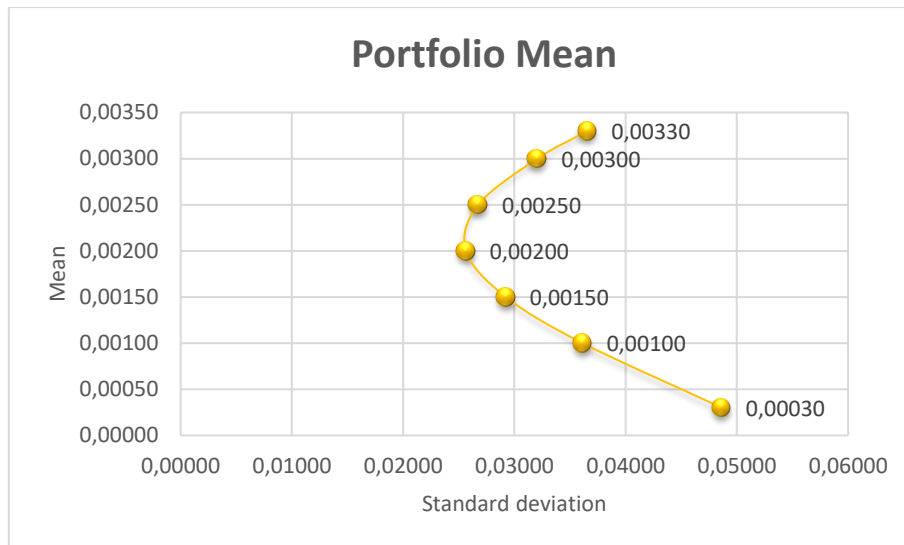


Figure 2. The efficient frontier based on the few portfolios calculated in previous step

## 5. Conclusion

This research has been conducted to select efficient portfolio in Bursa Malaysia and using by quadratic programming (QP) models. The developed research questions and objectives have been achieved after all the research process went through. All the data collected and calculated will be provided as evidence to support this study. The secondary data will be collected from internet such as Wall Street Journal and Bursa Malaysia. There are 15 companies have been selected and identify the unit price of each stock. After that, the data analysis process will be implemented to obtain the final results. There are many technical models to analysis stock and Mean-Variance Model (MVM) is one of them. In this study, researcher succeed use Mean-Variance Model (MVM) to analysis stock's value and indicate which portfolio should be recommended based on defined scenario. A rational trading investor should understand the ideal scenario of the portfolio regarding the number of stocks will be selected and weight of each stock selected based on the defined and preferred risk-reward ratio. Lastly, the findings obtained have been analyzed and further discussion also established. All these findings could provide important sources to concerned party such as investors in order to minimize the loss problem. Besides, suggestions for future study have been proposed to improve the performance of collected data.

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