THE RESAMPLED METHOD TO IMPROVE THE EFFICIENT FRONTIER IN MINIMIZING ESTIMATION ERROR: THE CASE OF MALAYSIA EQUITY PORTFOLIOS

by

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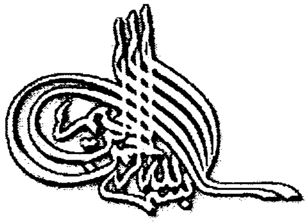

IN THE NAME OF ALLAH

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THE RESAMPLED METHOD TO IMPROVE THE EFFICIENT FRONTIER IN MINIMIZING ESTIMATION ERROR: THE CASE OF MALAYSIA EQUITY PORTFOLIOS

ABSTRACT

Since the work of Markowitz (1952), Mean-Variance (MV) analysis has been a central focus of financial economics. MV theory is still used as a foundation of the modern finance for asset management. Problems involving quadratic objective functions or loss functions generally incorporate a MV analysis.

However, estimation error is known to have huge impact on MV optimized portfolios, which is one of the primary reasons to make standard Markowitz optimization unfeasible in practice. Therefore, in this study we improved the efficient frontier using a relatively new approach introduced by Michaud (1998), i.e., the resampled efficient. Michaud argues that the limitations of MV efficiency in practice generally derive from a lack of statistical understanding of MV optimization. We support his statistical view of MV optimization that leads to new procedures which can reduce estimation error.

Focusing only on short term investment, one of the most important aspects in this research is to investigate the effect of estimation error on our Malaysia equity portfolio based on different situations; historical period and different risk aversion. We investigate the behaviour of the volatility or risk for main board, second board and diversified portfolio and examine the consequences on the efficient frontier.

In general, the results give strong indication of estimation error effect on the efficient frontier, especially on the main board portfolio, and hence, the unsuitability of MV efficient frontier. Our results confirmed that the uses of short historical period and second board portfolio are the most suitable accomplishment of our objectives in this study. Optimal portfolios based on both methods are compared using Sharpe ratio, and the results show that the resampled efficient has superior performance on the Malaysia equity portfolios compared to MV efficient frontier, and at the same time, lead to minimization of the estimation error.

KAEDAH PENSAMPELAN-SEMULA BAGI MEMPERBAIKI SEMPADAN CEKAP UNTUK MEMINIMUMKAN RALAT PENGANGGARAN: KES BAGI POTFOLIO EKUITI DI MALAYSIA

ABSTRAK

Bermula dengan hasil kerja Markowitz (1952), analisis "Mean-Variance" (MV) telah menjadi fokus utama dalam analisis ekonomi kewangan. Kini, teori MV digunakan sebagai asas dalam bidang kewangan moden bagi pengurusan asset. Permasalahan yang melibatkan fungsi objektif kuadratik atau fungsi menyusut, secara amnya turut menggabungkan penggunaan analisis MV.

Namun, ralat penganggaran memberi impak yang besar terhadap potfolio yang telah dioptimumkan oleh analisis MV, di mana ia merupakan salah satu sebab utama menjadikan piawai pengoptimuman Markowitz tidak lagi dapat digunakan secara praktikal. Oleh itu, kajian ini memperbaiki sempadan cekap menggunakan pendekatan baru yang diperkenalkan oleh Michaud (1998) iaitu pensampelan-semula cekap. Michaud membantah penggunaan kaedah MV kerana secara praktikal batasan "MV efficiency" wujud disebabkan oleh kurangnya pemahaman statistik daripada proses pengoptimuman MV. Kita turut menyokong pandangannya yang seterusnya menjurus ke arah satu kaedah baru yang boleh mengurangkan kesan ralat penganggaran.

Memfokuskan hanya kepada pelaburan jangka pendek, satu daripada aspek utama dalam kajian ini adalah untuk melihat kesan ralat penganggaran ke atas potfolio ekuiti di Malaysia berdasarkan situasi yang berbeza; panjang tempoh data dan perbezaan penerimaan risiko. Kita ingin mengkaji tentang perlakuan bagi ketidakstabilan atau risiko ke atas ekuiti potfolio dari papan utama, papan kedua dan gabungan kedua-duanya, seterusnya mengkaji kesannya terhadap sempadan cekap.

Secara amnya, keputusan yang diperolehi memberi penjelasan kukuh mengenai kesan ralat penganggaran terhadap sempadan cekap, terutamanya ke atas papan utama dan seterusnya kesesuaian sempadan cekap menggunakan kaedah MV. Keputusan kajian mengesahkan bahawa penggunaan tempoh data jangka pendek dan potfolio dari papan kedua adalah yang paling sesuai untuk mencapai objektif kajian. Potfolio optimum berdasarkan kedua-dua kaedah kemudiannya dibandingkan menggunakan nisbah Sharpe, dan hasil menunjukkan bahawa pensampelan-semula cekap mendominasi keputusan ke atas potfolio ekuiti Malaysia, dan seterusnya meminimumkan ralat penganggaran.

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The main goal of any asset allocation strategy is to determine, as accurately as possible, the combination of assets that will produce the best outcome for investors. This is where Mean-Variance (MV) optimization pioneered by Markowitz (1952) is being applied. MV optimized portfolios have potentially many attractive investment characteristics (Markowitz, 1959). Optimized portfolios may reduce risk without reducing expected return. MV optimization also enables tailoring portfolios to various risk and return preferences. Although the MV approach is widely accepted among practioners, it is also widely accepted that failures have been found (Frankfurter *et al.*, 1971; Stefanski, 1985; Chopra and Ziemba, 1993), and that there is an urgent need to correct them.

Tests show that MV efficiency in the presence of estimation error has very poor out-of-sample investment performance characteristics (Jorion, 1985; Best and Grauer, 1991; Britten-Jones, 1999). MV optimized portfolios "error maximized" the optimization inputs leading to portfolios that are typically investment unintuitive and have little investment value. For the rest of us, the message is that portfolio optimization used without the proper statistical framework could actually generate portfolios that are dangerously far from optimal.

Dealing with the problem, many works have focused on correcting the estimation error (Jorion, 1985; Jobson and Korkie, 1981; Frost and Savarino, 1986; Jorion, 1986; Michaud, 1998; Lediot and Wolf, 2003, 2004). For this study, we are interested in a generalization of MV efficiency, called resampled efficient frontier optimization introduced by Michaud (1998), which leads to superior investment performance on average relative to MV efficiency (Jiao, 2003). This is Monte Carlo based method for computing many alternative realizations of return forecast and several simulated efficient frontiers. Because of optimization instability, these simulated efficient frontiers may be very different from the original one. Resampled efficient frontiers are an average of the simulated efficient frontiers portfolios and it controls estimation error by allowing the investor to condition the MV optimization according to an assumed level of forecast certainty. Needless to say, controlling estimation error implies that we are able to understand the uncertainty in the problem.

Therefore, we improve our efficient frontier by implementing this relatively new approach, resampled efficienct frontier. As pointed out by Michaud in resampled efficiency, the most serious problems in practical application of MV optimization are instability and ambiguity. By instability and ambiguity, we mean small changes in input will often lead to large changes in the optimized portfolio. Optimal portfolios based on MV efficiency and resampled efficiency is compared in an empirical out-of-sample study in terms of their Sharpe ratio performance (Sharpe, 1966; Fung and Hsieh, 1997; Errunza *et al.*, 1999).

We also aim to see the effects of economic environment on the construction of portfolios' efficient frontier. As changes in economy are also influenced the stock prices movement, and at the same time, alters the efficient frontier. Over the years, Malaysia's economy has performed remarkably well due to the country's political stability, the sound financial and economic policies adopted by the government, and the efficient management of its natural resources. Even more impressive is the fact that economic growth in Malaysia is achieved within an environment of relatively low inflation. However, Malaysia has to face a lot of obstacles in order to achieve such accomplishment. Historical data used for the estimation is known to associate with the economic history based on the length of the period. The comparison of the historical period's length used for generating the efficient frontier is also discussed in this study.

1.2 Problem Statement

The purpose of this study is to determine the best efficient frontier but not the efficiency of the stock market. Markowitz's MV efficient frontier approach is now common place among institutional portfolio managers who use it both to structure their portfolios and measure their performance (Rubinstein, 2002). Although MV efficiency is a convenient and useful theoretical framework for defining portfolio optimally, in practice it is a procedure that often results in maximizing error. This will effect in misinterpreted the findings and vitally wrong investment strategy that can lead to serious lost.

A new statistical approach called resampled efficient frontier helps to improve the portfolio optimization and asset allocation. Resampled efficient frontier portfolios are provably effective at enhancing investment value. Despite of easy to manage, they are unintuitively appealing often without the need for constraints, lower trading costs, and dominate MV efficient frontier portfolios in performance. However, a question arises, in how to determine which one of this methods works better on our Malaysia equity portfolio. Does our developing market lead the equity portfolio to choose the resampled efficient frontier or, does it is still suitable with the MV efficient frontier?

In this study, we show the problems of MV efficiency as a practical tool of institutional asset management based on the Malaysia stock market for a period from 2000 to 2005. We implement these methods on 200 selected Malaysia equity stocks (main board and second board) using the daily return data, and compare the effect on the different portfolios, created in this study.

Moreover, most literature in Malaysia is more concern on the way to find maximum profit from a portfolio, despite on finding the accurate efficient frontier to evaluate the portfolio's performances. Most investors used the MV efficiency without concerning about the estimation error occurred, as there is small study has been done to select the best method in constructing the efficient frontier and on analysing the estimation error using Malaysia stock prices. Also, there are only a few literatures on comparing the effectiveness of efficient frontier based on our Malaysia stock portfolio.

1.3 Objectives of the Study

To start discussing a problem, it is crucial to have a broad understanding of what the query is. Our main objective is to see whether our portfolio is located on the efficient frontier, relatively near or absolutely distorted. The argument arises on the method of constructing the efficient frontier. We will mull over two efficient frontier methods, MV efficient frontier and resampled efficient frontier.

In this study, based on Malaysia stock market, we want to achieve these objectives:

1. As a developing country, we want to examine the historical period's length effect on the efficient frontier in short term investment's outcome
2. To see how the outcome of efficient frontier, under great influence of estimation error, lead the investors in making wrong decisions
3. To investigate the portfolios performance under the circumstances of different investor's risk aversion (different type of portfolios)

1.4 Research Scope of Study

This study focused on most sectors in the Bursa Malaysia stock market; namely, industrial product, consumer product, technology, trading, finance, hotels, properties, construction, mining, trust and plantations. This study included 200 stocks; 100 stocks from main board and 100 stocks from second board, which were traded on a daily basis and were divided into four groups of portfolios. The data used in this study are daily closing stock price as reported by New Straits Times.

Since all stocks are chosen according to the most volume traded in July 2005 (considered the month of the investor want to analyze), it is appropriate to assume that the conclusions of this study are true reflection of the real investment. However, since this study covers a period from 3 January 2000 until 29 July 2005, its conclusions may not be true for other time periods. We want to focus only on the single-period investment and short-term investments, as investment horizon affects portfolio choice, and knowledge of one's utility function is not enough to influence his choice of portfolio (Gresiss *et al.,* 1976).

We do not do a complete research on the overall securities market. Rather, our data are being limited entirely on selected equity stocks. As other securities, like loans, notes, bonds, warrants and others, have different atmosphere and distributions, which have to be considered with other analysis. So, the results in this study are only true to represent portfolios for equity investments. Nevertheless, we believe our findings are of value to MV efficient and resampled efficient work.

1.5 Significance of Study

The significance of the study is to illustrate the importance of determining the accurate efficient frontier as investors use it as a bend over in making decisions.

Investors have to choose whether to use absolute historical data or resampled data in order to come up with precise portfolio selection. The short-term investment, focused in this study, required investors to supervise the portfolio regularly, as the decision may vary according to the historical period. Hope that this study shed new way of improving the efficient frontier for investment analysts.

The results are also hope to widen the pool of literature on the determination of the efficient frontier with minimum estimation error. Most notably, is the used of the new method on constructing the efficient frontier based on our Malaysia stock market environment.

1.6 Organization of Thesis

This thesis is a practical research on stock portfolio optimization and efficient frontier. Its contents generally are: introduction to efficiency, classic MV optimization, understanding MV, portfolio review and MV efficiency, estimation error, portfolio analysis and the resampled efficient frontier, portfolio revision and confidence regions.

The first chapter introduces the market efficiency and its importance. We also give the main purpose and the outline of the whole thesis constructions. Next in the second chapter, we review a number of literatures based on past research which contribute to the process of understanding the research. Here, we discuss the findings of various researchers related to our study.

Chapter 3 carries the important part, methodology. We describe the essential technical issues that characterize MV optimization and portfolio efficiency. Then, we convey the most important tool for portfolio analysis and revision that is frontier, which is a computable and practical alternative investment strategy. So, we outline the MV efficient frontier procedure and discuss the estimation error. Next we describe the new method for correcting the estimation error that is resampled efficient frontier. We also compare the performance using the Sharpe ratio statistic.

In Chapter 4, we present the elementary tests of descriptive statistics for data analysis. We compare the means and standard deviations among the portfolios. We test the normality of the data, using the Jarque-Bera goodness-of-fit test, skewness, and kurtosis value for each stock. We also analyses the effect of Malaysia economic changes on the portfolios under different situations.

In Chapter 5, we show the results of limitations of MV efficiency as an investment management tool, its instability and ambiguity features and argues that MV optimization requires modification and constraints, which lead to estimation error. We show the results by visualizing the estimation error for the data. The next section in this chapter is an extension where we continue the discussion on the statistical characteristics of resampled efficiency. In this chapter we explain the procedures using tables, exhibits and appendices. The techniques discussed would immensely help practicing asset managers improve their efficiency. We draw statistical inference to see whether a portfolio needs revision or change in the existing structure. This is because those portfolios that are already efficient should be left undisturbed in the safe frontier while others are kept under watch. For drawing inference the MV efficiency has to be run through statistical tests. By the end of this chapter, we discuss our results based on our finding.

The last chapter wraps up our study with conclusion from our finding and answers all of our research objectives. Our conclusions are based on different environments of the data. It came to view that for capturing and enhancing the investment value of optimized portfolios and avoiding implementation errors, the asset managers or investors should carefully consider investment theories and intuition, investor objectives, and optimizer behaviours.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

In order to understand the problems and to complete the study, we have reviewed a number of past and recent publications. They put the study on the right frameworks and in obtaining results which are reliable and implementable for the Malaysia stock market. Therefore, this chapter discusses some of the literatures that have documented the use of methods used in this study. We divided the discussions into five sections: Investment and Market Efficiency, MV Efficiency, Estimation Error, Resampled Efficiency, and Sharpe Ratio Measurement.

2.2 Investment and Market Efficiency

One of the major advances in the equities investment field over the past couple of decades has been the creation of an optimum investment portfolio. It is not simply a matter of combining a lot of unique individual stocks that have desirable risk-return characteristics. Specifically, it has been shown that we must consider the relationship among the stocks if we are going to build an optimum portfolio that will meet the investment objectives.

Portfolio investments have various types of analyses concerning securities that can be used as the raw basis of a portfolio analysis (Graham and Dodd, 1934; Markowitz, 1952). The first source of information is the past performance of individual securities. A second source of information is the belief of one or more security analysts concerning future performances. However, when past performances of securities are use as inputs, the outputs of the analysis are portfolios which performed particularly well in the past. When belief of security analysts are use as inputs, the outputs of the analysis are the implications of these beliefs for better or worse portfolios.

Whenever the performance of a portfolio deviates too far from its benchmark (which reflects the performance of the overall market), this means that the portfolio has failed to eliminate systematic risk inherent by a number of stocks in the portfolio. Reilly and Brown (1997) in their book, classify the risk for equity investment into two categories; non-systematic and systematic. A non-systematic risk (diversifiable risk) is risk that unique to a particular security or industry. On the other hand, systematic risk is more macro in nature and attributed by overall market factors. This type of risk normally affects the financials of almost all forms of businesses. Among the factors contributing to such inconsistency are incorrect weighting of assets or stocks in the portfolio, the portfolio is not a good presentation of the benchmark or vice-versa, and poor stocks combination.

Market efficiency is defines as a condition where the prices fully reflect all current information on stock values so that no gain from trades can be made with publicly available information. Market efficiency has an influence on the investment strategy of an investor because if securities markets are efficient, there is no reason trying to pick winners.

Therefore, there will be no undervalued securities offering higher than deserved expected returns, given their risk. So, in an efficient market, an investment strategy concentrating simply on the overall risk and return characteristics of the portfolio will be more sensible. If however, markets are not efficient, and excess returns can be made by correctly picking winners, then it will pay investors to spend time finding these undervalued securities.

Dawson (1984) stated that there are various reasons as to why market efficiency should hold. First, stock markets must rank highly among markets on a priori likelihood of being competitive: there are no serious entry barriers, there are many buyers and sellers, and transaction costs are low and continue to get lower. Second, test of market efficiency are joint test of the hypothesis and the price-generating model assumed in the tests. Therefore, a failure to document efficiency might be prejudiced by failure in the asset pricing model itself. Third, there is a solid body of empirical work documenting the general validity of efficient market hypothesis and qualified interpretation of market inefficiencies. Forth, there is a powerful and irreversible tendency existed for a market's efficiency to increase over time than to diminish, that is, markets learn from experience.

On a prior basis, one would expect a developing stock market to become more efficient as it develops. Developing securities markets are characterized by low liquidity, unsophisticated investors, inadequate disclosure requirements and some non-trivial barriers to entry. It is therefore critical that appropriate test of market efficiency on these markets take into account these characteristics.

The efficiency of the emerging markets assumes grater importance as the trend of investments is accelerating in these markets. There is enough evidence on market efficiency in the develop market; however, the same is not true for the Asian emerging stock market. Poshakwale (1996) prove it with the empirical evidence using Bombay Stock Exchange over a period of 1987 to 1994.

Studies on testing of market efficiency of Asian emerging stock markets are also surprisingly few. Los (1998) tests the market efficiency of six Asian countries: Hong Kong, Indonesia, Singapore, Malaysia, Taiwan, and Thailand in the period June 1986 to July 1996. He used Sherry's non-parametric methods, developed to analyze the information processing efficiency of nervous systems. It was appeared that, all six Asian stock markets are inefficient. A tentative ranking in order of stock market efficiency is: Singapore, Thailand, Indonesia, Malaysia, Hong Kong, and Taiwan. Malaysia stock market efficiency is ranked fourth after Singapore, Thailand and Indonesia.

The developed securities markets, such as Malaysia, Thailand, Indonesia and other Asian countries, generally conform to the expectation of efficiency, and are characterized by active trading, a large turnover, a large number of utility maximizing investors, no entry barriers and efficient dissemination of relevant information. In Malaysia, the Bursa Malaysia itself is relatively small in size and thinly traded compared to the developed market like US and Europe. Test of efficiency on Asian market always generate full of loopholes results (Poshakwale, 1996; Ariff and Johnson, 1990; Ariff and Finn, 1986). Much of the evidence suggests that the actively traded stocks tend to be efficiently priced.

With the purpose to provide further evidence on Malaysia stock market efficiency, Muzafar (1998) tests the informational efficient market using the macroeconomic variables, money supply and national output to predict the stock prices in Malaysia. His result suggests that Malaysia stock market is informationally inefficient.

Pandey (2002) investigates the existence of seasonality in Malaysia stock market as it shows inefficient of the market. Monthly closing price data of the Kuala Lumpur Stock Exchange's Index, called EMAS were used for the period from January 1992 to June 2002. The results of the study confirmed the monthly effect in stock returns in Malaysia. This proved the seasonality implications that the Malaysia stock market is informationally efficient.

It shows that efficiency is important in making portfolio investment decisions to ensure approximately precise outcomes. MV efficiency model uses the absolute risk measure variance to find out the efficient portfolio, in practice however, benchmark relative portfolio optimization is widely used. This is due to fact that investors would like to know what kind of risk their portfolios carry relative to benchmark and given the amount of relative risk how well do their portfolio perform. Thus the benchmark is becoming an important standard to evaluate the portfolio managers' performances, and at the same time brings more questions to the portfolio construction process.

2.3 Mean-Variance (MV) Efficiency

Markowitz (1952) pioneered this field by associating the return of an asset with the mean of its historical returns, and its risk with the historical variance of its return. Markowitz seminal works on modern portfolio theory introduced the idea of a trade off between risk and expected return of a portfolio and define the efficient frontier. Along the efficient frontier are portfolios whose expected returns may not increase unless their variances increase. Portfolio theory assumes that all investors want to maximize the return of their investments while ensuring a minimum risk. Since in reality high return is usually correlated with high risk, investors must consciously make a trade off between these two often contradictory goals. This formalization is often referred to as MV optimization, and it can be efficiently solved using quadratic programming techniques.

Wallingford (1967) showed that, the great achievement of the Markowitz portfolio selection model was its ability to explain the occurrence of diversification theoretically compared to Sharpe's single index model (Sharpe, 1966).

The result presented by Pulley (1981), Kroll, Levy, and Markowitz (1984), and Reid and Tew (1986) reinforce the conclusion that the MV criterion is an excellent empirical efficiency criterion for selecting investment portfolios.

The purpose of Pulley (1981) study is to derive a general MV formulation which can be used to approximate a wide class of utility functions. He use monthly security returns from 1960 to 1976 for selected samples having ten securities each. He shows that the MV formulation provides a very good local approximation to expected utility for more general utility functions, thus the investors can confidently rely on MV optimization, with attitudes toward local changes in portfolio values reflected by the local relative-risk-aversion coefficient.

Furthermore, the best MV efficient portfolio has almost maximum expected utility when chosen from any infinite number of portfolios. Kroll, Levy and Markowitz (1984) prove it on 149 investment company portfolios for various utility functions and the historical returns. It was also found that the excellence of the MV result is not due to the normality distribution of data.

Reid and Tew (1986) gave a comment on comparisons of MV approximations to direct utility maximization. The problem that has arisen is measuring the quality of the MV approximations, or more precisely, measuring the relative stochastic efficiency achieved by MV approximations. The results based on such a *naïve* portfolio, may understate the relative efficiency of MV portfolios, especially for the more risk averse utility functions where a high degree of diversification may increase utility values. In addition, their results present that the MV criterion is an excellent empirical efficiency criterion for selecting investment portfolios.

Samuelson (1970) also showed that for all distributions, the MV rule is a reasonable selection rule when the "riskiness" of returns is limited. It is well known from Bawa (1975) that when the distribution of portfolio return is normal, the MV selection rule is the optimal selection rule in that the admissible set of portfolios for all risk-averse individuals with increasing and concave utility functions is given by the MV selection rule.

Since then, many researchers use MV framework as their tool for portfolio analysis. Some even transform or modify the model as an approach to apply it on various areas like, hedge fund, tracking error, indexing portfolio, etc.

Chow (1995) recreated MV efficient portfolios as the MV-tracking-error (MVTE) utility function. The purpose of the MVTE utility function is to model investor preference accurately and to allow an optimizer to deliver more useful results.

In order to show that the MV analysis of hedge funds approximately preserves the ranking of preferences in standard utility functions, Fung and Hsieh (1997) used the correlation between these two ranking to measure the quality of the quadratic approximation. A high rank correlation means that the ranking based on the quadratic approximation is close to the truth, and low rank correlation means the ranking is not good. They selected a subsample of 233 hedge funds having at least 5 years of monthly returns, and used the Arrow-Pratt coefficient of risk aversion confined between 0 and 30. Their results suggest that using a MV criterion to rank hedge funds and mutual funds will produce rankings which are nearly correct.

Schwartz (2000) applied the Markowitz MV optimization techniques to generate efficient frontier portfolios of the long-run efficiency for Standard&Poors (S&P) 500 index over the period of 1978 to 1998. In his study, he found that the out-of-sample performance of the efficient frontier portfolios is superior to that the S&P 500 in both return and risk. He concludes that the common practice of indexing portfolios to the market has been an inefficient investment strategy that can be dominated by investing in optimized portfolios.

It shows that MV analysis is important for both practitioners and researchers in finance. However, practitioners have reported difficulties in implementing MV analysis. The main difficulty concerns are the extreme weights that often arise when sample efficient portfolios are constructed. The sensitive nature of portfolio weights implies that estimation error in estimates of asset means and covariances feed through to the estimates of efficient portfolio weights.

2.4 Estimation Error

Present model for constructing the efficient frontier according to MV efficient frontier criteria do not account for the simultaneous effect of estimation error. Previous studies describe the impact of estimation error which is so strong that the usefulness of present MV approaches to portfolio optimization is brought into question.

As a matter of fact, there are a number of studies that show how difficult can be, in a first stage, to implement MV analysis, and in a second stage, to correct the failures of the theory. Black and Litterman (1992) suggested that, "when investors have tried to use quantitative models to help optimize the critical allocation decision, the unreasonable nature of the result has often thwarted their efforts".

The statement was related to the fact that as Best and Grauer (1991) have shown, the sample efficient portfolio was highly sensitive to changes in asset means. The main difficulty concerns the extreme weights that often arise when sample efficient portfolios are constructed. They show that sample efficient portfolios are sensitive to changes in asset means and formulate the MV portfolio problem and the sensitivity analysis for it as special cases of a parametric quadratic programming problem. They derive solutions for the change in the optimal portfolio's weights, means, and variances as function of changes in assets means. The results provide understanding on how an investor's MV efficient portfolio deviates from the market portfolio when he identify that the means differ from equilibrium means.

Using 20 years of data in 11 country stock indexes, Britten-Jones (1999) found that the sampling error in estimates of the weights of a global efficient is large. Traditionally, researchers thought about portfolio efficiency in terms of returns. This approach is subject to sampling error based on the location (in MV space) both the test portfolio and the efficient frontier. Britten-Jones used the Gibbons, Ross, and Shanken (GRS) F-test of portfolio efficiency as a test of the restriction that the weights of the 'tangency' portfolio equal the weights of the test portfolio. Acception of this restriction implied acception of the efficiency of the test portfolio. This procedure could be used to assess the precision of the weights of a sample efficient portfolio.

Some studies not only focus on the means solely, but also examine the estimation error effect on the variances and covariances of security returns. Frankfurter *et al.* (1971) showed the effect in estimating means, variances and covariances of security returns. They conduct an empirical analysis on estimators that have entered into actual portfolio selection decisions by using means from three securities. The returns are generated and collected in trial groups representing from 5 to 50 accounting periods. In this study, it is found that inefficient portfolio designated using true parameters appeared efficient in a large proportion of the time. In general, both seem to appear on the efficient frontier with relative frequencies that would not differentiate them. This may cause the efficient frontier being dominated by inferior portfolio with high proportion. Even the security offers reputable returns, the variance are quite high. These result to the presence of error in estimating the required parameters, in which MV model do not accounted for.

Chopra and Ziemba (1993) showed that it is important to distinguish the relative impact of errors in means, variances, and covariances as investors rely on limited data to estimate the parameters of the distribution and estimation errors are unavailable. The data consisted of ten Dow Jones Industrial Average (DJIA) securities, range monthly from January 1980 through December 1989. In order to examine the influence of errors in parameters estimates, they changed the true parameters and compute the resulting optimal portfolio. Next, they computed the cash-equivalent values of the base portfolio and the new optimal portfolio. The percentage cash-equivalent loss from holding the suboptimal portfolio instead of the time optimal portfolio measures the impact of errors in input parameters. They concluded that errors in means are about ten times as important as errors in variances and covariances.

Moreover, Stefanski (1985) presented a general formulation of the errors-in-variables problem, which includes both linear and nonlinear models, functional and structural cases and dependent measurement errors. He also showed the way to asses the asymptotic bias in the estimator when error is present, and to construct an estimator with smaller bias. The asymptotic distributions are derived and results from a small Monte Carlo study are presented after the technique was applied to the class of generalized linear models. He gave the evidence of the measurement error diminish impact on model fitting. He also found that, the correcting for measurement error are likely to depend on the given model, the range of parameters, the distribution of design variables and sample size.

Stefanski's supports the study which was done by Frankfurter and Philip (1980). They concluded that the failure of a portfolio to eliminate the estimation error is due to; the small number of stock in the portfolio that the uncertainty in the regression estimates is not reduce substainly, and the estimation error in grouped portfolio is not independent of the error in the final portfolio estimates.

Simaan (1997) showed that estimation error is more severe in small samples (small observations relative to the number of assets) and for investors with high risk tolerance. The MV model's lower estimation error is most striking in small samples and for investors with a low risk tolerance.

Typically, past averages are surrogated for expected returns and the uncertainty inherent in these parameter values shows shortcomings. Jorion (1985) argued that estimation risk due to uncertain mean returns has a considerable impact on the optimal portfolio selection and that alternative estimators for expected returns should be explored. Data from seven major equity markets; Austria, Australia, Canada, France, Italy, Japan, Mexico, New Zealand, South Africa, U.K., U.S.A. and Venezuela, are used for the period from 1971 to 1983. The findings showed that, when using the classical approach the most prominent are the instability of portfolio weights and the decline of performance when out-of-sample data are used. Using the Stein estimator, Jorion discounted that portfolio selection should rely more on the minimum variance portfolio if all the expected returns were equal.

However, the goal of risk management in portfolio management is not to eliminate risk, but rather to choose which risk to bear and to avoid unnecessary risks. Connor and Korajczyk (2003) discussed about risk budgeting and the combination of portfolio risk management with three separate components: strategic asset allocation, tactical asset allocation and security selection. The aim is to have an optimal portfolio that suits investor's return requisite and risk aversion. They also presented various method proposed by previous researches, bringing many important aspects of risk management for consideration. The impact of estimation risk on optimal portfolios is explored as in the previous literatures.

2.5 Resampled Efficiency

The underlying financial reality explained by resampled efficiency is that it is the structure of the portfolio, not its mean and variance parameters, that defines optimality and how a portfolio performs out-of-sample. This is what has been missing in our understanding of portfolio efficiency nearly 50 years (Michaud and Michaud, 2003b).

First of all, we review a relatively new approach introduced by Michaud (1998), the resampled efficiency, invented and patented by Richard Michaud and Robert Michaud. Michaud argued that the limitations of MV efficiency in practice generally derive from a lack of statistical understanding of MV optimization. He advocated a statistical view of MV optimization that lead to new procedures that can reduce estimation risk. His procedure is to draw repeatedly from the return distribution based on the original optimization inputs (sample means and sample covariance matrix) and compute efficient frontier portfolios based on these resampled returns. Averaging portfolio weights over these simulated portfolios yields resampled efficient portfolios, which show desirable attributes: they exhibit a higher degree of diversification, and their proposition is less prone to changes in expected returns. Resampled method provides the full distribution of portfolio weights and therefore is a useful tool to illustrate the variation in portfolio weights and to perform statistical tests regarding the significance of asset weights.

A study titled "An Introduction to Resampled Efficiency" written by Michaud (2002) explained briefly the importance of resampled efficiency. The method is based on resampling optimization inputs. This is a Monte Carlo simulation procedure to create alternative optimization inputs that are consistent with the uncertainty in our forecasts. However, he showed that resampled efficiency is not simply a way of creating consistent alternative efficient frontiers and optimized portfolios. Resampled efficiency is an averaging process that extracts the entire alternative efficient frontier into a new efficient frontier and set of optimized portfolios. Most importantly, resampled efficieny can be shown to improve investment performance, on average.

Michaud and Michaud (2003a) discussed the resolutions on the common misunderstanding about the resampled efficiency. Resampled efficiency controls the estimation error by allowing the user to customize the optimization process according to an assumed level of information certainty. They stated that resampled efficiency defines a new efficient frontier that is consistent with most application of MV efficiency. It is effective at improving investment value, leads to portfolios that are intuitive and stable, reduces the need to trade, does not *ad hoc* constraints, and is generally much easier to manage than MV efficiency.

Furthermore, Michaud and Michaud (2004) also discussed the optimization issues related to equity portfolio optimization. Many equity optimizations may include 500 or more stocks when optimizing, therefore, investors are less guided by investment intuition. In using the MV optimization, there are many forces in the investment today encourage assets managers to assume more than ordinary amounts of risk. Too much risk is reckless and often commercially dangerous. Luckily, resampled efficient optimization allowed the investors to determine whether the level of risk desired is consistent with portfolio risk-return optimally.

Many works of several authors has focused on resampled efficiency, where the numbers of times that data values are resampled form an exchangeable sequence. MV optimized portfolios regularly exhibit a low degree of diversification. Only few assets are included in the optimal portfolio. They showed sudden shifts in allocations along the efficient frontier and are also very unstable across time. The unintuitive and extreme solutions are a consequence of optimizers being "estimation error maximizers" (Michaud, 1998). MV optimizers overweight these assets that have large estimated expected return, low estimated variances and low estimated correlations to other assets. These assets are the ones most likely to have large estimation errors. Consequently, Jorion (1985), using rolling-window estimates based on actual data, and Jobson and Korkie (1980, 1981) resampling a simulation approach, document poor out-of-sample performance of MV optimized portfolios compared to non-optimized heuristic approaches (equally-weighted portfolio and market portfolio).

Fletcher and Hillier (2001) examined the out-of-sample performance of using resampled portfolio efficiency in international asset allocation strategies. They used an investment universe of the U.S. risk-free asset and ten international equity index returns to estimate the MV and resampled efficiency strategies. They compared the January 1983 to May 2000 out-of-sample performance of the monthly MV strategy and monthly resampled efficiency strategy for a given estimator of expected returns and covariance matrix. They also examined the robustness of the results to different models of expected returns, including the historical mean, the James-Stein shrinkage estimator, and the world CAPM. The result showed evidence, which resampled efficiency strategies, would have generated a marginal increase in Sharpe performance and slightly better abnormal returns than using a traditional MV approach.

A research by Pawley and Helen (2005) compared the efficiency of the MV optimization (Markowitz, 1952) and the resampled efficiency technique (Michaud, 1998), using the South African domestic equity market and diversification of U.S.A. market. Comparison is made to construct resampled efficient portfolios and an equal weighted, MV portfolio, on the aspect of market integration, selection of equity asset classes, and portfolio asset allocations. The result yield that, the resampled portfolios are significantly performed better than others. Data resampled do seem to produce stable portfolio results that are effective at capturing a higher proportion of future returns than a naïve investment portfolio.

Shrinkage is hardly a new and revolutionary concept in statistics, although it certainly was when first introduced by Professor Charles Stein of Stanford University in 1955. An excellent non-technical primer on shrinkage using real-life examples of baseball batting averages was written by Efron and Morris (1977). This idea has not yet percolates to a field where it would be most useful, portfolio management, is a testimony that Chinese walls still exist between theoretical and applied disciplines that would benefit from talking to each other more. We endeavour to knock these walls. Early attempts to use shrinkage in portfolio selection were made by Frost and Savarino (1986) and Jorion (1986), but their particular shrinkage technique broke down when the number of stocks on the menu exceeds the number of historical return observations, which is very often in the case in practice.

Recently Jagannathan and Ma (2003) proved that MV optimizer are already implicitly applying some form of shrinkage to the sample covariance matrix when short sales are ruled out, and that this is generally beneficial in terms of improving weights stability. All the reason then is to do it explicitly so that the optimal shrinkage intensity can be applied. Much of the foundations for the present work have been laid out by the authors in other papers, as one of the popular are from Ledoit and Wolf (2003, 2004). Those are largely theoretical and general-interest articles, whereas the present one focuses specifically on how to employ the technology toad value to active portfolio management.

2.6 Performance's Measurement: Sharpe Ratio

In this study, we incorporate the well known Sharpe ratio as the measure of performance to compare the MV efficiency and resampled efficiency. Here we review the literature by Sharpe and some other authors who used Sharpe ratio as their measurement.

Sharpe ratio is a risk-adjusted measurement developed by William Sharpe (1966). It is calculated by first determining the incremental average return over the risk free rate of return and then dividing this result by the standard deviation. The higher the Sharpe ratio, the better the investment's historical risk-adjusted performance.

Sharpe (1966) introduced a measure for the performance of mutual funds and proposed the term *reward-to-variability ratio* to describe it (known as Sharpe ratio). Throughout Markowitz' MV model, which assumes that the mean and standard deviation of the distribution of one-period return are sufficient statistics for evaluating the prospects of an investment portfolio. Clearly, comparisons based on the first two moments of a distribution do not take into account possible differences among portfolios or distributions with different levels of investor utility. When such concerns are especially important, return mean and variance may not suffice, requiring the use of additional measures. Sharpe's goal is to examine the situations in which two measures (mean and variance) can usefully be summarized with one (the Sharpe ratio). The Sharpe ratio is designed to measure the expected return per unit of risk, and does not cover cases in which only one investment return is involved.