

MODERN PORTFOLIO THEORY TOOLS

A METHODOLOGICAL DESIGN AND APPLICATION

Siu Han Wang

A research report submitted to the Faculty of Engineering and the Built Environment, of the University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree of Master of Science in Engineering.

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DECLARATION

I declare that this research report is my own, unaided work. It is submitted in partial fulfilment of the requirements for the degree of Master of Science in Engineering in the University of Witwatersrand, Johannesburg. It has not been submitted before for any degree of examination in any other University.

Siu Han Wang

_____ day of _____ (year) _____

ABSTRACT

A passive investment management model was developed via a critical literature review of portfolio methodologies. This model was developed based on the fundamental models originated by both Markowitz and Sharpe. The passive model was automated via the development of a computer programme that can be used to generate the required outputs as suggested by Markowitz and Sharpe. For this computer programme MATLAB is chosen and the model's logic is designed and validated.

The demonstration of the designed programme using securities traded is performed on Johannesburg Securities Exchange. The selected portfolio has been sub-categorised into six components with a total of twenty- seven shares. The shares were grouped into different components due to the investors' preferences and investment time horizon. The results demonstrate that a test portfolio outperforms a risk- free money market instrument (the government R194 bond), but not the All Share Index for the period under consideration. This design concludes the reason for this is due in part to the use of the error term from Sharpe's single index model. An investor following the framework proposed by this design may use this to determine the risk- return relationship for selected portfolios, and hopefully, a real return.

To my family, for their support

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LIST OF SYMBOLS

$\alpha_{i,t}$	Alpha of security, i at time t
α_i	Alpha estimate, by regression analysis, in this design OLS, of the individual security
$\hat{\alpha}_{BA}$	Alpha calculated by applying adjusted beta value using Vasciek's technique
$\hat{\alpha}_{ML}$	Alpha calculated by applying adjusted beta value using Merrill Lynch's adjustment
β_i	Beta estimate by regression analysis, in this design OLS, of the individual security
$\beta_{i,t}$	Beta of security, i at time t
$\beta_{j,t}$	Beta of security, j at time t
$\overline{\beta}_i$	Average of the betas of all stocks in the portfolio
$\hat{\beta}_{BA}$	Adjusted beta value using Vasciek's technique
$\hat{\beta}_{ML}$	Adjusted beta value using Merrill Lynch's adjustment
$D_{i,t}$	Dividend of security, i, at time t
$e_{i,t}$	Random error associated with security i at time t
i_{nir}	Nominal interest rate
$I_{i,j}$	Returns in j^{th} security n i^{th} component
m	Number of compounding periods
N	Sample size
P_0	Initial price of an individual security, i.e. the initial reference point
$P_{i,t}$	Price of an individual security, i, at time t
r	Effective interest rate
$R_{i,t}$	Return of an individual security, i, at time t
$\overline{R}_i$	Sample mean of individual security, i

$\overline{R_{i,t}}$	Sample mean of individual security, i at time t
$R_{M,t}$	Return on market at time t
$\overline{R_M}$	Sample mean of market
$\overline{R_{M,t}}$	Sample mean of market at time t
$R_{n,P}$	Return of n^{th} subportfolio or component
R_{OP}	Overall return of test portfolio
$\rho_{i,j,t}$	Correlation coefficient between R_i and R_j at time t
σ_i^2	Variance of security i
$\sigma_{M,t}^2$	Variance of market at time t
$\sigma_{\beta_i}^2$	Variance of the beta estimate
σ_p	Cross- sectional standard deviation of all beta estimate in the portfolio
$\sigma_{i,t}$	Standard deviation of individual security, i, at time t
$\sigma_{j,t}$	Standard deviation of individual security, j at time t
$\sigma_{i,j,t}$	Covariance between R_i return on asset i and R_j return on asset j at time t
w_i	Weight associated with security i
w_j	Weight associated with security j
w_{nn}	Weight associated with n^{th} security in n^{th} subportfolio or component
x_{ij}	Amount of investment in j^{th} security in i^{th} subportfolio or component
ω_i	Investment fraction associated with i^{th} subportfolio or component

NOMENCLATURE

AFB	Alexander Forbes Limited
AGL	Anglo American plc
ALSI	FTSE/ JSE Africa All Share Index
AMS	Anglo Platinum Ltd.
ASA	ABSA Group Ltd.
BA	Bayesian Adjustments
BAW	Barloworld Limited
BCX	Business Connexion Group Limited
BDEO	Bidvest Call Option
BVT	The Bidvest Group Ltd.
CLH	City Lodge
DRS	Design Requirement Specification
DST	Distell Group Limited
EMH	Efficient Market Hypothesis
ERP	ERP.com Holdings Ltd.
FBR	Famous Brand Limited
FSR	FirstRand Limited
IPL	Imperial Holdings Ltd.
JSE	Johannesburg Securities Exchange
LBT	Liberty International plc
ML	Merrill Lynch Adjustment
MPT	Modern Portfolio Theory
MTN	MTN Group Ltd.
MUR	Murray & Roberts Holdings Limited
OLS	Ordinary Least Squares
PIK	Pick n Pay Stores Limited
PPC	Pretoria Portland Cement Company Ltd.
REM	Remgro Limited

RLO	Reunert Limited
SAB	SABMiller plc
SBK	Standard Bank Group Ltd.
SHP	Shoprite Holdings Ltd.
TBS	Tiger Brands Limited
VNF	VenFin Ltd.
WHL	Woolworths Holdings Ltd.

Chapter 1 Introduction

1.1 Background

South Africa is a country regarded as a developing and emerging market (International Marketing Council of South Africa, 2007 and Li, 2007), where there is potential for growth, thus, its 'bullish' economic phase will continue for the very near future (Li, 2007). The immediate entry to a country's economy is through its securities market, in this case, the JSE Securities Exchange (hereforth known as JSE) (JSE, 2007).

The JSE Securities Exchange South Africa was previously known as the Johannesburg Stock Exchange. JSE is South Africa's only security exchange and it is also ranked as African's largest security exchange.

The JSE has operated as a trading ground for financial products for nearly 12 decades. Therefore the JSE is a valuable money market instrument in South Africa's economic landscape (JSE, 2007).

The JSE is not as heavily traded as many other exchange markets, for example: New York, Chicago and London. The efficiency of the JSE is an issue of importance to South African investors. During the last three decades numerous studies have addressed this issue and concluded that the market efficiency for JSE is semi-strong¹ (Correia et al., 2003).

A securities exchange may be a fair reflection of an economy. Many investors consider entering the security market to gain a better access to the overall market. Therefore, some may think 'beating' or outperforming the market is not a difficult task in an emerging

¹ Semi-strong asserts that security prices adjust rapidly to the release of all new public information, thus the security prices fully reflect all public information. This is discussed in more details in Chapter 2.

market. However, the consistent out-performance of benchmark positions² is rare (Hobbs, 2001). The rarity of out-performing the market gives rise to the two broad classes of market views as well as the asset investment management approach.

When an investor analyses a market, he or she tends to take one of the two views namely contrarian³ or smart money⁴ views (Malkiel, 1999 and Schweser Kaplan Financial, 2006b). Once an investor has committed to one of these trading views, the management approach may be decided. The approach that an investor can adopt is either the active or the passive management approach. For the active management approach, the investors need to research the market thoroughly and know when they are to sell or to buy; whereas for the passive approach, an investor mostly practices the “buy-and-hold” strategy. Passive management is favoured by risk-averse investors, where the key to profitability lies with portfolio selection and asset allocation.

The allocation between active and passive management approaches depends on skills, and rather subjectively, personal preferences (Sorensen et al., 1998).

1.2 Motivation

South Africa’s GDP (PPP)⁵ per capita income is \$13300, this is lower than the developed economies of USA with \$44000, Japan \$33100, UK \$31800 and France \$31300 in 2006⁶. When citizens save, their funds may not be sufficient to hire financial advisors and managers⁷ due to the high service costs involved. Nevertheless, these private investors

² In this design, benchmark position refers to the index chosen, i.e. ALSI.

³ Contrarians argue that the majority of the market is generally wrong; hence they do the opposite to what the majority of investors are doing. (Schweser Kaplan Financial, 2006b: p.170)

⁴ Smart investors know what they are doing, so investors better follow them while there is still time. (Schweser Kaplan Financial, 2006b: p.170)

⁵ Gross domestic product at purchasing power parity, where purchasing power parity (PPP) is a theory that states the exchange rates between currencies are in equilibrium when their purchasing power is the same in each of the two countries.

⁶ These figures, were listed by CIA World Factbook, and were taken directly from http://en.wikipedia.org/wiki/List_of_countries_by_GDP_%28PPP%29_per_capita.

⁷ This is referring to the general public and does not include the elites of the society.

may seek suitable investment opportunities on the JSE for their funds. By investing accurately and cautiously, these investors can avoid the reducing purchasing power of money due to the interest rate, inflation and tax. An increase in interest rate leads to the increased interest costs for the businesses, hence businesses raise the prices of their goods. As a direct consequence, this leads to the reducing purchasing power of money as for the same amount of money, customers can now buy less than what they could prior to the interest increase. The design proposed in this document attempts to provide a framework which these investors can use to make better investment decisions.

Some questions that an investor may ask when conducting the investigation related to this design are the following:

- What are the aspects that one should consider when constructing an investment portfolio?
- How may one determine the optimal split between asset classes within the portfolio?
- How would one determine a reasonable rate of returns on the portfolio?

This design attempts to address these pertinent questions, hence private investors will gain understanding and knowledge in this field. As a result, an investor can make sound decisions on investments based upon modern theory.

1.3 Scope of Design

The objective of this design is to develop a passive portfolio management model using both Markowitz's mean-variance framework and Sharpe's single index model that may be easily used by a private investor through its automation via a computer program. The market for the automated models is private investors or the potential private investors on the JSE. To achieve this objective, the design is approached in two stages. Firstly, a model for passive portfolio management using Modern Portfolio Theory (hereforth known as MPT) tools is developed via a critical literature review. Secondly, a computer

programme is developed. The computer programme is the validation vehicle for the model developed. In the first stage, the model validation is completed through an existing test portfolio. The test portfolio is then passed through the computer programme, where a set of results are generated. The reasons for security selection as well as the outcomes are discussed. The specific outcomes are the returns of portfolio. These will be compared to the risk-free money market instrument, i.e. a government bond, in the chapters to come in this document.

1.4 Limitations of Design

- A limitation of this design is that the model developed is limited to MPT related tools,
- the validation conducted for the computer programme was using limited sectors on the JSE, this is seen as a limitation since the limited sectors do not give a holistic view of JSE,
- short-selling of securities has not been discussed in this design report, and
- R-squared statistics have been left out of this design report, as this design focuses on the design of the methodology.

1.5 Statement of Task

This design aims to:

- develop a model for passive portfolio management using MPT tools via a critical literature review, and
- develop a computer programme where the model is validated through the use of a test portfolio. One of the elements that the computer programme will be evaluated on is its user-friendliness (this is defined in Design Requirement Specification).

1.6 Methodology

In Chapter 2, a critical literature review is discussed. Through this discussion, a model for passive portfolio management is developed.

In Chapter 3, the development of computer programme is developed. This discussion had been divided into three stages, namely design requirement specification, software selection and the code written for computer programme. Each of the three stages are discussed below:

- First stage, design requirement specification of a computer programme is introduced, where the criteria and constraints of the computer programme are tabulated and discussed. The computer programme is designed based on the model for passive portfolio management.
- Second stage, the computer packages considered for the computer programme is discussed. The discussion includes the advantages and disadvantages of each of the packages. Based on this, an evaluation matrix is drawn, and a final decision is reached on the package selection.
- Third stage, the detailed design logic is discussed, where the procedures on the formation of the computer programme is described. This stage concludes with the validation of the model.

In Chapter 4, the application of the validated automated model is necessary. Therefore, the test portfolio and the benchmarks are selected. The reasons for these selections are introduced.

In Chapter 5, the outcomes achieved by applying the automated model to the test portfolio are analysed and discussed in detail.

In Chapter 6, conclusions and findings of this design are revisited and summarised.

The proposed methodology is graphically represented in Figure 1.1 below.

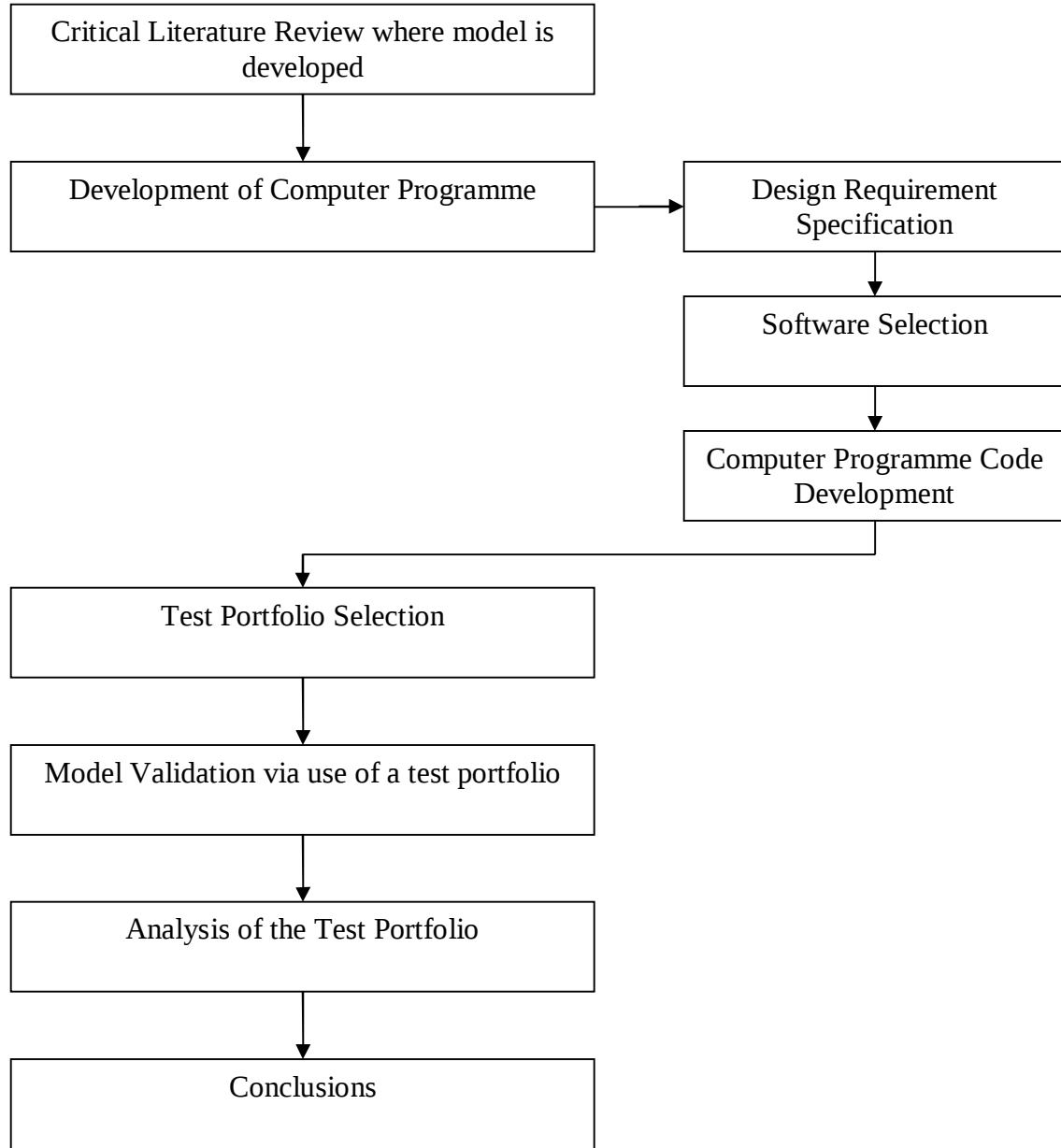


Figure 1.1: Proposed Methodology

In summary, the fundamental elements of software development project management methodology have been employed. Thus, in the forthcoming chapters of this report, the critical literature reviews are discussed, in particular, the Markowitz's mean-variance model and Sharpe's single index model are discussed critically in the literature review. The MPT model forms the requirement for the development of the computer programme. A test portfolio is chosen for the validation of the automated model, and the outcomes are

discussed. Lastly, the major conclusions reached from the analysis are discussed, and a discussion of possible implications for further work.

Chapter 2 Development of a Passive Management Model Via a Critical Literature Review of Portfolio Methodologies

2.1 Introduction

In this chapter, the literature that forms the foundations and techniques of MPT is critically reviewed. The structure of the review is represented in Figure 2.1. The review begins with the broad concept of financial engineering, narrowing down the concept to the specific management approaches that are currently being employed in the industry, such as active and passive management⁸. The primary focus of this review is on the passive management approach including the foundations and the techniques associated with it. The motivation for using the passive management approach will be discussed later. A review of a general portfolio construction method which forms the base of the model design methodology is then undertaken followed by an analysis of the application of Markowitz's mean-variance framework and Sharpe's single index model. This chapter concludes with the presentation of passive management MPT model which is the primary objective of this design.

⁸ Active management approach refers to the use of human element in managing a portfolio. Passive management refers to an investment strategy which mirrors index composition and doesn't attempt to beat the market, (Hobbs, 2001).

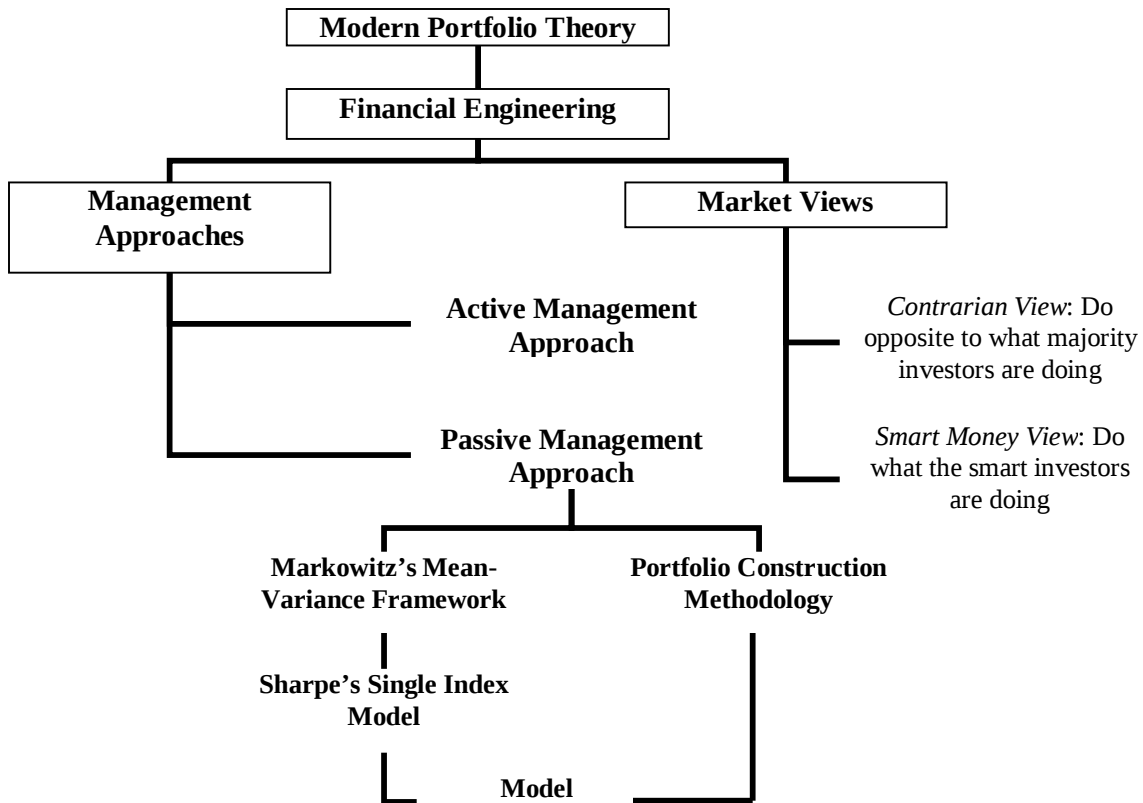


Figure 2.1: Structure of Literature Review & Model Development

2.2 Modern Portfolio Theory

MPT is an overall investment strategy that seeks to construct an optimal portfolio by considering the relationship between risk and return (Correia et al., 2003). This theory is “...generally perceived as a body of models that describes how investors may balance risk and reward in constructing investment portfolios.” (Holton, 2004: p. 21). MPT is otherwise known as portfolio management theory (Reilly, 1989).

The main indicators used in MPT are the alpha and the beta of investment (Hobbs, 2001). Beta is a measurement of volatility of an asset or a portfolio relative to a selected benchmark, usually a market index. A beta of 1.0 indicates that the magnitude and direction of movements of returns for an asset or a portfolio are the same as those of the benchmark. A beta value greater than 1.0 indicates the higher volatility, and a beta value

less than 1.0 indicates the lesser volatility when measured against the benchmark (Yao et al., 2002). Alpha calculates the difference between what the portfolio actually earned and what it was expected to earn given its level of systematic⁹ risk, beta value. A positive alpha indicates return of the asset or the portfolio exceeds the general market expectation. A negative alpha indicates return of the asset or the portfolio falls short of the general market expectation (Yao et al., 2002).

Although the growth of MPT has been both normative and theoretical, there are some general issues associated with MPT (Compass Financial Planner Pty Ltd., 2007), as follows:

- 1) Volatility is a measure of risk in a historical period. One relies heavily on historical data when attempting to predict the future. It can also be understood as a measure of uncertainty that quantifies how much a series of investment returns varies around its mean or average. Mathematically, volatility is represented by standard deviation (Yao et al., 2002). Uncertainty is associated with randomness and one of the best ways to deal with randomness is the use of non-parametric models, namely neural networks (Harvey et al., 2000). Non-parametric refers to interpretation which does not depend on the data filling any parameterized distributions (Winston, 2004). A neural network is a set of nodes, which can be categorised into three components, namely the units, neurons and processing elements. A neural network is usually applied to pattern recognition, content addressable recall and approximate, common sense reasoning (Campbell, 2007).
- 2) One should not put too much faith in an “efficient” portfolio performing at all well if world markets become unstable for a little while (Harvey et al, 2000). A study done by Merrill Lynch in 1979 showed that a typical diversified investment portfolio eliminates so much of the specific risk, that roughly 90 percent of all the

⁹ Systematic risk refers to the risks that cannot be diversified away, such that they are inherent in the system.

portfolio risk is market risk, therefore if market is unstable, an investor should not be disappointed if the portfolio is not performing (Derby Financial Group, 2008).

Further to the issues that are associated with MPT, the implementations of this theory have also been limited. The three major reasons for the limited implementation of MPT are (Elton et al., 1976: p. 1341):

- 1) The difficulty in estimating and identifying the type of data necessary for correlation matrices.
- 2) The time and expenses needed for generating efficient portfolios that is the costs associated with solving a quadratic programming problem. The input data requirements are voluminous for portfolios of a practical size (Renwick, 1969).
- 3) The difficulty in educating portfolio managers to express the risk-return trade-off in terms of covariances, returns and standard deviations (Renwick, 1969).

The literature suggests that the development of MPT has led to the development of the field of financial engineering.

2.3 Financial Engineering

Financial engineering is a relatively new discipline; it originated in the late 1980s when the field of finance was changing (Financial Engineering News, 2006). This is one of the new disciplines which emerged from MPT.

Financial engineering is the art¹⁰ of risk management where financial opportunities are exploited through complex financial formulations. This is supported by the following:

Topper (2005: p. 3) asserts that “(t)he art of financial engineering is to customize risk. Financial engineering is based on certain assumptions regarding the statistical behaviour

¹⁰ The word ‘art’ refers to the methods or the techniques used.

of equities (securities), exchange rates and interest rates.” In MPT, customizing risk refers to managing a measurement of uncertainties of expected returns (Yao et al., 2002). Additionally, Jack Marshall, as cited in the Financial Engineering News (2006), suggests that “(f)inancial engineering involves the development and creative application of financial theory and financial instruments (securities) to structure solutions to complex financial problems and to exploit financial opportunities.”

Through this discipline, one would be able to reach sound decisions regarding savings, investing, borrowing, lending and managing risk (Financial Engineering News, 2006).

One of the core objectives of financial engineering is to manage risk; therefore the active and passive management approaches need to be understood, as each refers to a different method of portfolio risk management.

2.4 Active and Passive Management

To gain a better understanding of these management approaches, this report proceeds to discuss both active and passive management approaches in more detail.

2.4.1 Active Management

This management approach refers to the active frequent trading of securities. It is an attempt to outperform the market as measured by a particular index (Sharpe, 2006 and Frank Russell Company, 2006). An active portfolio manager uses research findings and market forecasts to purchase securities that he believes will outperform various benchmarks; when he feels the value of the investment is at its peak, he will sell the securities (Hobbs, 2001).

This approach is associated with the constant rebalancing of asset classes within a portfolio (Evanson Asset Management, 2006). Rebalancing is referring to the process of resetting a portfolio at a predetermined interval back to a default asset allocation (Compass Financial Planner Pty Ltd., 2007). Rebalancing can also mean adjusting the weight of each asset in the portfolio or dropping certain assets from the portfolio (Yao et al, 2002).

The core benefit of an active investment strategy is the potential for higher returns. The greatest drawbacks are the high operating expenses (Hobbs, 2001 and Evanson Asset Management, 2006).

2.4.2 Passive Management

Passive management is commonly known as indexing. It is an investment approach based on investing in identical securities, in similar proportions as those in an index (Sharpe, 2006 and Evanson Asset Management, 2006). Passive managers generally believe it is difficult to outperform the market, thus strategies such as purchasing, holding and adjusting a selection of securities are used to replicate the performance of a given index (Hobbs, 2001).

The benefits of a passive management strategy are the lower operating expenses and action-free requirements from investors (Hobbs, 2001 and Frank Russell Company, 2006). Passively managed portfolios seek to provide only the market returns, hence index performance dictates portfolio performance (Mesirow Financial Holdings Inc., 2006). In light of passive management, action-free means that on average the same performance can be achieved by simply buying the entire asset class or a representative sample (as the chosen benchmark) without using either security selection or market timing (Hultstorm, 2007).

Passive portfolio management is designed to be stable and to match the long term performance of one segment of the capital market. It has distinct sectoral and asset emphasis depending on the investors' attitude toward risk and the economic environment (Rudd, 1980).

While the understanding of both management approaches allow risk associated with portfolio to be optimised (Lin et al., 2004), the model focuses on passive management, the “buy- and- hold” strategy. Cheng et al. (1971: p. 11) have explained this choice, “(t)he buy- and- hold strategy under efficient markets is an optimal strategy since it minimizes transaction costs.” The reason for this choice is that the foundations of MPT form part of the origin for passive management approach (Hobbs, 2001). The foundation of MPT lies in Markowitz's and Sharpe's work, both of which were developed in the 1950s and 60s (Hobbs, 2001). The primary reason for these choices of models was that these models have rekindled interest in normative (modern) portfolio theory (Frankfurter, 1990); this is reinforced by winning the 1990 Nobel Prize in economics (Njavro et al., 2000).

Prior to the theoretical discussion of Markowitz's mean-variance framework and Sharpe's single index model, in section 2.6.1 and section 2.6.2 respectively, it is important to understand the methodological framework, that is, portfolio construction through which these models are applied as set out in section 2.5.

2.5 Portfolio Construction

The applications of MPT are outlined as follows according to Hagin (1979):

- security valuation,
- asset allocation,
- portfolio optimisation, and
- performance measurement.

Each of the four steps is discussed below.

2.5.1 Security Valuation

This is the first step in developing a portfolio. At this initial stage, one needs to be able to select securities with the potential for sustainable growth (Malkiel, 2003). Value investing refers to the determination or identification of a firm's intrinsic value¹¹ (Buffet et al., 2002 and Bernstein, 1992). Value investing is an investment paradigm that generally involves the identification and buying under-priced securities (Graham et al., 1962). The intrinsic value can be estimated by the using two of the most commonly used techniques, namely the fundamental and the technical analyses, discussed below.

1. Fundamental Analysis

Fundamental analysis is a tool that financial analysts use to determine a firm's value through its financial data and operations. The view is echoed by Malkiel (1999: p. 127), who asserts that “(f)undamental analysis is the technique of applying the tenets of the firm-foundation theory to selection of individual stocks (securities).”

This analysis can be used to determine a security's proper value. The suggested determinants are (Malkiel, 1999):

- expected growth rate,
- expected dividend payout, and
- degree of risk.

This choice of determinants is echoed by Graham et al. (1962). These three determinants are usually predicted using a firm's historical financial data. As a result, sets of ratios are generated. A ratio expresses the relationship between one quantity and another, thus

¹¹ The underlying fair value of a stock based on its future earnings potential.

through ratio analysis one would be able to tell how a firm is doing, what its financial conditions are and what its weaknesses are (Feinberg, 2005). Ratios are often used by analysts to make predictions regarding the future, hence the factors which affect these ratios should also be considered. The usefulness of the ratios is dependent upon the analyst's skilful application and interpretation of them (Correia et al., 2003).

Ratios often used for the financial analysis are (Feinberg, 2005):

- Return On Equity (ROE)
- Debt/ Equity Ratio
- Price Earning Ratio (P/E)
- Earnings Per Share
- Dividend Per Share
- Dividend Yield

This report will, thus, use ratios, to determine a firm's financial position. These ratios are usually given in a firm's financial statements. Fundamental analysis considers the variables that are directly related to the company itself, rather than the overall state of the market. Technical analysis, on the other hand, considers the overall market directly and complements the fundamental analysis.

2. *Technical Analysis*

Technical analysis is usually understood as the making and interpreting of security charts. From these security charts, the past (both movements of common security prices and the volume of trading) will be studied for an indication of the likely direction of future change. This is supported by Ryan (1978: p. 116), who says, "(t)echnical, or chart, analysis is the term applied to the work of a particular school of stock (security)-market analysts whose theories of stock (security) price movements rely heavily on the use and interpretation of various types of charts or graphs."

The key principles of technical analysis are as follow (Standard Bank Group, 2006):

- everything is discounted and reflected in market prices,
- prices move in trends and trends persist, and
- market action is repetitive.

This report uses this stance as proposed by Standard Bank Group. Technical analysis principles are based on the market movements, where it is assumed that the movements are repetitive and all information is reflected in the market prices.

3. Combination of Fundamental & Technical Analyses

Instead of using either fundamental or technical analysis alone in order to analyse a firm, it is recommended to use the combination of both together for firms' analysis.

One of the most sensible procedures for selecting the securities which are attractive for purchase can be summarized by the following three rules (Malkiel, 1999). The following rules also coincide with Buffet's methodology (Buffet et al., 2002).

Rule 1: "Buy only companies that are expected to have above-average earnings growth for five or more years." (Malkiel, 1999: pp. 141 - 142)

The single most important element contributing to the success of most security investments is an extraordinary long-run earnings growth rate. The continued, repeated performance is more impressive than a single occurrence (Graham et al., 1962). This refers to the sustainability of the firm. Therefore, the security which has been performing consistently in the past is more likely to be purchased. This is usually done by examining the trend for price-earning (hereforth know as P/E) ratio. P/E ratio represents a valuation ratio of a company's current share price compared to its per-share earning. In general, a high P/E ratio suggests that investors can expect higher earnings growth in the future compared to companies with a lower P/E.

Rule 2: “Never pay more for a stock (security) than its firm foundation of value.”
(Malkiel, 1999: pp. 142 - 143)

This rule can be summarised as never paying more for a security than its intrinsic value. This reinforces Buffet’s approach of intrinsic value investments (Buffet et al., 2002). This valuation process usually consists of the following basic components (Graham et al., 1962):

- expected future earnings,
- expected future dividends,
- capitalization rates of dividends and earnings, and
- asset values

It should be noted that these four components include a number of elements that are both quantitative and qualitative in nature. Chief among these are the past and expected rates of profitability, stability and growth; the abilities of the management via corporate governance concept (Graham et al., 1962).

A rough estimation of a firm’s intrinsic value is usually calculated by its ‘Return on Investment’ (ROI) ratio.

Rule 3: “Look for stocks (securities) whose stories of anticipated growth are of the kind on which investors can build castles in the air.” (Malkiel, 1999: pp. 143 - 144)

This rule refers to the possibility of future news being released by the firm which will affect the security’s price. This can be demonstrated with use of Economic Value Added (henceforth known as EVA). EVA is a financial measure that attempts to capture a creation of shareholder wealth over time (Correia et al., 2003). Thus, EVA is a relevant performance measure for this rule. EVA is calculated by taking a firm’s profit after tax then subtracts the rate of the cost of the capital multiplied by the average total assets less the average non-interest bearing current liabilities (Feinberg, 2005).

2.5.2 Asset Allocation

Portfolio theory aims to optimise the relationship between risk and reward for an investment, and this optimisation is reached through diversification of assets. Asset allocation is the division of investments among asset categories, that is “(a)asset allocation is an investment portfolio technique that aims to balance risk and create diversification by dividing assets among major categories such as cash, bond, stocks (security), real estate and derivatives.” (Investopedia Inc., 2003). Asset allocation with efficient diversification is the heart of portfolio theory (Jacquier et al., 2001).

Asset allocation is a major determinant of return and risks, as well as the investment performance (Elton et al., 2000 and Derby Financial Group, 2008).

The process of asset allocation includes one or all of the following approaches, and they are displayed in Figure 2.2 below:

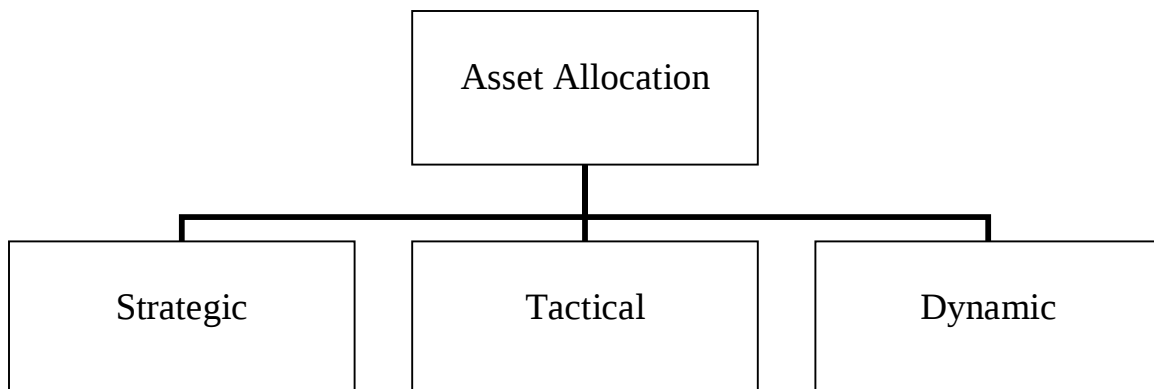


Figure 2.2: Asset Allocation Approaches

Strategic asset allocation refers to the use of historical data in an attempt to understand how the asset has performed and predict its future performance. Tactical asset allocation uses period assumptions regarding performance and characteristics of the asset and/ or the economy. Dynamic asset allocation is dependent upon the changes in investors’ circumstances (Derby Financial Group, 2008).

Furthermore, there are two attributes that need to be considered under asset allocation (Gallant, 2005):

a) Financial situation and investment goals

Items considered are the age of the investors, the amount of capital available and the possible future needs and investment purposes. Based on different financial goals set, an investor chooses different securities. For example, if an investor is risk- seeking and the investment period is short-term, then derivatives would be a better option than cash and bonds.

b) Personality and risk tolerance

One should decide, whether one is willing to encounter more risks in exchange for higher potential returns. An investor needs to decide on what level of risk he or she wants to take in order to receive a higher return. Thus for a risk-seeking¹² investor, an aggressive portfolio can be formed and higher returns can be the outcome.

Asset allocation is dependent on the two attributes mentioned above. An investor's financial position, investment goals and personal risk tolerances would affect the asset classes chosen. The most familiar rule of thumb for asset allocation are (Campbell, 2002):

“Aggressive investors should hold stocks (security), conservative investors should hold bonds. Long-term investors can afford to take more stock market risk than short-term investors.” That is different types of investors and time horizons set for investments would affect the asset classes chosen. For example: for a conservative investor¹³, he/ she would seek to maintain the purchasing power of his/ her money. This is usually done by holding the risk- free security, namely the bonds. Alternatively, for a risk-seeking investor, he/ she would seek to obtain a higher return; therefore he/ she would consider securities in his/ her investment portfolios.

¹² Risk- seeking refers to aggressive. These terms will be used interchangeably throughout this report.

¹³ Conservative refers to risk- averse. These terms will be used interchangeably throughout this report.

2.5.3 Portfolio Optimisation

Portfolio optimisation refers to a group of assets which have been grouped together to either maximise the returns for a given level of risk or to minimise the risk for a given expected return (Cuthbertson et al., 2004 and WebFinance Inc., 2007a). The goal of portfolio optimisation is to maximize the investor's expected utility by taking into account all relevant information (Sharpe, 2006). Expected utility refers to the total satisfaction received or experienced.

2.5.4 Performance Measurement

Performance can be defined as the outcomes of investment activities over a given period of time (Sharpe, 2006). The most common performance or dimension of a portfolio would be its return, i.e. its profitability. More importantly, an investor should also consider sustainability for future returns, ie. whether the future returns can be maintained indefinitely. Future returns are dependent on the sustainability of a firm and its intrinsic value.

To examine portfolio performance, Markowitz's and Sharpe's models are used as the basis for data analysis. Markowitz's framework forms the foundation for MPT. Sharpe's model elaborates on applications of Markowitz's framework.

2.6 Development of The Model

The model has been developed by using both Markowitz's mean- variance framework and Sharpe's single index model. Each of the pertinent models are discussed in more details below.

2.6.1 Markowitz's Mean-Variance Framework

Markowitz's (1952) mean-variance framework forms a basis for his portfolio selection model. This is a tool for quantifying the risk-return trade-off of different assets (Lynu, 2002), and it leads to minimum variance portfolios (Luenberger, 1998). The pertinent statement is supported by the investors who attempted to minimize portfolio variances at any given level of expected returns (Fisher et al., 1997). Markowitz's mean-variance framework has had many financial applications in macroeconomics and monetary theory (Tobin, 1981).

Markowitz mean-variance framework is, however, usually applied in portfolio selection, where it involves the estimation of means, variances and covariances of the parameters chosen. This is supported by Barry (1974: p. 515), who says, "(t)he use of mean-variance analysis in portfolio selection involves the estimation of means, variances, and covariances for the returns of all securities under consideration." Markowitz's model is discussed through a direct adaptation from Elton et al. (2003). This is introduced in Figure 2.3 below.

Therefore, the necessary input data for Markowitz's model are the historical estimates of (Hagin, 1979):

1. Expected returns for each security

Markowitz (1959) suggests that the expected returns for each security can be calculated by:

$$R_{i,t} = \frac{P_{i,t} - P_0 + D_{i,t}}{P_0} \dots\dots\dots (2.1)$$

West (2005) places emphasis on equation (2.1) regarding its simplicity in determining the expected returns of a financial security.

Suppose an investor has a portfolio with n assets, the i^{th} of which delivers a single period return R_i with mean μ_i and a variance σ_i^2 . Suppose further, that the weight assigned to asset i in the portfolio is w_i . Then the single period return on the portfolio is:

$$R = \sum_{i=1}^n w_i R_i$$

The expected return on the portfolio is then:

$$E[R] = E\left[\sum_{i=1}^n w_i R_i\right]$$

$$E[R] = \sum_{i=1}^n w_i \cdot E[R_i]$$

$$E[R] = \sum_{i=1}^n w_i \mu_i$$

The variance of the portfolio is

$$\sigma^2(R) = E(R - \mu)^2$$

$$\sigma^2(R) = E\left[\sum_{i=1}^n w_i (R_i - \mu_i)\right]^2$$

$$\sigma^2(R) = E\left[\sum_{i=1}^n w_i (R_i - \mu_i) \sum_{j=1}^n w_j (R_j - \mu_j)\right]$$

$$\sigma^2(R) = \sum_{i=1}^n \sum_{j=1}^n E[w_i w_j (R_i - \mu_i)(R_j - \mu_j)]$$

$$\sigma^2(R) = \sum_{i=1}^n \sum_{j=1}^n w_i w_j \text{covar}(R_i, R_j)$$

$$\sigma^2(R) = \sum_{i=1}^n \sum_{j=1}^n w_i w_j \sigma_{ij}$$

Where,

- σ_{ij} is the covariance between R_i the return on asset i and R_j the return on asset j .

Figure 2.3: Markowitz's Mean-Variance Framework

2. Standard deviation for each security

The sample standard deviation has been used as an estimator of the population standard deviation (Mason et al, 1990). It is represented by equation (2.2).

$$\sigma_{i,t} = \sqrt{\frac{\sum_{i=1}^N (R_{i,t} - \overline{R_{i,t}})^2}{N-1}} \dots\dots\dots (2.2)$$

Where $\overline{R_{i,t}} = \frac{\sum_{i=1}^N R_{i,t}}{N}$, the mean of an individual security, is calculated as the sum of its returns by its sample size (Sharpe, 1970).

3. Correlation coefficient between each possible pair of securities for the securities under consideration

This is defined as the covariance between two random parameters divided by the product of their standard deviations, and represented by equation (2.3) (Ryan, 1978).

$$\rho_{i,j,t} = \frac{\sigma_{i,j,t}}{\sigma_{i,t}\sigma_{j,t}} = \frac{\beta_{i,t}\beta_{j,t}\sigma_{m,t}^2}{\sigma_{i,t}\sigma_{j,t}} \dots\dots\dots (2.3)$$

The correlation coefficient is bound in the range between -1.0 and +1.0, which corresponds to perfect negative and positive correlation respectively (Ryan, 1978).

The covariance between two variables is expressed in equation (2.4).

$$\sigma_{i,j,t} = \frac{\sum_{i=1,j=1}^N (R_{i,t} - \overline{R_{i,t}})(R_{j,t} - \overline{R_{j,t}})}{N-1} \dots\dots\dots (2.4)$$

Further to the above, Markowitz's model can be formulated as the following:

Assume that there are N assets. The mean (or expected) returns are $\overline{R}_1, \overline{R}_2, \dots, \overline{R}_N$ and the covariances are $\sigma_{i,j,t}$ for $i, j = 1, 2, \dots, N$. A portfolio is defined by a set of N weights w_i , $i = 1, 2, \dots, N$, that sum to 1. To find a minimum- variance portfolio, the mean value is fixed at some arbitrary value $\overline{R}$. Thus the problem can be formulated as follows (Adapted from Cuthbertson et al., 2004):

$$\begin{aligned} \text{Minimize} \quad & \frac{1}{2} \sum_{i,j=1}^N w_i w_j \sigma_{i,j,t} \\ \text{Subject to} \quad & \sum_{i=1}^N w_i \overline{R}_i = \overline{R} \\ & \sum_{i=1}^N w_i = 1 \end{aligned}$$

There is no particular significant reason for the constant value ' $\frac{1}{2}$ ' in the above formulation, its presence just make the "algebra neater" (Cuthbertson et al., 2004: p. 143), this can be interpreted as making the mathematics easier to understand and follow. An identical model was proposed by Luenberger (1998).

Markowitz's model provides the foundation for single-period investment theory. Single-period refers to a particular period as defined by the investor, that is an interval of time characterized by a single occurrence of an investment decision. This model explicitly addresses the trade-off between the expected rate of return and the variance of the return in a portfolio (Luenberger, 1998).

2.6.2 Sharpe's Single Index Model

Sharpe shows that the index model can simplify the portfolio construction problem as proposed by Markowitz (Jacquier et al., 2001). The simplification was achieved by

introducing assumptions. This is shown by Ryan (1978: p. 90), who says that “(i)ndex models owe their origin to a seminal paper by Sharpe which introduced a simple but far-reaching modification to the basic Markowitz framework. Sharpe added an additional assumption that observed covariance between the returns on individual securities is attributable to the common dependence of security yields upon a single common external force – a market index”

Even though assumptions were introduced in this model, these will not affect the quality of results generated as the “... single index model, developed to simplify the inputs to portfolio analysis and thought to lose information due to simplification involved, actually does a better job of forecasting than the full set of historical data.” (Elton et al., 2003: p. 147)

The single index model (Sharpe, 1964) is implemented when one tries to estimate a correlation matrix, conduct efficient market tests or equilibrium tests (Elton et al., 2003). This is a simplified approach to portfolio formulation. Sharpe’s single model is discussed by a direct adaptation from Elton et al., (2003). This is described in the Figure 2.4 and Figure 2.5.

Basic Equation

$$R_i = \alpha_i + \beta_i R_M + e_i \quad \text{for all stocks (securities) } i = 1 \dots n$$

By Construction

$$\text{Mean of } e_i = E(e_i) = 0 \quad \text{for all stocks (securities) } i = 1 \dots n$$

By Assumption

1. The index is unrelated to unique return: $E[e_i (R_M - \overline{R_M})] = 0$ for all stocks (securities) $i = 1 \dots n$
2. Securities are only related through their common response to the market: $E[e_i e_j] = 0$ for all pairs of stocks (securities) $i = 1 \dots n$ and $j = 1 \dots n$ but $i \neq j$

By Definition

1. Variance of $e_i = E(e_i)^2 = \sigma_{ei}^2$
2. Variance of $R_M = E(R_M - \overline{R_M})^2 = \sigma_M^2$

The expected return, variance and covariance for Single Index Model are:

1. The mean return, $\overline{R_i} = \alpha_i + \beta_i \overline{R_M}$
2. The variance of a security's return, $\sigma_i^2 = \beta_i^2 \sigma_M^2 + \sigma_{ei}^2$
3. The covariance of return between securities i and j , $\sigma_{ij} = \beta_i \beta_j \sigma_M^2$

The expected return on a security is

$$E(R_i) = E[\alpha_i + \beta_i R_M + e_i] = E(\alpha_i) + E(\beta_i R_M) + E(e_i)$$

By linearity of expectations, since α_i and β_i are constants and since the expected value of e_i is zero by construction, thus,

$$E(R_i) = \alpha_i + \beta_i \overline{R_M}$$

The variance of return on a security is given by:

$$\sigma_i^2 = E(R_i - \overline{R_i})^2$$

Figure 2.4: Sharpe's Single Index Model (Part I)

$$\sigma_i^2 = E[(\alpha_i + \beta_i R_M + e_i) - (\alpha_i + \beta_i \overline{R_M})]^2$$

$$\sigma_i^2 = E[\beta_i (R_M - \overline{R_M}) + e_i]^2$$

$$\sigma_i^2 = \beta_i^2 E(R_M - \overline{R_M})^2 + 2\beta_i E[e_i (R_M - \overline{R_M})] + E(e_i)^2$$

Since by assumption $E[e_i (R_M - \overline{R_M})] = 0$, thus,

$$\sigma_i^2 = \beta_i^2 E(R_M - \overline{R_M})^2 + E(e_i)^2$$

$$\sigma_i^2 = \beta_i^2 \sigma_M^2 + \sigma_{ei}^2$$

The covariance between any two securities can be written as

$$\sigma_{ij} = E[(R_i - \overline{R_i})(R_j - \overline{R_j})]$$

Substituting for $R_i, \overline{R_i}, R_j$ and $\overline{R_j}$ yields,

$$\sigma_{ij} = E\left\{ \left[(\alpha_i + \beta_i R_M + e_i) - (\alpha_i + \beta_i \overline{R_M}) \right] \left[(\alpha_j + \beta_j R_M + e_j) - (\alpha_j + \beta_j \overline{R_M}) \right] \right\}$$

$$\sigma_{ij} = E[\beta_i (R_M - \overline{R_M}) + e_i][\beta_j (R_M - \overline{R_M}) + e_j]$$

$$\sigma_{ij} = \beta_i \beta_j E(R_M - \overline{R_M})^2 + \beta_j E[e_i (R_M - \overline{R_M})] + \beta_i E[e_j (R_M - \overline{R_M})] + E(e_i e_j)$$

Since the last three terms are zero, by assumptions. Therefore:

$$\sigma_{ij} = \beta_i \beta_j \sigma_M^2$$

Where by regression analysis, the beta and alpha values can be calculated as follows:

$$\beta_i = \frac{\sigma_{iM}}{\sigma_M^2} = \frac{\sum_{t=1}^N [(R_{it} - \overline{R_{it}})(R_{Mt} - \overline{R_{Mt}})]}{\sum_{t=1}^N (R_{Mt} - \overline{R_{Mt}})^2}$$

$$\alpha_i = \overline{R_{it}} - \beta_i \overline{R_{Mt}}$$

Figure 2.5: Sharpe Single Index Model (Part II)

The input data requirements for performing a portfolio analysis using Sharpe's single index model are the historical estimates of (Hagin, 1979):

- expected return for each security,
- expected return of the market (in this report, the market refers to the index chosen),
- standard deviation for each security,
- standard deviation for the market, and
- correlation coefficients between each security and the market.

The pertinent historical estimates have been established by applying and adapting the equations (2.1) to (2.4).

The basic equation for Sharpe's single index model is represented by equation (2.5). This is also the basic equation for a linear regression model (Raftery et al., 1997).

$$R_{i,t} = \alpha_{i,t} + \beta_{i,t} R_{M,t} + e_{i,t} \dots\dots\dots (2.5)$$

for all stocks (securities) $i = 1 \dots N$

From equation (2.5), $R_{i,t}$ is represented as a linear function of $R_{M,t}$ and $e_{i,t}$. This view is supported by Cuthbertson (2004: p.179), who indicated that "...a return on any security $R_{i,t}$ can be adequately represented as a linear function of a single (economic) variable (parameter) $R_{M,t}$ where $e_{i,t}$ is a random error term".

The parameters represented in equation (2.5), are $\alpha_{i,t}$, known as alpha, $\beta_{i,t}$, as beta and $e_{i,t}$ a random error term. The interpretations of these constants are that alpha represents "...the extent to which a security is mispriced" (Tucker et al., 1994: p. 577), and beta is "... a measure of systematic risk of a security or portfolio," (Tucker et al., 1994: p. 577).

These values can be estimated by regression analysis. Beta and alpha can be represented mathematically by equations (2.6) and (2.7) respectively (Elton et al., 2003: pp. 140-141).

$$\beta_{i,t} = \frac{\sigma_{i,M,t}}{\sigma_M^2} = \frac{\sum_{t=1}^N [(R_{i,t} - \overline{R_{i,t}})(R_{M,t} - \overline{R_{M,t}})]}{\sum_{t=1}^N (R_{M,t} - \overline{R_{M,t}})^2} \dots\dots\dots (2.6)$$

$$\alpha_{i,t} = \overline{R_{i,t}} - \beta_{i,t} \overline{R_{M,t}} \dots\dots\dots (2.7)$$

Beta represents the sensitivity of an individual share to changes in the market. The market has a beta of one. Individual securities will thus have betas reflecting their relative sensitivities to the market beta of one (Correia et al., 2003). Alternatively, beta can be explained by the slope of a security line in the Capital Asset Pricing Model (CAPM) (Correia et al., 2003). When the beta value is less than 1, this suggests a lower gradient slope, ie. a flatter slope and a low rate of change between the price of securities and the market index, as a result, lower volatility. Furthermore, the parameter beta is also one of the performance measures of this model. It can be interpreted as “... the sensitivity of a security’s return to an underlying factor.” (Tucker et al., 1994: p. 577) The calculated beta value, using equation (2.6), is also known as ordinary least square (hereforth known as OLS) beta. OLS betas are adjusted in an attempt to improve predictive ability of the betas on securities and portfolios (Elton et al., 2003), since individual securities betas have a regression tendency towards grand mean of all the securities on the exchange. The adjustments are discussed in more details later.

Alpha represents the difference between a portfolio’s returns and its expected returns given its risk level as measured by its beta. It gives an indication of the extent to which a security is mispriced. Based on equation (2.7), from a mathematical perspective, it is reasonable to deduce that alpha is inversely related to beta.

The error is also estimated by using the regression model. The following describes the formulation of the parameters for the regression model.

Let the sample subset of returns on the market index have n elements. Denote this as $\{R_{M(1)}, R_{M(2)}, \dots, R_{M(n)}\}$. Let $\underline{y}_i$ be the (n by 1) vector of returns on share i, the response parameter (n is the same for each of the securities in the test portfolio, for more details please refer to Chapter 5 Design Outcome – The Data). Let X equal to the (n by 2) matrix of predictor parameters (Adapted from Hobbs, 2001: p.16):

$$X = \begin{bmatrix} 1 & R_{M(1)} \\ \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \\ 1 & R_{M(n)} \end{bmatrix} \dots\dots\dots (2.8)$$

$\underline{\beta}_i$ is the vector of unknown regression coefficients:

$$\underline{\beta}_i = \begin{bmatrix} \alpha_i \\ \beta_i \end{bmatrix} \dots\dots\dots (2.9)$$

$\underline{e}_i$ is the vector of error terms:

$$\underline{e}_i = \begin{bmatrix} e_{i(1)} \\ \cdot \\ \cdot \\ \cdot \\ e_{i(n)} \end{bmatrix} \dots\dots\dots (2.10)$$

So that $e_{i(t)}$ values are random variables, the parameters of whose distribution are unknown.

The regression model is given by (Hobbs: 2001, p. 16):

$$\underline{y}_i = X\underline{\beta}_i + \underline{e}_i \dots\dots\dots (2.11)$$

The least squares estimator $\hat{\beta}_i = \begin{bmatrix} \hat{\alpha}_i \\ \hat{\beta}_i \end{bmatrix} = (X'X)^{-1} \underline{y}_i \dots\dots\dots (2.12)$

if $X'X$ is non-singular.

For the purpose of this design, the vectors $\underline{y}_i$ and X are known. These values have been calculated using the raw daily price data collected. The least square estimator is then established using equation (2.12).

The error vector is calculated by changing the subject of formula in equation (2.11). The equation (2.11) becomes: $\underline{e}_i = \underline{y}_i - X\hat{\beta}_i$. When the errors are established, the values obtained are substituted into equation (2.5), to calculate R_i .

There are two adjustments which are made to the OLS beta values; these are Bayesian and Merrill Lynch's adjustments.

1. Bayesian Adjustment

Vasciek's technique is an application of Bayesian adjustment (hereforth known as BA) (Bradfield, 2003). BA presents the method of adjusting a security's beta based on the degree of uncertainty instead of assuming all securities move by the same amount toward the average (Elton et al., 2003).

The BA equation is shown in equation (2.13) (Bradfield, 2003), where the adjusted beta value is equal to the sum of both the product of a weight factor with the OLS beta estimate and the product of 1 less the weight factor with the average of the betas of all the securities in the portfolio.

$$\hat{\beta}_{BA} = \omega_{BA,i} \hat{\beta}_i + (1 - \omega_{BA,i}) \bar{\beta}_i \dots\dots\dots (2.13)$$

The weight factor in equation (2.13) is calculated using equation (2.14), shown below, (Bradfield, 2003: p. 50):

$$\omega_{BA,i} = \frac{\sigma_p^2}{\sigma_p^2 + \sigma_{\beta_i}^2} \dots\dots\dots (2.14)$$

This technique is relevant to South African's environment, since Cadiz Financial Strategists use it to determine beta values on JSE (Profile Group (Pty) Ltd., 2006a).

2. *Merrill Lynch's Adjustment*

The motivation for Merrill Lynch's (known as ML hereafter) adjustment on OLS beta estimates is the observation that, on average, the beta coefficient of securities seems to regress toward 1 over time (Elton et al, 2003: p. 144). Jarnecic et al. (1997: p. 7) suggest the statistical explanation for this is that "...when beta is estimated over a particular sample period, an unknown sampling error of estimated beta is sustained. The greater the difference between the estimated beta and 1, the greater the chance that a large estimation error has occurred; when the same beta is estimated in a subsequent sample period, the new estimate would be closer to 1."

Beta is adjusted by taking the sample beta estimate, OLS in this design, multiplying this value by two-thirds then plus a third (Jarnecic et al., 1997). The equation is shown in equation (2.15). The significance of constant, 1, from equation (2.15) has been described above.

$$\hat{\beta}_{ML} = \frac{2}{3}\beta_i + \frac{1}{3}.1 \dots\dots\dots (2.15)$$

Furthermore, from Sharpe's single index model, alpha, α_i can be determined by applying equation (2.7). The association between the two relevant adjustments and Alpha is also determined using equation (2.7); the results will be different due to the different beta outcomes. Beta, β_i , can also be estimated dynamically by the use of Kalman Filtering.

A Kalman filter, also known as linear quadratic estimation, is a set of mathematical equations that provide an efficient computational means to estimate the state of a process (Welch et al., 2001). The Kalman filter is applied to estimate the state of a system from measurements which contain random errors. This technique is usually used in control theory and control systems engineering (Welch et al., 2004). This technique also has applications in finance (Wellis, 1996). It is often used for the dynamic estimation of beta values (Bradfield, 2003). This is done by the two distinctive phases in Kalman filtering, that is, predict and update. The predict phase uses the estimate from the previous time state to produce an estimate for the current time state. In the update phase, the measurement information at the current time is used to refine this prediction in order to arrive at a new, hopefully more accurate estimate, for current time (Welch et al., 2001).

This report has chosen to model beta using a regression model. The adjustments that were done to the OLS beta, are BA and ML (Profile Group (Pty) Ltd., 2006a). Kalman filtering is not used due to the dynamic nature of this tool.

The models that are applicable to MPT have been discussed above. The examinations of the environment of the investment, namely the forms of the market, are introduced below.

2.6.3 Efficient Market Hypothesis

An efficient market is assumed for the concept of passive management approach (Hobbs, 2001). The “Efficient market hypothesis (EMH) is the set of arguments leading to the assertion that market prices fully reflect available information.” (Tucker et al., 1994: p.580) EMH is a set of implications that are associated with each different form of the market.

There are three forms of the EMH:

1. Weak Form

The weak form of the EMH assumes that current security prices fully reflect all security market information, including the historical sequence of prices, price changes, trading volume and any other market information such as odd lot transactions (Reilly, 1989, Correria et al., 2003 and Cuthbertson et al., 2004). Therefore, technical analysis is of no use when attempting to outperform the market; it is merely an approach that is used in the hope of predicting future trends (Hobbs, 2001). Yet, this form of the EMH suggests that future security prices cannot be predicted by the use of historical prices, this means that future cannot be predicted by using historical data, that further suggests that whatever happened in the past is unlikely to happen in the future, thus stock prices behave according to a random walk (Malkiel, 1999).

2. Semi-Strong Form

The semi-strong form of the EMH asserts that security prices adjust rapidly to the release of all new public information; thus security prices fully reflect all public information (Reilly, 1989, Correria et al., 2003 and Cuthbertson et al., 2004). Thus, fundamental analysis is of no use in outperforming the market, instead it is used in the hope of identifying new information (Hobbs, 2001 and Correria et al., 2003).

3. Strong Form

The strong-form of the EMH contends that security prices fully reflect all information, whether it might be public or private (Reilly, 1989, Correria et al., 2003 and Cuthbertson et al., 2004). In other words, not even insider information can be used in the quest to outperform the market.

The tools derived in this report may perform differently in different market environments.

From the above, the theories and methodologies for the model have been reviewed and developed. The model is graphically represented in Figure 2.6 and summarised as follows:

1. calculate returns of securities, using equation (2.1),
2. calculate the averages of securities and the chosen index,
3. estimate the error terms from Sharpe's single index model, using equations (2.8) to (2.12),
4. calculate the variances of securities, using equation (2.2),
5. calculate the covariances between securities, using equation (2.4),
6. estimate OLS beta values by regression model, using equation (2.6),
7. perform adjustments to OLS beta, the adjustments done were:
 - a. Bayesian adjustment, using equation (2.13),
 - b. Merrill Lynch adjustment, using equation (2.15),
8. estimate the alpha values using equation (2.7), and
9. calculate the expected returns using equation (2.5).

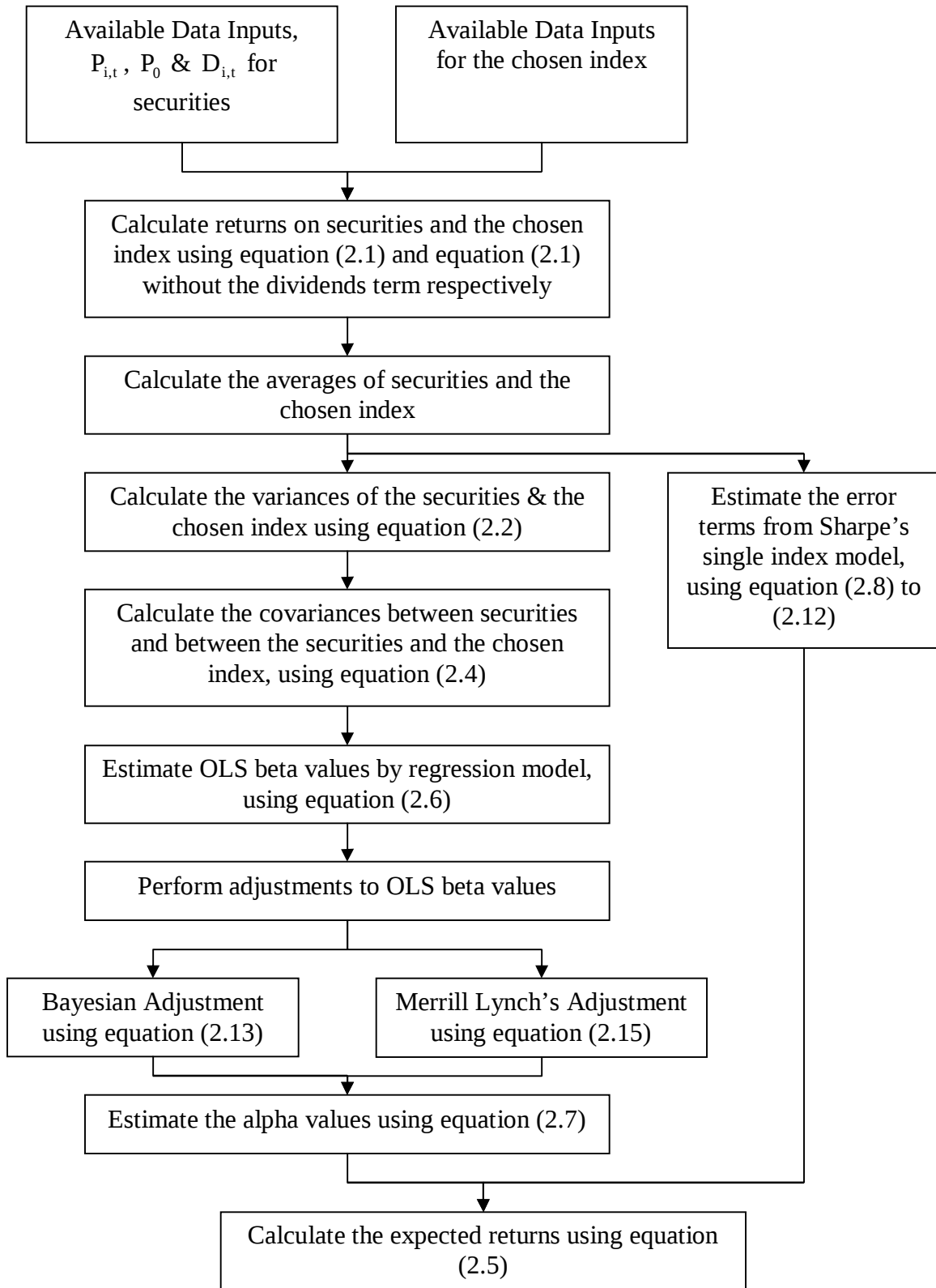


Figure 2.6: Process Flow Diagram of the Model

The model is subject to the following assumptions and limitations:

- Investors' behaviour plays a significant role in investment returns (Fridson, 2007).

Investors are assumed to behave rationally, for example:

- a. Investors consider each investment alternative as represented by a probability distribution of expected returns over some holding period.
 - b. For a given level of risk, investors prefer higher returns to lower returns. Similarly, for a given level of expected returns, investors prefer lower to higher risks.
- Investors base their decisions solely on expected returns and risk, so their utility curves are a function of expected return and variance (or standard deviation) of returns only.
 - There is assumed to be a perfectly efficient investment market, which suggests zero trading costs, et cetera.
 - Investment decisions are based only on the risk-return preferences of investors.
 - This model will also give an efficient frontier.
 - The investor has a quadratic utility function, but this is not always possible.
 - Security movements are related to the changes in the overall market.
 - This model also assumes that the expected value of a residual is zero and there is no correlation between the market returns and residuals (Kam, 2006).
 - The residuals of assets are uncorrelated. This suggests that any association between the returns of assets is attributable only to the common market movement (Kam, 2006).

2.7 Next Steps

To satisfy the objectives of:

- validity of the model and
- user- friendly utilisation of the model

The model is automated via a computer program.

Chapter 3 Development of Computer Programme

In this chapter, the development of the computer programme is divided into three stages, namely design requirement specifications, software selection and code written for the computer programme. Each of the stages are discussed below.

3.1 Design Requirement Specifications

In this section, the objectives of this computer programme are discussed. This leads to a needs analysis where a design requirement specification (hereforth known as DRS) is developed. The DRS consists of a list of requirements, criteria and constraints associated with the computer programme.

3.1.1 The Objectives

The motivation for creating this computer programme has been discussed in section 1.2, and the design objectives have been made apparent.

The objective is achieved by completing the following tasks:

- develop a model for passive portfolio management using MPT tools via a critical literature review as discussed in Chapter 2, and
- based on the above, develop an automated model via a computer programme that shall perform the relevant calculations as described in the critical literature view.

3.1.2 Needs Analysis

3.1.2.1 Design Overview

The computer programme designed is intended to be used by private investors. The level of computer competency needed is minimal. ‘Minimal’ refers to the basic skills in Microsoft Office packages, in particular, the Excel package.

3.1.2.2 Design Requirement Specification

As a direct consequence of the above, the requirements, constraints and criteria of the computer programme are discussed below.

Functional Requirement

The computer programme developed needs to demonstrate the automation of the model as discussed in Chapter 2. The computer programme follows the approach as proposed in Figure 2.6.

Constraints

The constraints with regards to this design of the computer programme were:

- limited **time**,
- limited **financial resources**, therefore some of the more advanced statistical packages were not considered, and
- lack of experience in writing a computer programme in all computer languages.

Criteria

The criteria form the guidelines to which the computer programme needs to adhere. Furthermore, the criteria considered need to be classified as either demand (hereforth known as D) or high wish (hereforth known as HW). D refers to the criterion that is the ‘must- have’ and high wish refers to the criterion that is nice to have.

The criteria considered for this computer programme have been tabulated in Table 3.1.

Table 3.1: Criteria for Design Requirements

Design Requirements	Criteria
<i>The model to be built based on the critical literature review</i>	D
<i>The outcomes of the model need to be specified</i>	D
<i>The computer package should be easy to learn</i>	D
<i>The computer package used should be relatively inexpensive without compromising the accuracy of calculations</i>	HW
<i>All data resulting from the model should be satisfactory for recording and analysing</i>	HW
<i>Model should process data speedily</i>	D
<i>Model should be clearly defined and structured in a logical manner</i>	D

3.2 Software Selection

3.2.1 Introduction

In this section, the processes followed to achieve the final software selection are discussed. The section starts with the introduction of the types of statistical packages, namely Microsoft Excel, MATLAB and SAS, that were considered for the computer programme. Each package is introduced, followed by their respective applications, advantages and disadvantages. This section concludes with the decision matrix used for software selection.

3.2.2 Types of Statistical Packages

As mentioned under the needs analysis, in section 3.1.2, the way to achieve the objectives that were set for this design is to build a model through the use of statistical packages. The types of statistical packages considered for this design is shown in Figure 3.1 below.

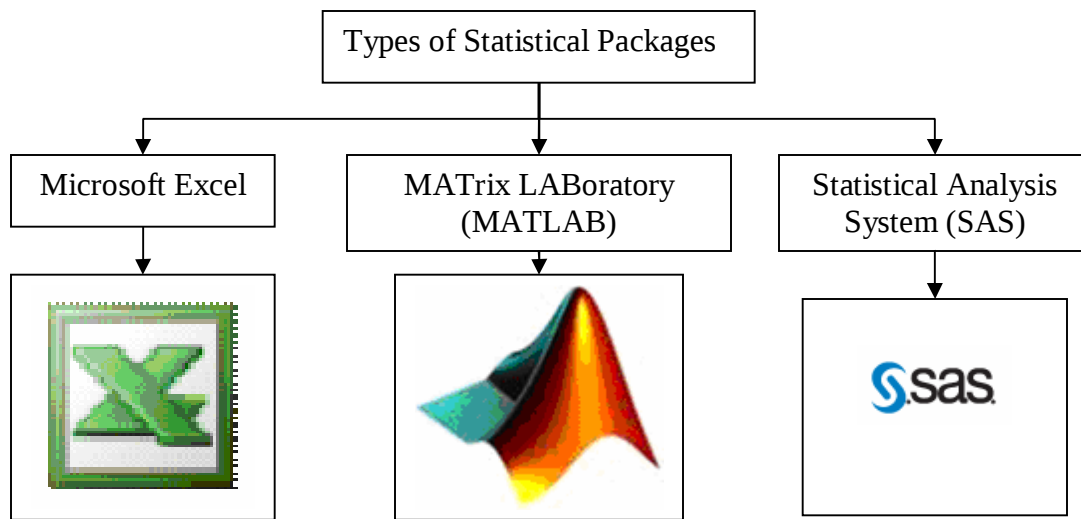


Figure 3.1: Types of Statistical Packages Considered

3.2.2.1 Microsoft Excel

Microsoft Excel (full name Microsoft Office Excel) is a spreadsheet¹⁴ application written and distributed by Microsoft. It features calculation, graphing tools, pivot tables and a macro programming language called Visual Basic for Application (henceforth known as VBA) (Microsoft Corporation, 2003 and Wikimedia Foundation Inc., 2007a). There are various add-on applications available that can conduct more in-depth analysis, examples of which are ‘Analysis ToolPak’ and ‘Solver Add-In’.

Some strengths and weaknesses of Microsoft Excel are described below:

Strengths

- It is user- friendly, very easy to learn.
- It can import, organise and explore data sets (Microsoft Corporation, 2007). This implies that Excel has strong analytical functionality. As a result, professional-looking graphs can be created.
- Ability to graphically compare results from a model and observations (Carleton College, 2007).

¹⁴ A spreadsheet is a grid of information, often financial information, (Wikimedia Foundation Inc., 2007b).

- Smart documents. These are documents that are programmed to extend the functionality of a workbook by dynamically responding to the context of ones actions. For example, the documents can be connected to a database that automatically fills in some of the required information (Microsoft Corporation, 2003).

Weaknesses

- Microsoft Excel was built based on floating point calculation. As a direct consequence, its statistical accuracy has been criticized, since it lacks certain statistical tools (Wikimedia Foundation Inc., 2007a).
- It is effective at certain tasks and not others (Wikimedia Foundation Inc., 2007b). Excel is effective at analytical functions, such as generating graphics, but not effective in mathematical modelling.
- It is loosely structured. Therefore it is easy for someone to introduce an error, either accidentally or intentionally. An example of this is that there is a lack of revision control. It is difficult to determine who changed what and when. This can cause problems with regulatory compliance, among other things (Wikimedia Foundation Inc., 2007b).

3.2.2.2 MATLAB

MATLAB is the abbreviation for MATrix LABoratory. It is a high performance language for technical computing. It can integrate visualisation, computation and programming in an easy-to-use environment, where problems and solutions are expressed in familiar mathematical notation. Some applications of this programme are maths & computation, data acquisition, data analysis, graphics application, modelling, simulation and statistical analysis (The MathWorks Inc., 2006 and Wikimedia Foundation Inc., 2007c).

Some strengths and weaknesses of MATLAB are described below:

Strengths

- It is relatively easy to learn (Northeastern University: College of Computer and Information Science, 2003).
- MATLAB code is optimised to be relatively quick when performing matrix operations. It's an interactive system whose basic elements don't require dimensioning. Therefore, this package is more robust than Excel, allowing complicated technical problems to be solved (The MathWorks Inc., 2006 and Northeastern University: College of Computer and Information Science, 2003).
- There are various toolboxes (add-on applications for specific solutions in a field) that can be accessed easily (The MathWorks Inc., 2006).
- Although the package is primarily procedural, MATLAB does have some object orientated elements (Wikimedia Foundation Inc., 2007c).

Weaknesses

- MATLAB is an interpreted language, making it, for most part, slower than a compiled language such as C++ (Northeastern University: College of Computer and Information Science, 2003).
- It is designed for scientific computation; therefore it is not a general purpose programming language and not suitable for some things. (Northeastern University: College of Computer and Information Science, 2003). An example is that MATLAB doesn't support references, which makes it difficult to implement certain data structures (Wikimedia Foundation Inc., 2007c). This point can also be identified as a characteristic of this package.

3.2.2.3 SAS

SAS (originally known as *Statistical Analysis System*) is an integrated system of software products. Some applications of this software are statistical & mathematical analysis, operations research & project management, business planning, forecasting & decision supports, report writing and graphics.

Some strengths and weaknesses of SAS are described below:

Strengths

- Being one of the most powerful data mining technologies, there is a huge user base for this software (Yates, 2006).
- It can handle large data sets (Mitchell, 2007).
- It can perform the vast majority of statistical analyses.

Weaknesses

- Relatively hard to learn (Yates, 2006 and Wikimedia Foundation Inc., 2007d) for a person with limited programming experience. One of the reasons is that the syntax it uses is unlike that of any other programming language.
- Doesn't have sophisticated graphical functions (Mitchell, 2007 and Wikimedia Foundation Inc., 2007d). The graphics generated by SAS are not as clear and structured as those produced by Excel.
- Costs, especially when compared to its open source competitors such as R-squared statistics. It is an open source statistical package that can be downloaded free of charge.

3.2.3 Decision Process

Based on the DRS, discussed in section 3.1, the most important factors¹⁵ that affect the choice of statistical packages used, as identified from Table 3.1, are: the processing speed of the package, the cost to obtain the licence of the package and the ease of learning the package.

By combining DRS and the strengths & weaknesses of each of the packages considered, this gives rise to Table 3.2 below, where each of the packages have been benchmarked against each other.

From Table 3.2, each of the three factors have been assigned different weighting factor, based on the DRS. Also, the score of 5 refers to the package being considered as the best

¹⁵ The term 'factor' has later on become 'category' in Table 3.2.

in the category and 0 being the least desirable in the category. The choice of scores was chosen to show the differentiation between the choices. Therefore, the scores were made to demonstrate a decision matrix.

Table 3.2: Decision Matrix of Concepts

	Weighting Factor	Maximum Score	Minimum Score	Microsoft Excel	MATLAB	SAS
Speed	0.5	10	0	0	3	5
Cost	0.2	10	0	5	3	0
Ease to Learn	0.3	10	0	5	3	0
TOTAL				2.5	3	2.5

Therefore, the package with the highest score from Table 3.2, MATLAB was chosen as the final package that is to be used for this design project. With this decision, a complete programme for the discussion in Chapter 2 needs to be undertaken, following the other design requirements in Table 3.1.

3.3 Code Written for Computer Programme

3.3.1 Introduction

In this section, the detailed model logic is discussed, which includes the coding of the computer programme.

3.3.2 Detailed Computer Programme Logic

The computer programme (hereforth known as model) logic has been segmented into three stages, namely inputs, computer programme and outputs. In this section, the details associated with each of the stages are described. The order of discussion is outputs, inputs

and computer programme, as shown in Figure 3.2 below. The rationale, for this order of discussion, is that it is important to keep in mind the set objectives of this design, followed by examining the inputs that are available and can be used to establish the objective. Finally, the computer programme is written to convert the available inputs into the proposed outputs.

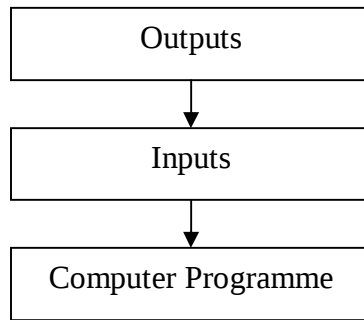


Figure 3.2: Order of Discussion

3.3.2.1 Outputs

The proposed method to achieve this relationship requires the following output parameters, as seen in Figure 3.3 below.

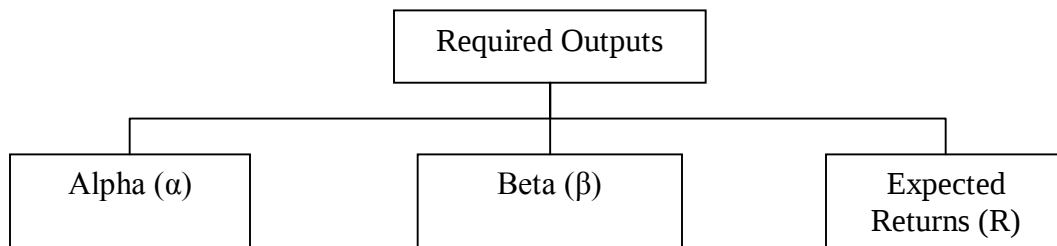


Figure 3.3: Required Outputs

The detailed calculations of the pertinent parameters will be covered in section 3.3.2.3.

3.3.2.2 Inputs

The input parameters that are needed to calculate beta, alpha and the expected returns of the portfolio are the following, which are also graphically presented in Figure 3.4:

- daily closing share prices for each of the securities in the portfolio,
- weight¹⁶ assigned to each security,
- dividends of each security over a particular time frame, and
- daily closing value of All Share Index (also known as ALSI).

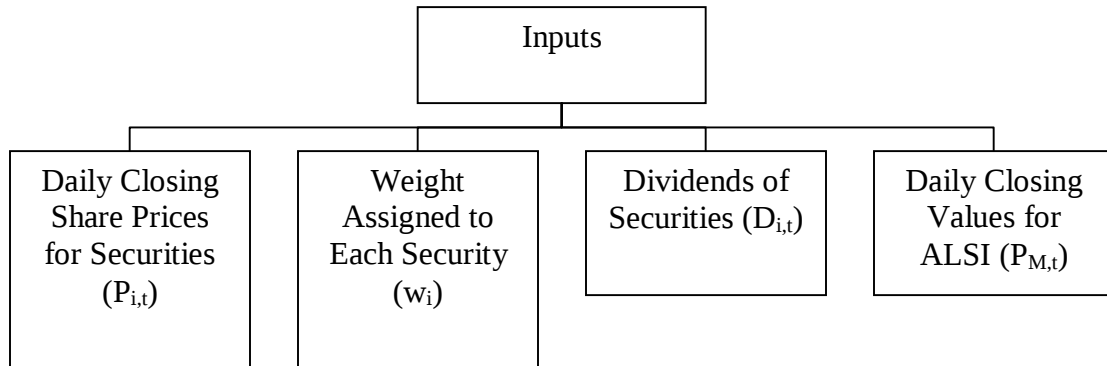


Figure 3.4: Inputs Parameters Used

3.3.2.3 Computer Programme

This computer programme serves as a tool that is necessary for the conversion from inputs to outputs. The inputs are fed into the model in one of two ways. Firstly, communication was set up between the input in raw data form in Excel as extracted from the source and MATLAB software. Alternatively, a user-interface was created to allow the user to enter the required information. As discussed above, the required outputs are beta, alpha and expected return of a portfolio. In this section, the flow process diagrams for each of the required outputs are discussed separately before they are combined in the overall computer programme's flow process diagram.

¹⁶ Weight, in this case, refers to the investment composition that is assigned to the security.

Beta Calculation

Beta is calculated by using the proposed inputs and applying them to the equations that were introduced in Chapter 2. The flow chart is shown below, Figure 3.5.

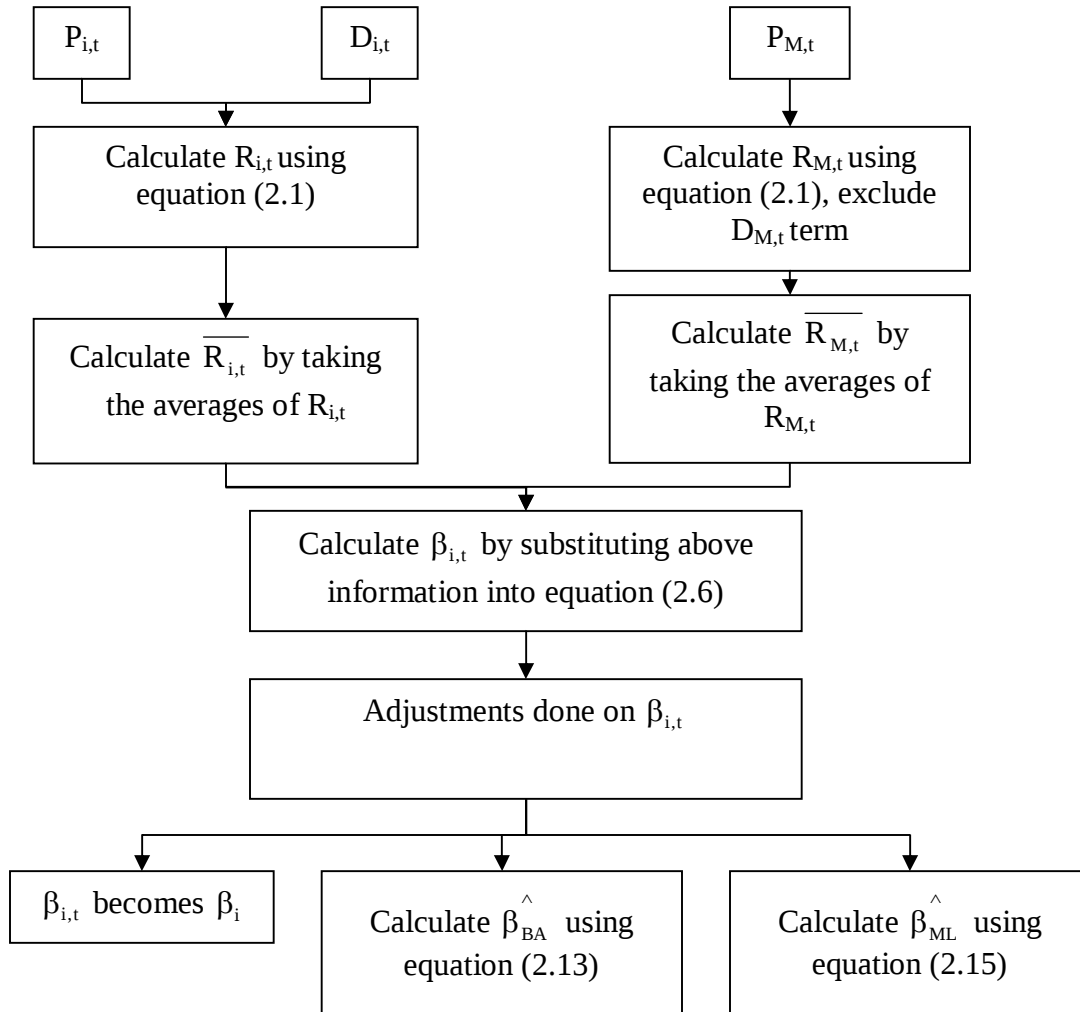


Figure 3.5: Process Flow Diagram for Beta Calculation

Alpha Calculation

Alpha is now calculated by applying equation (2.7). The input parameters needed for equation (2.7) have been calculated above under beta calculation, shown in Figure 3.5. The process of calculating alpha has been represented graphically in Figure 3.6 below.

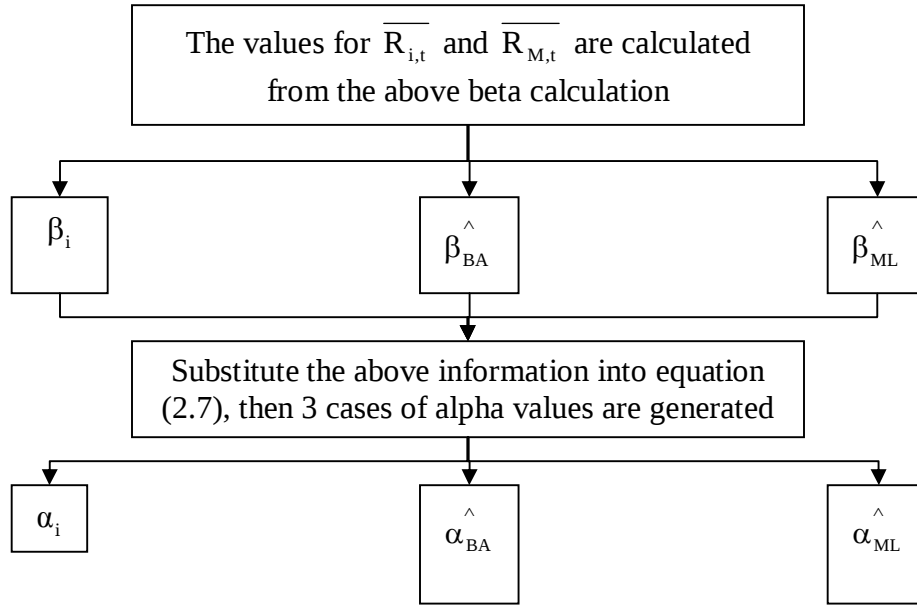


Figure 3.6: Process Flow Diagram for Alpha Calculation

Expected Returns Calculation

Expected returns are calculated by applying equation (2.5). All of the parameters from equation (2.5) can be calculated by applying equations from sections 2.6. These parameters include beta, alpha and the error terms.

3.3.3 Final Computer Programme

From above, the details of the error terms from Sharpe's single index model have been discussed in Chapter 2. The introduction of error calculations was done in section 2.6.2.

As a consequence, two sets of MATLAB codes have been written, one to include the error term from the single index model (Appendix A – MATLAB Code for Analysing Components of the Test Portfolio With Error Terms, p. 122) and the other to exclude it (Appendix B – MATLAB Code for Analysing Components of the Test Portfolio Without Error Terms, p. 134). The instructions for running the MATLAB codes are set out in Appendix C – Instructions for Running MATLAB Code (p. 149).

A set of codes to exclude error terms is written for the generic analysis. This code calculates the parameters, in isolation¹⁷, for an investor. If an investor wants to examine the parameters in relation to the general economic environment, it is necessary to include the error terms. By including the error, an investor would gain a more holistic view of his/her investment in relation to that of an economic environment. Hence, a separate set of codes are written for this reason. Comparisons are made between the results.

Process flow diagrams have been drawn for the cases where the error terms are included and excluded. These are shown below in Figure 3.7 and Figure 3.8 respectively.

¹⁷ Isolation refers to a closed system. In this research, it means to examine shares without considering the general economic environment.

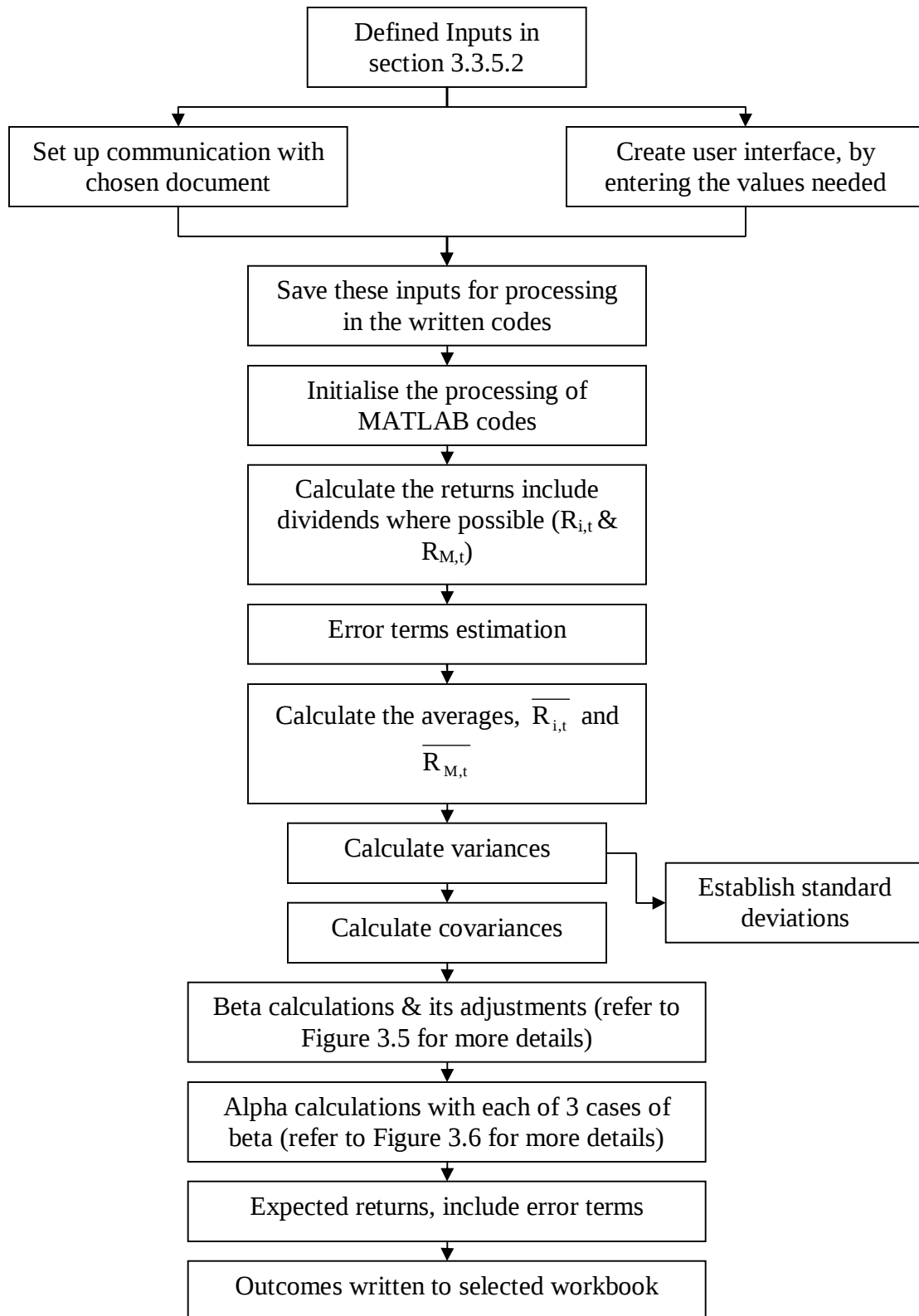


Figure 3.7: Overall Flow Process Diagram for MATLAB code Including Error Terms

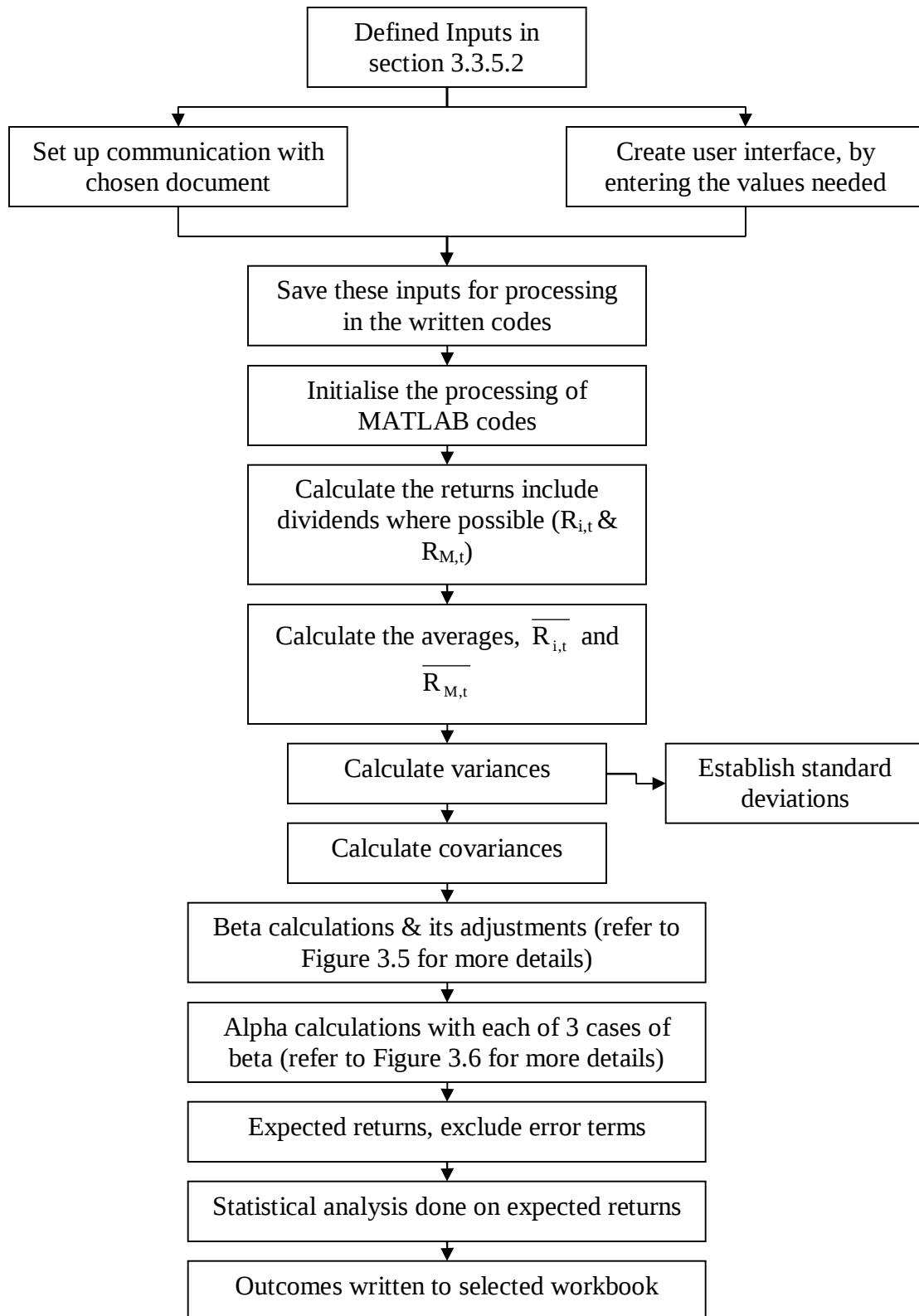


Figure 3.8: Overall Flow Process Diagram for MATLAB code Excluding Error Terms

3.3.4 Testing of Computer Programme

Testing (which can also be interpreted as validation) is a process that consists of four distinct steps, namely software, hardware, method and system suitability validations. This is represented below, in Figure 3.9 (Waters Corporation, 2007):

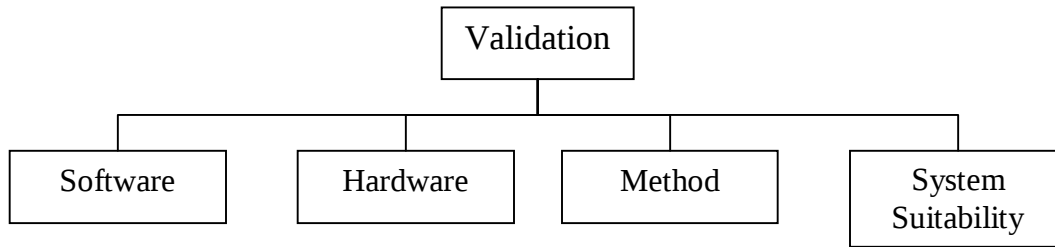


Figure 3.9: Steps for Validation

The testing of this computer programme is demonstrated through the use of an example as described below. The given data is as follows:

Observation	P_1	P_M
1	12	50
2	13	54
3	10	48
4	9	47
5	20	70
6	7	20
7	4	15
8	22	40
9	15	35
10	23	37

To ensure that the analytical system is validated, a validating computer programme has been written (Appendix D – MATLAB Code for Validating The Computer Programmes, p. 161). In this report, the analytical system refers to the computer programme written.

The validating computer programme written is similar to the final programmes found in Appendix A and Appendix B. The final computer programmes written have been broken down into smaller parts for ease of validation. The validating computer programme can be run by carrying on the steps (5) and (6) as described in Appendix C as well as selecting an output file to which the results are written. The validating programme consists of the following parts:

- calculation of the returns for individual share and the index,
- calculation of the arithmetic averages for individual share and the index,
- calculation of the variance,
- calculation of the covariance,
- calculation of the OLS beta and OLS alpha,
- adjustments of the beta by using Bayesian and Merrill Lynch adjustments, and
- calculation of the adjusted alpha values.

The results from this validation demonstration are found in Appendix E – Validation Results, p. 164. The validating computer programme and the results can be found on the CD provided.

Validation ensures that the model meets its intended requirements in terms of the method employed and results obtained. The validating computer programme is a reasonable model as the outcomes have matched the manual calculations with suitable precision. Thus the validation results, the error comparisons between the results obtained by the validating computer programme and the manual calculations are negligible. It is evident that the procedures followed in this report are valid, since the errors are negligible. The validating computer programme was then modified to give rise to the final computer

programme. The final computer programme is in a generalised format and is able to incorporate more data than the validating computer programme.

Chapter 4 Selection of Test Portfolio

4.1 Choice of Constituents in Test Portfolio

The theoretical preliminaries and design model logic have been established in the literature survey and development of the computer programme respectively. The next phase is to investigate the reasons for the constituents in the test portfolio. This section discusses the structure of the test portfolio.

4.1.1 Portfolio Selection

This is an ex-ante¹⁸ concept (Friend et al., 1965) and the process of selecting a portfolio can be divided into two stages. The first stage begins with observation and experiences and ends with a belief regarding the future performances of the available securities. The second stage starts with the relevant future performance belief and ends with portfolio choice (Markowitz, 1952).

In portfolio selection, there are four areas that one usually looks at (Cohen et al., 1987), namely the macroeconomic factors, investors' profile, fundamental and technical analyses.

- i. Macroeconomic factors: these refer to factors that can affect the entire economy (Muradzikwa et al., 2004). An investor should ask and obtain answers to the following questions in order to consider the relevant factors for the portfolio selection (Cohen et al., 1987):
 - What is the state of business or the economy? Is it a favourable time to invest? Where are we in the business cycle? Is a boom likely to top out shortly? Is a recession near at hand?

¹⁸ Ex- ante means before, first or prior to.

- What is the state of the market? Are we in the early stages of a bull market? Has the low point of a bear market been reached?
- What industries are likely to grow most rapidly? Are there any special factors that favour a particular industry?
- Which companies within the industry are likely to do best? Which companies are to be avoided because of poor prospects?

These pertinent questions are associated with macro-economic factors of the economy. By taking these factors into consideration, a better understanding of the economy is gained and more informed decisions are made regarding the portfolio selection.

Once the macroeconomic factors have been identified, one would decide upon the technical views that are going to be followed, i.e. whether it would be a contrarian or a smart money view.

- ii. Investors' profile: An investor's risk tolerance and investment goals play an important part in portfolio selection. These attributes have been discussed in section 2.5.2.
- iii. Fundamental analysis: This refers to examination of a firm's financial data and operations while ignoring the overall state of the market. This analysis is often referred to as ratio analysis. The ratios of interest in portfolio selection are generally earnings per share, price earning and return on investment. These have been discussed in section 2.5.1.
- iv. Technical analysis: This refers to investment decision-making by the use of charts. This gives a reasonable indication of the market and the direction it is heading; these have been explained in the discussion of section 2.5.1.

Fundamental and technical analyses are important in estimating the intrinsic value of a firm. From the former, an investor would be able to decide upon the firm's potential.

From the latter, an investor would be able to identify the possible trends of the firm in the future based on the chart patterns.

In the test portfolio, the macroeconomic factor of particular interest is the FIFA Soccer World Cup. On the 15th May 2004, it was decided that South Africa would be the host country for the 2010 Soccer World Cup (Wikimedia Foundation Inc., 2004). This immediately suggests the following:

- a) New stadiums need to be constructed, while existing ones need to be upgraded.
- b) Government needs to improve the current public transport infrastructure.
- c) Special measures need to be taken to ensure the safety and security of tourists.

The general consensus from a review of the literature regarding the 2010 Soccer World Cup is that an investor should pay special attention to the following sectors:

- a) Basic materials
- b) Consumer goods and services: these would contribute towards tourism.
- c) Telecommunications
- d) Industrial
- e) Financials

Brinson et al. (1995) give a set of guidelines for designing a portfolio, which involves at least four steps:

- i. Determine what asset classes or sectors are to be included and excluded from the portfolio. This supplements the concept of asset allocation, discussed under section 2.5.2.
- ii. Decide on the time horizon of the portfolio, whether it would be a short-, medium- or long- term investment; and on the weights associated with each of the asset classes.

- iii. From a strategic perspective, an investor should rebalance the portfolio annually to capture excess returns from short-term fluctuations (in capital gain) in asset classes. These fluctuations may be due in part to economic conditions.
- iv. Select individual securities within an asset class, which would achieve superior returns relative to the rest of that particular class. These are usually referred to as blue-chip or growth securities.

The structure of the test portfolio will take into account the sector breakdown as it appeared on JSE as well as the securities' categorisations. This is represented graphically below, Figure 4.1.

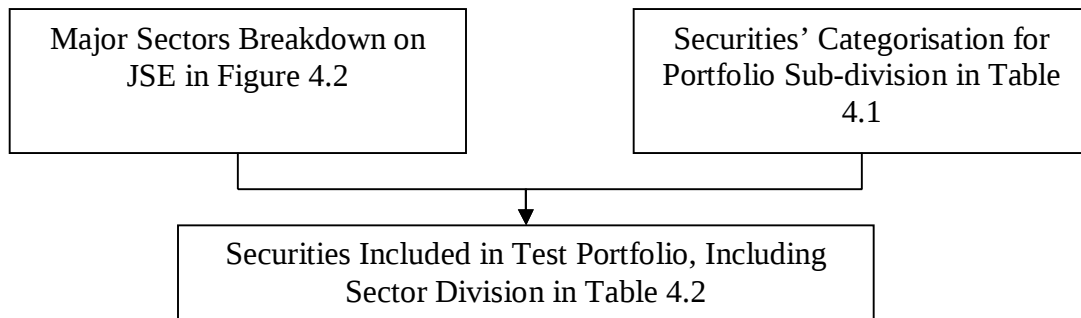


Figure 4.1: Structure of Test Portfolio

It is relevant to know which of the major sectors these shares fall under, therefore the major sector division of the ALSI is shown in Figure 4.2. There are Roman numeral superscripts present with each of the major sector divisions in Figure 4.2. The purpose of superscripts is to cross-reference between the major sector division and the security in the test portfolio. This will be evident in the sections to follow.

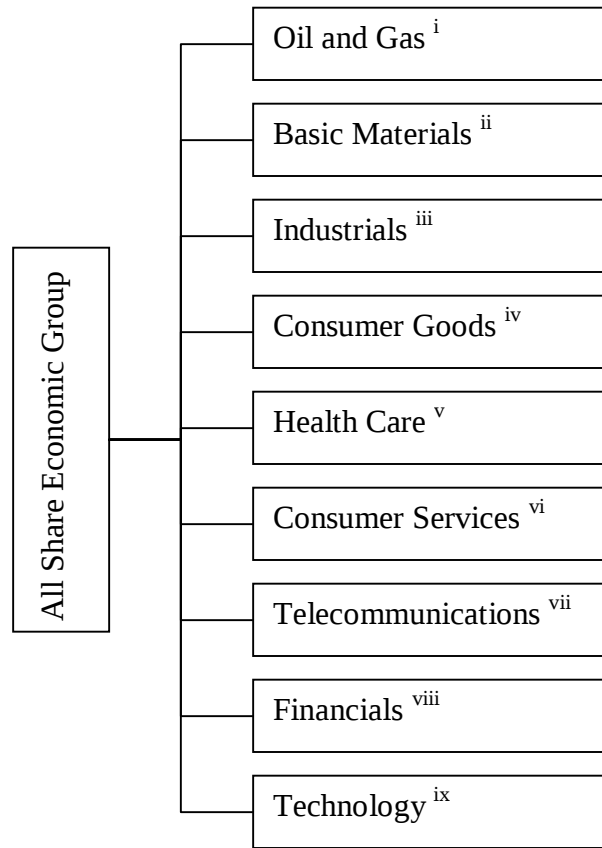


Figure 4.2: All Share Economic Group Breakdown

The next procedure is to determine the number of shares to be included in an investment portfolio.

As Sharpe (1995: p. 85) states, “(t)he number of securities in a portfolio provides a fairly crude measure of diversification”. This means many securities must be included in a portfolio in order to achieve diversification. The overall test portfolio used in this research includes a total of 27 shares (Appendix F – Sample Size of Test Portfolio, p. 168). This is a reasonable number of securities, since “...a well-diversified stock (security) portfolio must include at least 30 stocks (securities) for a borrowing investor...” (Statman, 1987: p. 362). Therefore the benefits of diversification are experienced in the test portfolio, and risk reductions are evident.

Securities included in this portfolio are merit firms. ‘Merit firms’ refers to companies with solid fundamentals. This is mostly emphasised by their presence in the headline indices such as the FTSE/JSE Africa Top 40 Index and Top 100 Securities in FTSE/JSE Africa All Share Index. Each of the firms is a leader in its particular industry. The test portfolio is divided into six components as displayed in Table 4.1. This division is due to different investment time horizons, market capitalisations and selection criteria. The securities’ categories shown in Table 4.1 are discussed below (Standard Bank, 2007).

Table 4.1: Securities’ Categories for Portfolio Sub-Division

Balanced	Conservatives	Core Alternatives	Core	Mid-Term	Small Caps
Commodity	Blue- chip	Blue- chip	Blue- chip	Blue- chip	Small Caps
Cyclical	Income	Value	Commodity	Cyclical	
Growth	Growth			Value	
Value					

Commodity securities are the firms whose security price is dependent on a value of commodity such as gold or oil. An example of these securities is Anglo Platinum plc.

Cyclical securities’ fortunes are tied closely with the economical cycle. South Africa is currently preparing for FIFA Soccer World Cup 2010. There is infrastructure which needs to be built, therefore cement and construction firms were chosen. These are Pretoria Portland Cement (PPC) and Murray & Robert (MUR).

Growth securities are the firms who have consistently produced above-average growth in revenue and profits for many years and look likely to continue in the future, such as Anglo Platinum plc. These are the securities that are supported by Buffet, who believes in the sustainability of firms (Buffet et al., 2002).

The securities of profitable companies that are selling at a reasonable price compared to their intrinsic value are the value securities. Examples are Woolworths Holdings Ltd. (WHL) and Shoprite Holdings Ltd (SHP).

Income securities are those securities whose security prices may be unexciting but will continue to pay out generous dividends and as a result yield very good returns to investors.

Blue-chip securities are the most stable ones, as they are large, financially solid firms that have been around for years and their securities are held by both professional and private investors. Examples are Standard Bank Group (SBK) and Anglo Platinum plc (AMS).

Smaller Caps' securities: There is always a possibility of investing early on in a firm that may become a growth security or blue chip of tomorrow.

The categories of securities can overlap due to the nature of the security. An example is AMS which is a blue-chip firm and a commodity-based firm with strong sustainable growth due to the current needs for platinum. Hence AMS can be categorised as blue-chip, commodity and growth security simultaneously.

Usually, when a firm can be placed into more than one category, the firm is a good security recommendation to an investor.

Table 4.2: Securities Included in Test Portfolio, Including Sector Division

Balanced	Conservatives	Core Alternatives	Core	Mid-Term	Small Caps
ANGLOPLAT ⁱⁱ	ABSA ^{viii}	ALEXFBS ^{viii}	ANGLO ⁱⁱ	BARLOWORLD ⁱⁱⁱ	BCX ^{ix}
CITYLDG ^{vi}	BIDVEST ⁱⁱⁱ	FIRSTRAND ^{viii}	BARLOWORLD ⁱⁱⁱ	FIRSTRAND ^{viii}	BDE ⁱⁱⁱ
MTN ^{vii}	IMPERIAL ⁱⁱⁱ	SAB PLC ^{iv}	LIB-INT ^{viii}	M &R HLD ⁱⁱⁱ	DISTELL ^{iv}
PPC ⁱⁱⁱ	REUNERT ⁱⁱⁱ	STANBANK ^{viii}	PICK’N PAY ^{vi}	MTN ^{vii}	ERP.COM ^{ix}
SHOPRITE ^{vi}	VENFIN ^{viii}	TIGER BRANDS ^{vi}	REMGRO ⁱⁱⁱ	PPC ⁱⁱⁱ	FAMBRANDS ^{vi}
WOOLIES ^{vi}				REUNERT ⁱⁱⁱ	
				SAB PLC ^{iv}	
				SHOPRITE ^{vi}	
				STANBANK ^{viii}	
				TIGER BRANDS ^{vi}	
				WOOLIES ^{vi}	

In Table 4.2, the securities under each category are shown. Also, the numerical superscripts associated with each securities, are referring to the corresponding sectors in Figure 4.2. Through this, the securities are paired with their respective sectors. In Table 4.2, the categories of securities chosen for each of the six components are displayed.

In summary, the constituents of the test portfolio form part of the headline indices. It is observed that the securities chosen are financially solid and their diversifications are evident. This is supported by the ratios calculated (Profile Group (Pty) Ltd., 2006b), the investments made in other firms as well as the cross-listing structures of some firms. Therefore their merit is recognised. An in-depth discussion on reasons for each security’s inclusion is available, (Refer to Appendix G – Rationale for Shares’ Inclusions in the Test Portfolio, p. 170). Furthermore, the choice of this test portfolio was supported by Korner (2005).

The reasons for the choice of securities have been discussed. Next, the model formulation and its composition will be considered.

The generic formulation of the test portfolio is as follows:

$$I_{ij} \quad 1 \leq i \leq N \text{ and } 1 \leq j \leq N$$

$$R_{1,p} = w_{11}I_{11} + w_{12}I_{12} + \dots + w_{1n}I_{1n}$$

$$R_{2,p} = w_{21}I_{21} + w_{22}I_{22} + \dots + w_{2n}I_{2n}$$

$$:$$

$$:$$

$$R_{n,p} = w_{n1}I_{n1} + w_{n2}I_{n2} + \dots + w_{nn}I_{nn} \dots \dots \dots (4.1)$$

$$R_{OP} = \omega_1 R_{1,p} + \omega_2 R_{2,p} + \dots + \omega_n R_{n,p} \dots \dots \dots (4.2)$$

$$\sum_{i=1}^n \omega_i = 1 \dots \dots \dots (4.3)$$

$$\forall i: \omega_i > 0$$

In this design, N goes up to 6.

The returns calculated using equations (4.1) and (4.2) form the effective interest rate. A conversion needs to be conducted to convert the effective interest rate into the nominal interest rate format. The reason for this conversion is that the yield of the risk-free interest money market instrument, the government R194 bond, is given in nominal form, compounded semi-annually. Equation (4.4) is used for this conversion:

$$i_{nir} = m \left[(r + 1)^{\frac{1}{m}} \right] - 1 \dots \dots \dots (4.4)$$

In Table 4.3, the investment composition is displayed; the percentages invested are based on the monetary value invested in each component.

Table 4.3: Investment Composition

Component Name	Amount Invested	Percentage Invested
Balanced	R 15 000	18.75%
Conservatives	R 10 000	12.50%
Core Alternatives	R 10 000	12.50%
Core	R 15 000	18.75%
Mid- Term	R 20 000	25.00%
Small Caps	R 10 000	12.50%
	R 80 000	100.00%

4.2 Choice of Index

The choice of index determines how much the portfolio return is correlated with the market (Hobbs, 2001: p.21).

The benchmark chosen is the FTSE/JSE Africa All Share Index, since it represents 99% of the full market capital value of all ordinary securities listed on the JSE that are eligible for inclusion in the index (JSE, 2007). The All Share Index is dominated by the firms in the resource sector which is the nature of the domestic economic environment.

The constituents chosen for the test portfolio are the headlines indices constituents; this emphasises the merit of these firms. The firms chosen also account for more than a third of the equity market capitalisation, (Appendix H – Ordinary Shares Listed Based on Market Capitalisation, p. 174). This reinforces the view that the sample chosen is a good representation of the market as a whole. This implies that the benefits of diversifications have been experienced and risk reductions become evident.

Chapter 5 Design Outcomes

5.1 Introduction

In this chapter, the results obtained by applying the computer programme, as outlined in Chapter 3, are discussed. These discussions are based on the models formulated in the critical literature review in Chapter 2.

5.2 The Data

Daily data from 1st September 2005 to 31st January 2007 was used to perform analyses. The test period began on 1st September 2005 because the test portfolio was only active as of that date, and the test period ends on 31st January 2007 as the government bond R194 had been redeemed around that time. The choice of using daily data was made since there was limited monthly and yearly data available over this test period. Also over this period, the market displayed a bullish state. This is shown in the increasing trend of the All Share Index.

The data was sparse for one particular share in the test portfolio, namely VenFin Ltd., since it was de-listed from the JSE equity market on 1st March 2006. The de-listing of VenFin was because of its acquisition by Vodafone. (VenFin Group, 2006: p.10) VenFin was kept in the portfolio to provide the holistic view of the component over the chosen test period.

5.3 Results with Discussion

Each of the shares, making up the components (also known as subportfolios) which made up the test portfolio, was individually regressed against the FTSE/JSE Africa All Share

Index. The raw data of each component was processed through sets of MATLAB code. The MATLAB codes were written based on the single index model. The process flow diagram of this computer programme has been discussed in Chapter 3.

Results may be found under the “Final Results” folder on the disk provided. The folder has further been categorised into two sections, one being the results without error terms and the other being with error terms. In the next sections, these outcomes are reviewed, according to different components, and the overall portfolio outcomes examined. The structure of discussion of the design outcome is best represented graphically in Figure 5.1 below.

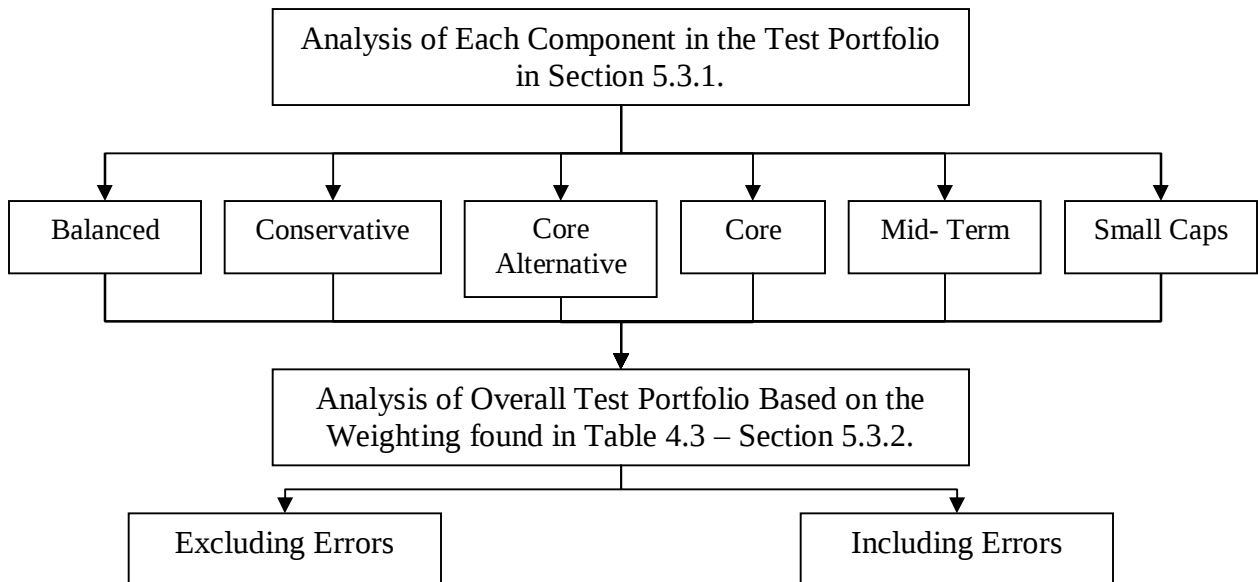


Figure 5.1: Structure of Discussion for Design Outcomes

Analyses on the outcomes of each of the components, namely the balanced, conservative, core alternative, core, mid-term and small caps components of the test portfolio are to be discussed separately. This discussion is found in section 5.3.1. The outcomes of the components are to be combined by using the weightings found in Table 4.3, into the overall test portfolio result. The overall test portfolio results will be discussed in both

contexts, one to exclude the error terms and the other to include the error terms. This discussion is found in section 5.3.2.

5.3.1 Results of Components

The results of each component of the test portfolio are reviewed below. The reason for examining each component separately is due to the presence of repeated shares in the test portfolio across components. Repeated shares have been double counted when viewing the test portfolio holistically. Some examples of the repeated shares are MTN and Barloworld. MTN was chosen for both balanced and mid-term components. Barloworld is present in both core and mid-term components. An investor needs to decide on an allocation between the securities within a portfolio. It is suggested to start with equal allocation among the securities in a portfolio. This is supported by Elton et al. (1997: p.417) who state, "... equal investment is optimum if the investor has no information about future returns, variances and covariances." Therefore, an equal split in investment has been assumed for each security in the component. From Table 4.3, the investment compositions of each component were stated as 18.75% for balanced component, 12.50% for conservative component, etc. These are the compositions used for combining the overall test portfolio. The above mentioned "equal split" refers to the equal split of the amount invested in each of the securities. For example: there are six securities in the balanced component. The monetary value of amount invested in balanced component is R15000. This means that the monetary value invested in each of the securities in balanced component would be R15000 divided by 6, which equals to R2500. R2500 is the monetary value invested in each of the securities in balanced component. Further investments in the same shares are made if the share is present in another component.

Individual shares' weighting, in each component, are based on the actual units held. The actual units held are calculated by dividing equal monetary value in investments of the component into the initial individual share prices (Refer to Appendix I – Dividends & Weightings Used for Beta Calculation, p. 188).

The outcomes generated by passing raw data through the MATLAB codes are the beta values, alpha values and expected returns of components. The returns on a portfolio may be decomposed into two parts:

- beta of the portfolio, which is linked to the return on the market, and
- alpha of the portfolio. This part can be attributed to characteristics of the individual shares comprising the portfolio.

Beta is the ratio of correlation between the component and the market to the variance of the market; this is as defined in Chapter 2. Practically speaking, beta represents the correlation between the portfolio and the market. If beta is positive, it represents positive correlation with the market. This means that the portfolio moves in the same direction as the market. Alpha can be interpreted as the values that can be added by human interventions, an example of which is a fund manager. Thus, when beta is high, it is expected that alpha would be low, when the expected returns stay constant. Therefore, there is an inverse relationship between alpha and beta. This was discussed in Chapter 2.

The raw data has been passed through two sets of MATLAB codes respectively. The results obtained are similar in both beta and alpha values but not the expected returns. This deviation has been previously mentioned, and it is due to inclusion of error terms from single index model. The reasons contributing to these errors are discussed in section 5.3.2.

1. Balanced Portfolio

In this section, the results, namely the betas, the alphas and the expected returns from this component are discussed. The results of this component have been written into “results_balanced.xls” which can be found on the disk provided.

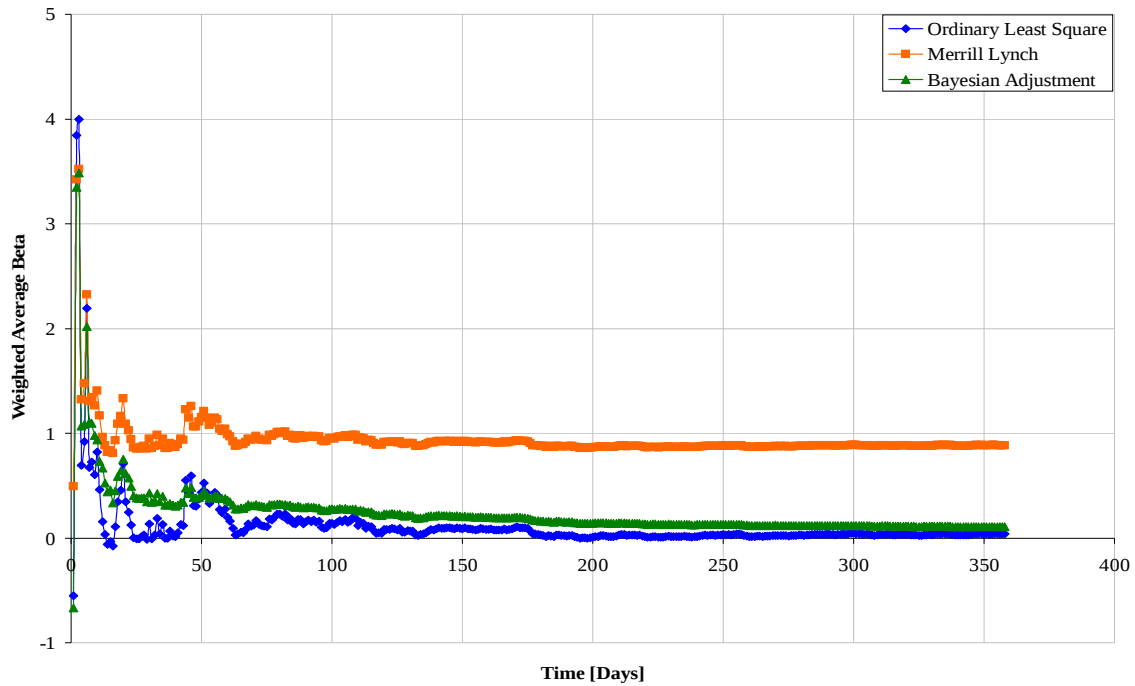


Figure 5.2: Weighted Average Beta for Balanced Component over Test Period

From Figure 5.2, the weighted average beta for balanced component has been plotted against the number of days' worth of data analysed. That is, the number of days into the test period. The purpose of representing results over the entire test period is to identify trends. This is applied to the analysis of all the components to come in this document. It is observed that the beta values stabilise around the 50th day, i.e. $t = 50$. The initial fluctuations, between $t = 0$ and $t = 45$, are inherent within the data. It is not unusual for data to fluctuate during the initial test period. The high fluctuations are associated with the choice of daily data used. The beta coefficients of stocks tend to move near 1 over time (this is shown by ML series), while OLS and BA series stabilised near 0 over time. This means that ML series indicate almost total correlation with the market while OLS and BA series indicate almost no correlation. The almost no correlation for both OLS and BA series implies that diversification has been managed adequately for this balanced component. The ML series indicates the almost total correlation, which is due to the constant $1/3$ added onto its beta adjustment as seen in equation (2.15), otherwise the ML series would stabilise at approximate values as that of BA series. Also, over time, all three series, OLS, BA and ML beta values have stabilised.

The general trend displayed, in Figure 5.2, is that ML series has the highest beta value followed by BA then OLS. BA results are higher than OLS because there are weighting factors incorporated. This trend is due to the adjustments made. The adjustments made on beta values are discussed in section 2.6. The OLS series has the lowest beta values; this is explained mathematically by using the equation (2.6). To obtain a low beta value, either the covariances¹⁹ between the shares and the market are low, or the variance present in the market is high. The securities were chosen from different sectors. So securities may have little similarity with each other. If securities have little similarity with each other then their covariance will be low.

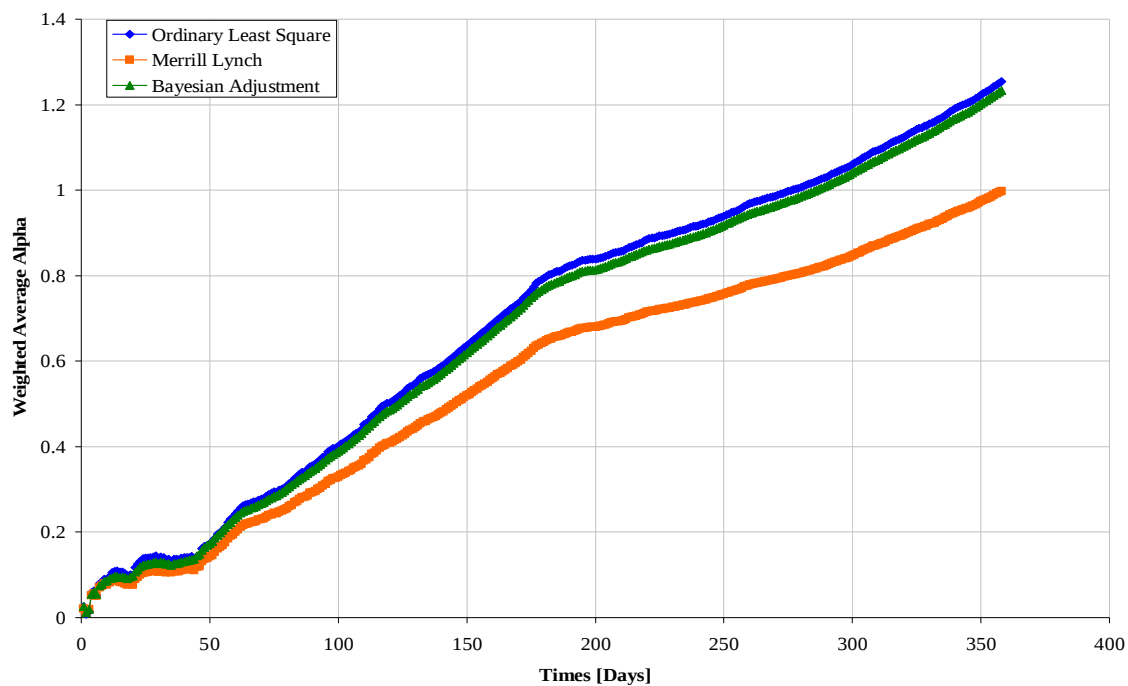


Figure 5.3: Weighted Average Alpha for Balanced Component over Test Period

From Figure 5.3, the positive alpha trends indicate that this component has been positively mispriced. This suggests that this component has exceeded the general market expectation. Alpha values can also be interpreted as the values added by human interventions. The rationale of this trend is the underlying constituents of this balanced

¹⁹ "Covariance is an unbounded measure of association between two random variables." (Tucker et al., 1994: p.579)

component, mainly commodity and cyclical shares. Cyclical shares' returns are in close relation with the economical cycle. South Africa is currently in the boom phase of the business cycle; hence selecting shares which are closely related to building infrastructure is preferable. Also, during the test period, the commodity prices display an upward increase trend globally. This suggests there is upward pressure on the commodity prices, which explains the better performance. It is also observed that the relationship between beta and alpha tend to be inversely related, because the lowest beta value is associated with the highest alpha value.

The results for expected returns over the entire test period are shown below. The exclusion and inclusion of error terms have been shown in separate figures. Figure 5.4 shows that there is a steady increasing proportional trend for the portfolio over the test period.

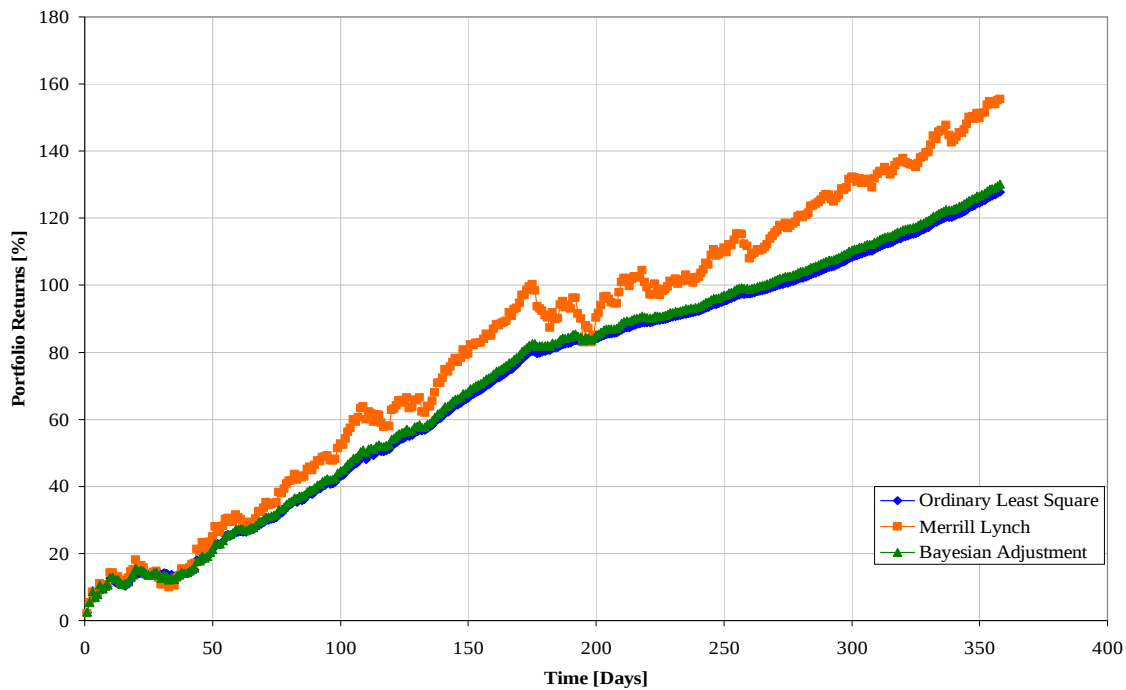


Figure 5.4: Returns Excluding Errors for Balanced Component over Test Period

When the error terms are included, the graphical results are shown in Figure 5.5. The troughs and ridges present are related to the local economic environment during the test period. The relationship between this component and the local economic environment is

identified by comparing the pattern established from this component, shown in Figure 5.5, to that of the All Share Index, shown in Figure 5.26. It is also noted that the trend displayed by alpha values is similar to that of the returns, excluding errors, of this component. This can be potentially explained by the fact that the alpha values have significant importance to the expected returns, as shown in equation (2.5), where expected returns are partially dependent on alpha values. Therefore, the similar trends are displayed by alpha values and expected returns excluding error figures.

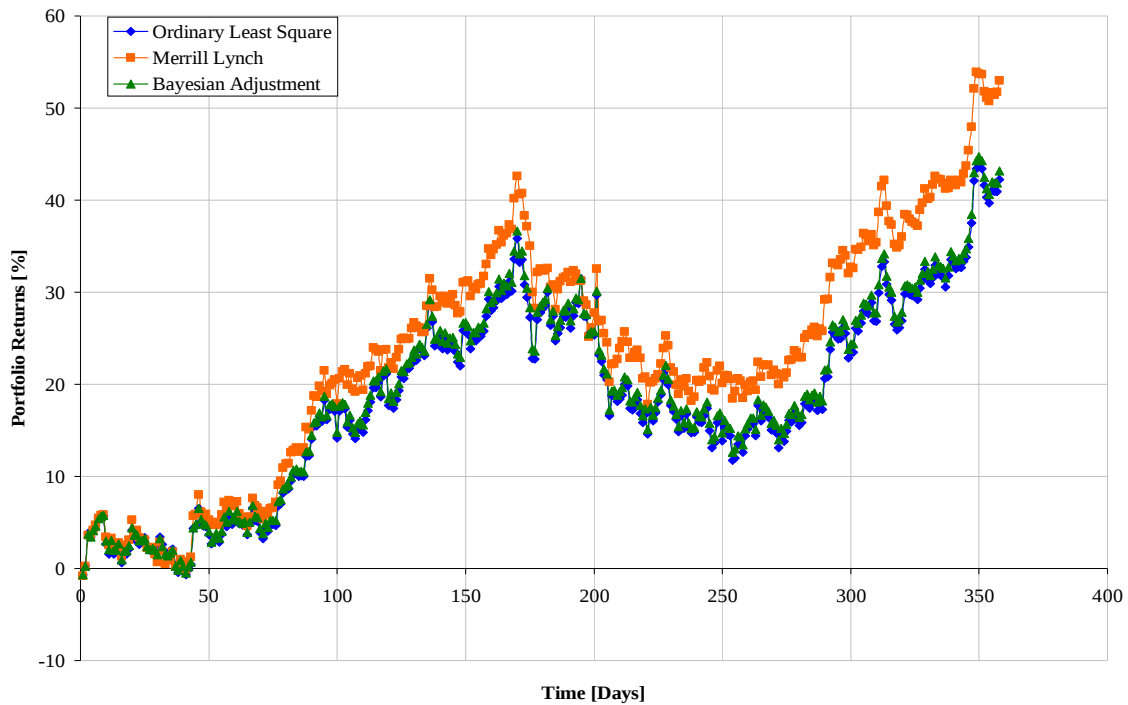


Figure 5.5: Returns Including Errors for Balanced Component over Test Period

By comparing Figure 5.4 and Figure 5.5, it is evident that the significance of the error terms cannot be ignored, as error terms play a significant part of expected returns. This is emphasised by the error results displayed in Table 5.1.

Leading from the discussion of results of this component over the test period, it is relevant to summarise results²⁰ of this component. These are tabulated below, in Table 5.1.

Table 5.1: Summarised Results for Balanced Component

	Beta	Alpha	Returns Include Error [%]	Returns Exclude Errors [%]	Errors [%]
OLS	0.115968	0.68821	18.4622208	70.54795797	52.0857372
ML	0.937312	0.5549095	23.17856253	82.6535753	59.4750128
BA	0.243772	0.6711464	19.08132616	72.00865596	52.9273298

From Table 5.1, ML beta value is 0.937312. As this value is close to one, this suggests the almost total correlation with the market. Thus the returns of this component are explained by the returns of the market, i.e. they move in the same direction. Also from equation (2.5), it is observed that the only parameter which can be controlled by an investor is the beta value. Selecting a portfolio that has a high beta value would increase the return. This statement is evident from Table 5.1, where the highest beta value, shown by ML, is associated with the highest returns.

It is also observed that there is an inverse relationship between the beta and alpha, as the lowest beta value is associated with the highest alpha value, as shown by OLS. The low beta values suggest the possibility of adding value by external means, i.e. a fund manager.

2. Conservative Portfolio

This is the component that includes the share with sparse data, VenFin Ltd. (VNF). Thus, the analyses have been separated into two parts. In the first part, VNF has been included in the subportfolio up to the point when it was de-listed, i.e. 1st March 2006 and in the second part, VNF has been excluded from the analysis since 1st March 2006. The detailed outcomes can be found in the file “results_conservatives.xls” on the disk provided.

²⁰ Summarise results refer to the average calculated over the entire test period.

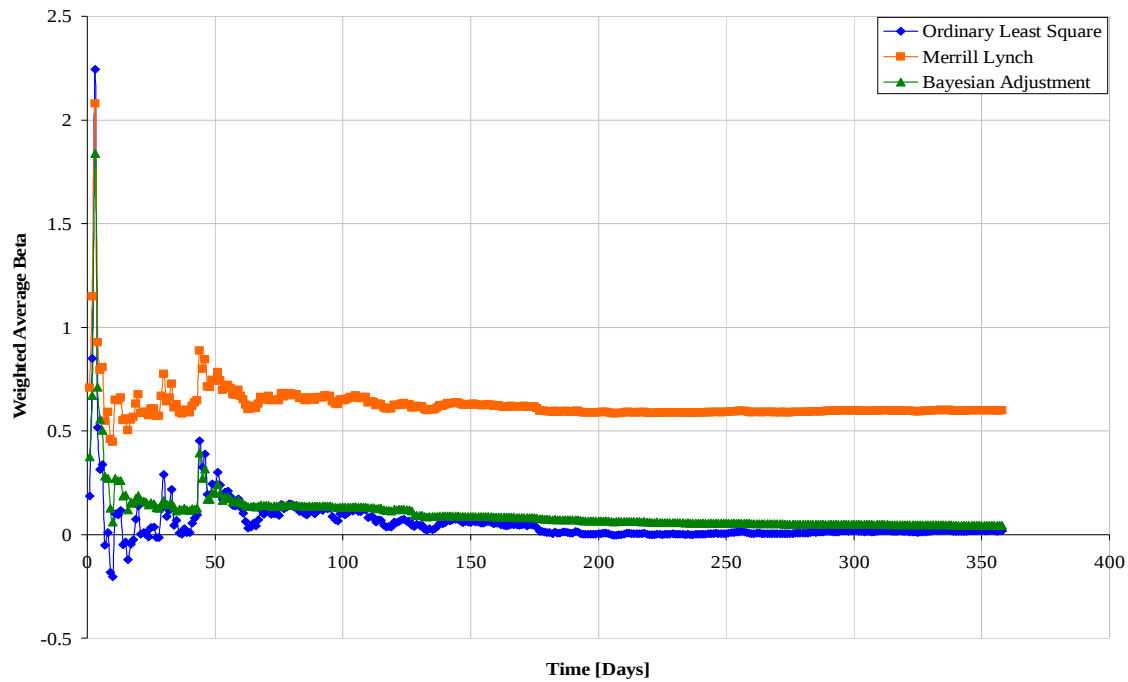


Figure 5.6: Weighted Average Beta for Conservative Component over Test Period

The beta trend displayed in Figure 5.6 is lower than the betas for the balanced component, shown in Figure 5.2. The reason is that the securities of this component are the blue chip²¹ and growth securities, where stable security prices are present, and therefore lower systematic risk. The beta values stabilise over the test period. The ML series stabilises around 0.6, which implies this portfolio is less volatile than ALSI. This also means that this component should return 6% when ALSI rises 10%, similarly this component should lose only 6% when ALSI drops by 10%. The OLS and BA series stabilise near 0 over the test period. The trend displayed in Figure 5.6 is that the ML series has the highest beta value followed by the BA series then the OLS series. The reason for this has been discussed under the section of balanced component.

From Figure 5.7, the alpha trend displays a negative slope between the 1st and 40th days, i.e. $t = 1$ and $t = 40$. This means that expected returns over the same period are negatively mispriced as predicted by their beta correspondent. This means that this component has

²¹ “These are the stocks that were bought with equal fervour and enthusiasm by both investors and speculators at the same exalted prices.” (Graham et al., 1962: p.410)

not exceeded the general market expectations between $t = 1$ and $t = 40$. Around the 130th day, i.e. when $t = 130$, there is a sharp downward vertical discontinuity in the alpha values because of the de-listing of VenFin Ltd. from JSE due to acquisition by Vodafone. (VenFin Group, 2006: p.10)

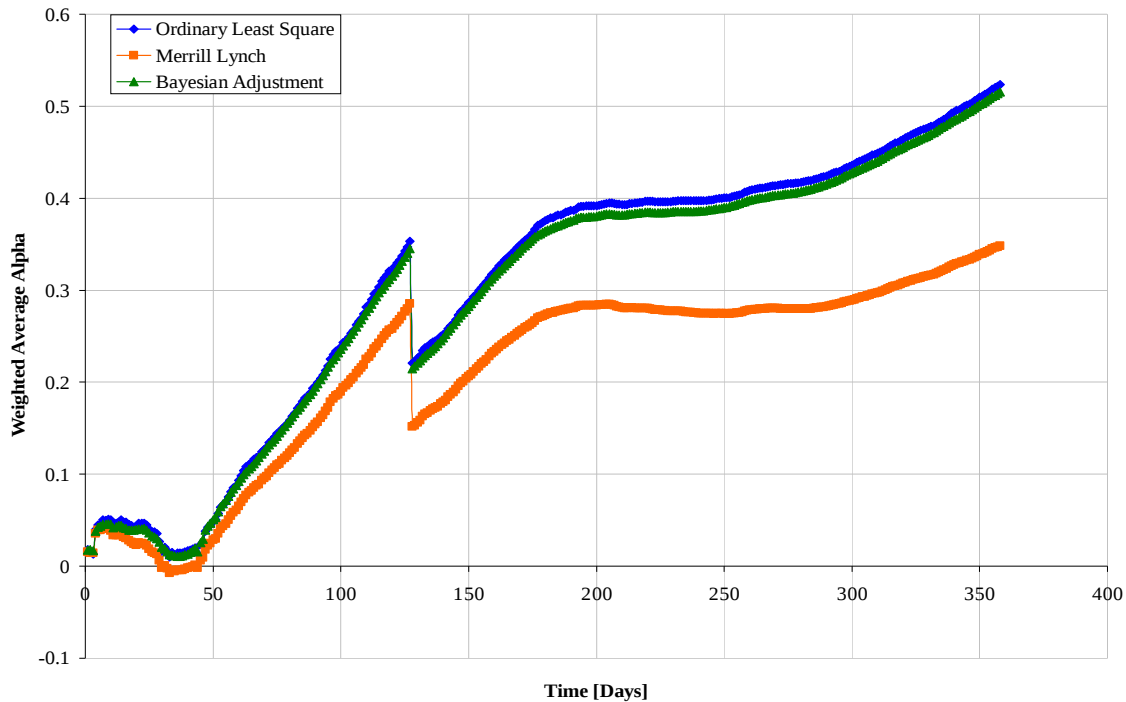


Figure 5.7: Weighted Average Alpha for Conservative Component over Test Period

The weighted average alpha over the test period is low. This means the securities in this component are priced relatively accurately. This is as expected since the majority of this component is made up of blue chip and growth securities.

From Figure 5.8, the initial downward slope from $t = 0$ to $t = 30$ suggests a decrease in security prices over this period. When this component is viewed in isolation, its returns move from 0% to just over 70% at the end of the test period. There is a sudden drop at the 130th day, i.e. $t = 130$, again due to the de-listing of VenFin Ltd. from JSE. This drop shows the significance of VenFin Ltd. in this component. This is caused by the 35% investment allocation placed with VenFin Ltd. when this subportfolio was formed.

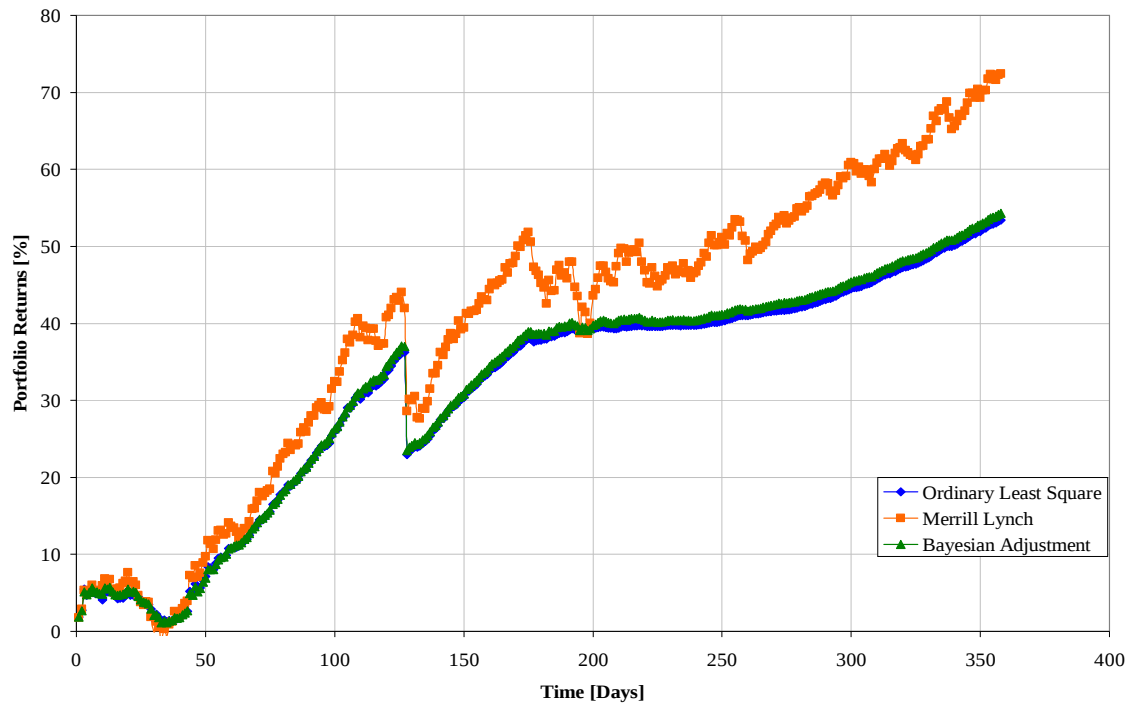


Figure 5.8: Returns Excluding Errors for Conservative Portfolio over Test Period

Furthermore, it is important to view the subportfolio in a domestic economic environment, where the uncertainty of the economy needs to be incorporated. This is shown graphically in Figure 5.9.

By including the errors into portfolio returns, there are more fluctuations along the increasing trend. The pattern shown in Figure 5.9 coincides with the general movement of the All Share Index, from Figure 5.26. The returns of this component accumulate from over 5% on the 50th day to below 30% at end of test period. This rate of return is conservative in relation to the balanced component discussed previously.

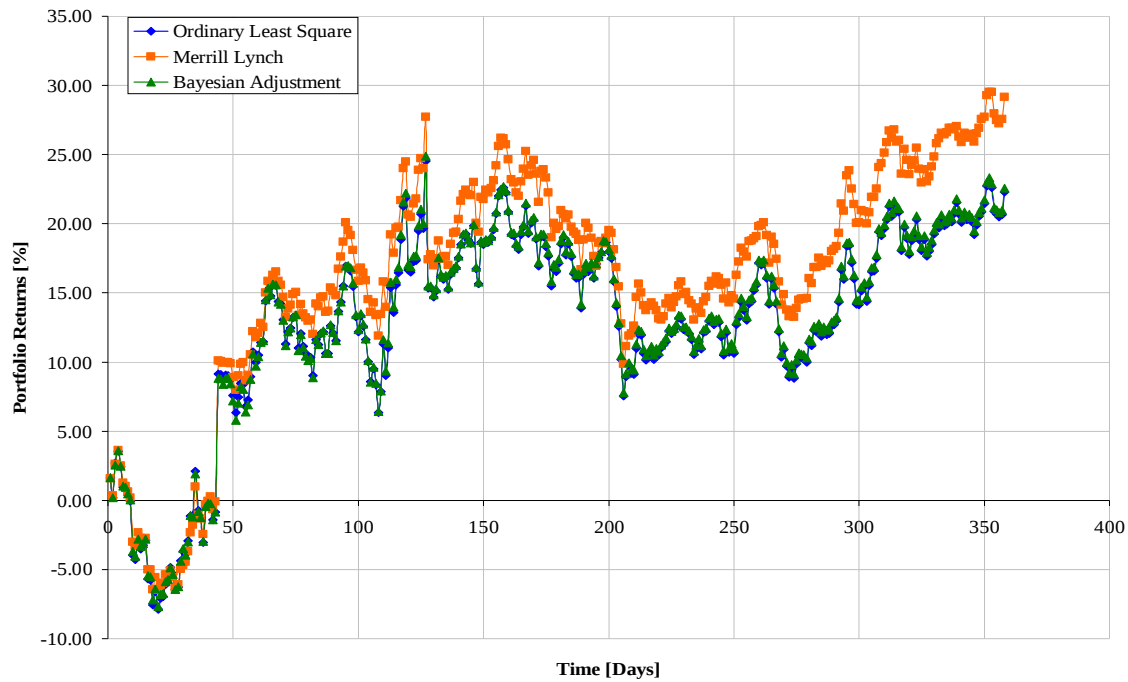


Figure 5.9: Returns Including Errors for Conservative Component over Test Period

The summarised results for conservative component over the test period is tabulated below, Table 5.2.

Table 5.2: Summarised Results for Conservative Component

	Beta	Alpha	Returns Include Error [%]	Returns Exclude Errors [%]	Errors [%]
OLS	0.055261	0.3042962	12.96138258	31.320745	18.3593624
ML	0.622325	0.2129558	16.19153807	39.6195382	23.4280001
BA	0.103182	0.2975688	13.13097797	31.87917021	18.7481922

OLS has the lowest beta value as shown in Table 5.2. OLS has a beta value of 0.055261; this value represents a flat slope and low rate of change. Therefore the market-related risk is low. The low beta value also suggests the diversification of securities in this component, where the covariances between securities are low, meaning there is little similarity between this component and the market.

3. Core Alternative Portfolio

The detailed outcomes of this subportfolio can be found in the file “results_corealternative.xls” on the disk provided.

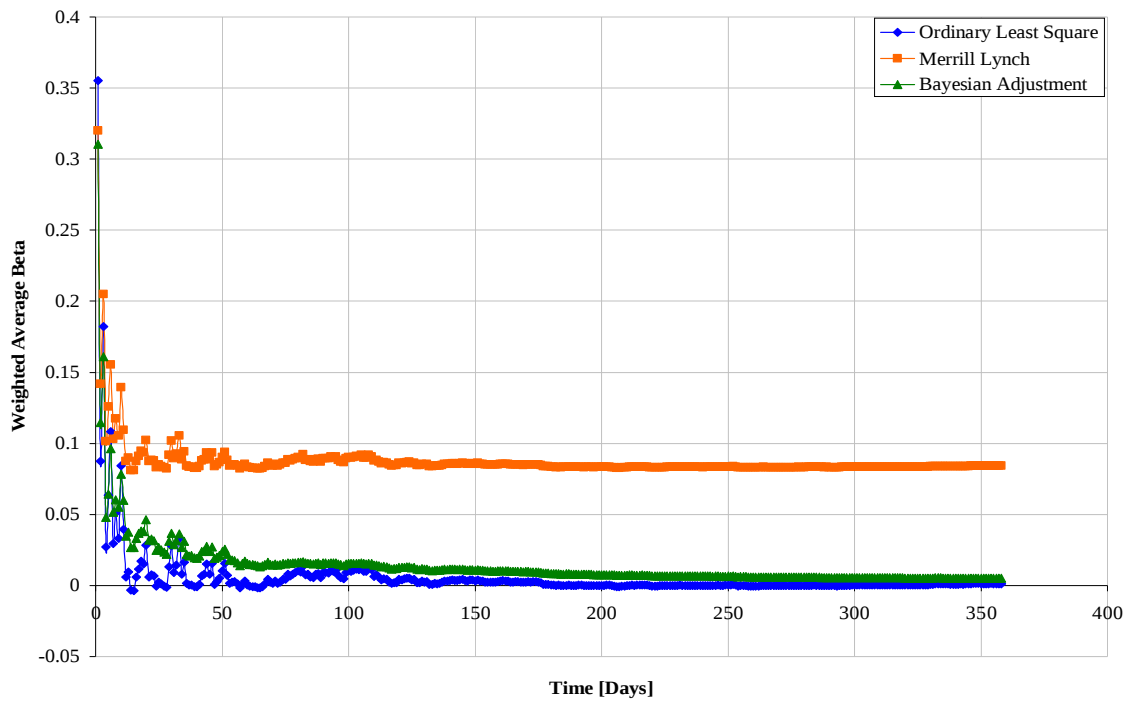


Figure 5.10: Weighted Average Beta for Core Alternative Component over Test Period

From Figure 5.10, the beta of this component is generally very low. The ML series stabilises below 0.1, and the OLS and BA series stabilise near 0. These values are very much lower than both the balanced and conservative portfolios. Hence, this suggests that there are limited correlations with the general market. The possible reason for this is the high degree of diversification present in this component, since 3 out of 5 securities included are dual-listed²². This has effectively diversified across different economies as well as sectors and has effectively transferred the risk across countries.

²² Dual-listed means the share is listed on two stock exchanges.

Because 3 out of 5 shares included in this component are focused in the financial sector, this has introduced the potential of concentration risks. They are, however, exposed to different magnitudes and classification of risks due to their different market capitalisation. For example: SBK is the largest bank in Africa based on the market capitalisation and mainly operates in emerging markets, while FSR is more focused on local markets whose market capitalisation is not as big as that of SBK.

From Figure 5.11, the alpha values move from below 0.05 at $t = 0$ to just below 0.3 at the end of the test period. These low alpha values suggest that this component has exceeded the general market expectations slightly, and implies that there is very little mispricing of these securities.

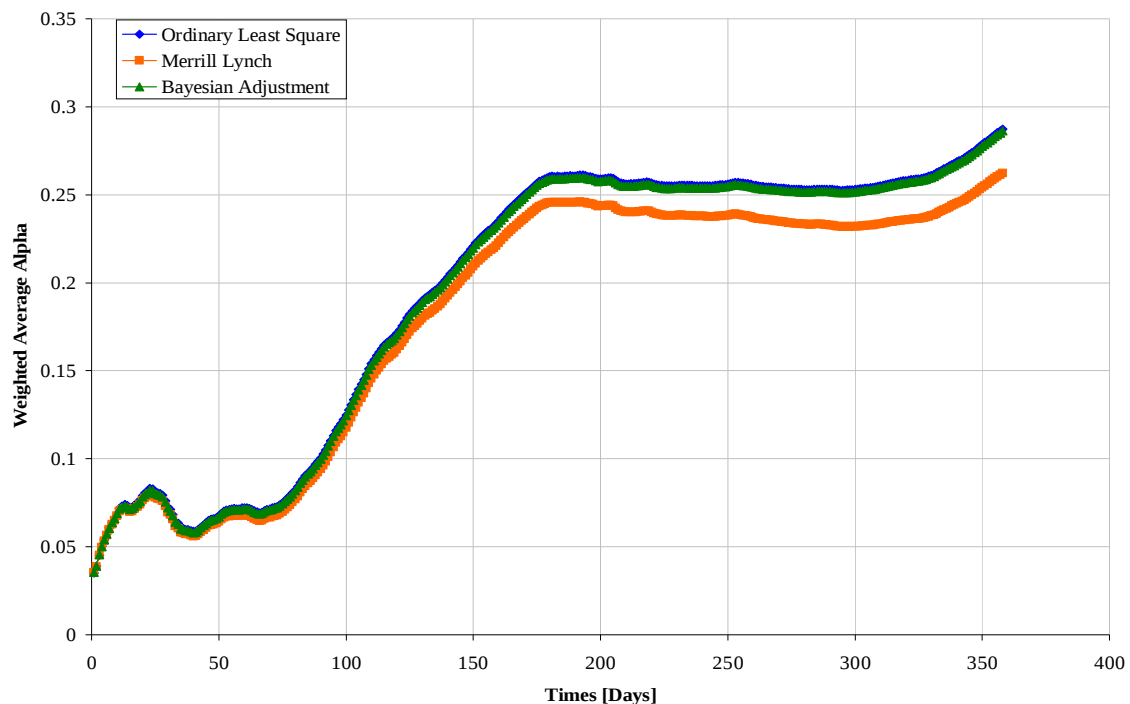


Figure 5.11: Weighted Average Alpha for Core Alternative Component over Test Period²³

²³ OLS and BA series shown in Figure 5.11 coincides. This means that their alpha values are very similar.

It is observed that the pattern shown in Figure 5.11 for the alpha values is similar to that displayed for returns excluding errors, in Figure 5.12. This component's returns increase in a proportional manner, where its returns increased from 0% at $t = 0$ to over 30% at end of test period. This rate of returns is expected since the securities in this component are mainly blue-chip and value securities where these categories of shares represent consistent growth over time. The consistent growth of shares is shown through their stable security prices; therefore it is unusual to see rapid and sudden growth in returns over a short test period. These views are emphasised by the low alpha values over the test period.

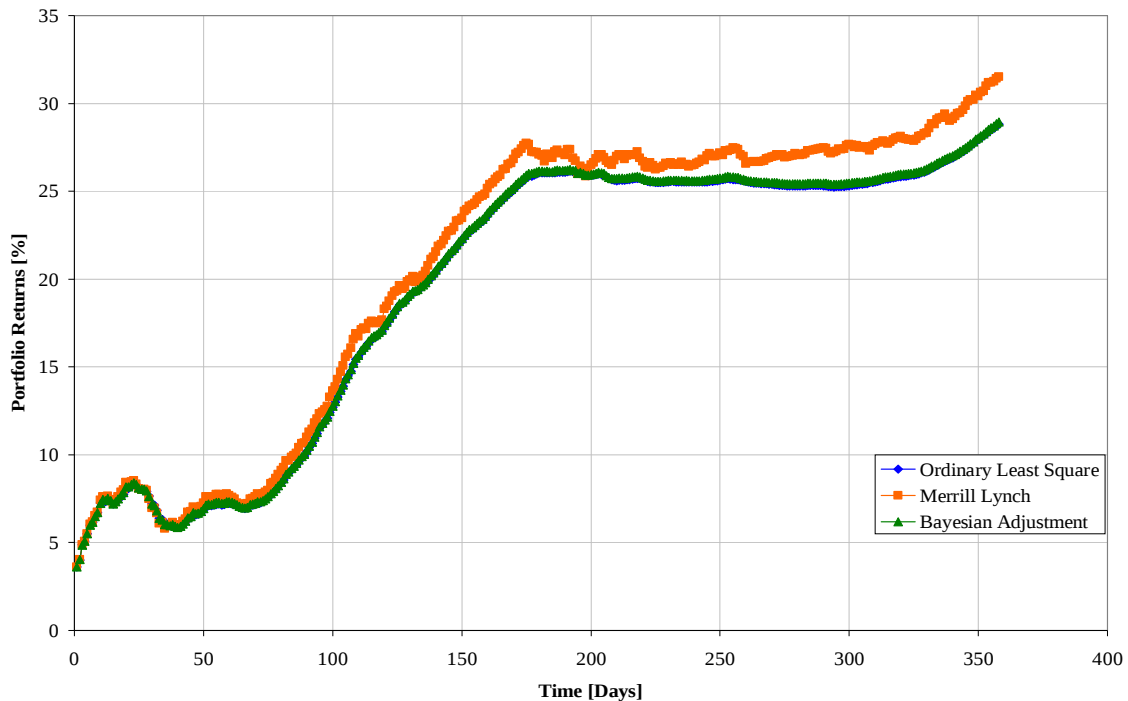


Figure 5.12: Returns Excluding Errors for Core Alternative Component over Test Period²⁴

By examining the returns of this component in the overall domestic economic environment where errors are included, Figure 5.13 is generated. From Figure 5.13, the rate of returns increased from above 0% at $t = 0$ to over 25%, shown by ML, at the end of

²⁴ OLS and BA series shown in Figure 5.12 coincides. This means that their returns without errors' values are very similar.

the test period. The pattern displayed coincides with the All Share Index shown in Figure 5.26.

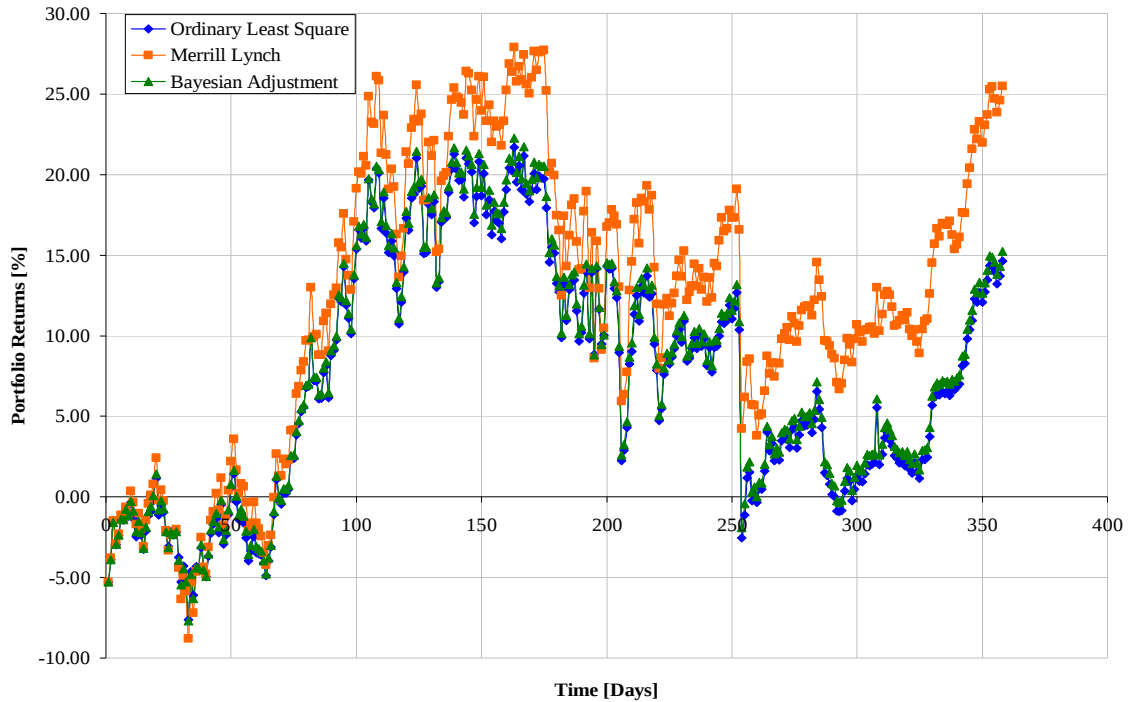


Figure 5.13: Returns Including Errors for Core Alternative Component over Test Period

From Table 5.3, it is evident that both alpha and beta values are low in this component. The low beta values across the three series suggest a steady rate of change between the covariance of securities and the market with the variance of the market. Therefore, this results in a flatter slope. A flatter slope is expected since this component compliments the core component, and no drastic changes are expected.

Table 5.3: Summarised Results for Core Alternative Component

	Beta	Alpha	Returns Include Error [%]	Returns Exclude Errors [%]	Errors [%]
OLS	0.00553	0.1953271	7.50754386	19.58359531	12.0760514
ML	0.08702	0.1822235	12.28867446	20.77674891	8.48807445
BA	0.014024	0.1942573	7.909994432	19.67691018	11.7669157

Another reason for low beta values is that this component is well-diversified, hence most of the systematic risk (β) has been eliminated. The rate of return generated from this component is reasonable. The reason for this is that the rate of return has exceeded the government's target inflation of maximum 6%.

4. Core Portfolio

The outcomes of this subportfolio can be found in the file “results_core.xls” on the disk provided.

At the initial start up of the data process, beta fluctuates to a maximum value of just below one; which is seen in Figure 5.14. The beta values stabilise at just over 0.2 for ML, 0.05 for BA and nearly zero for OLS.

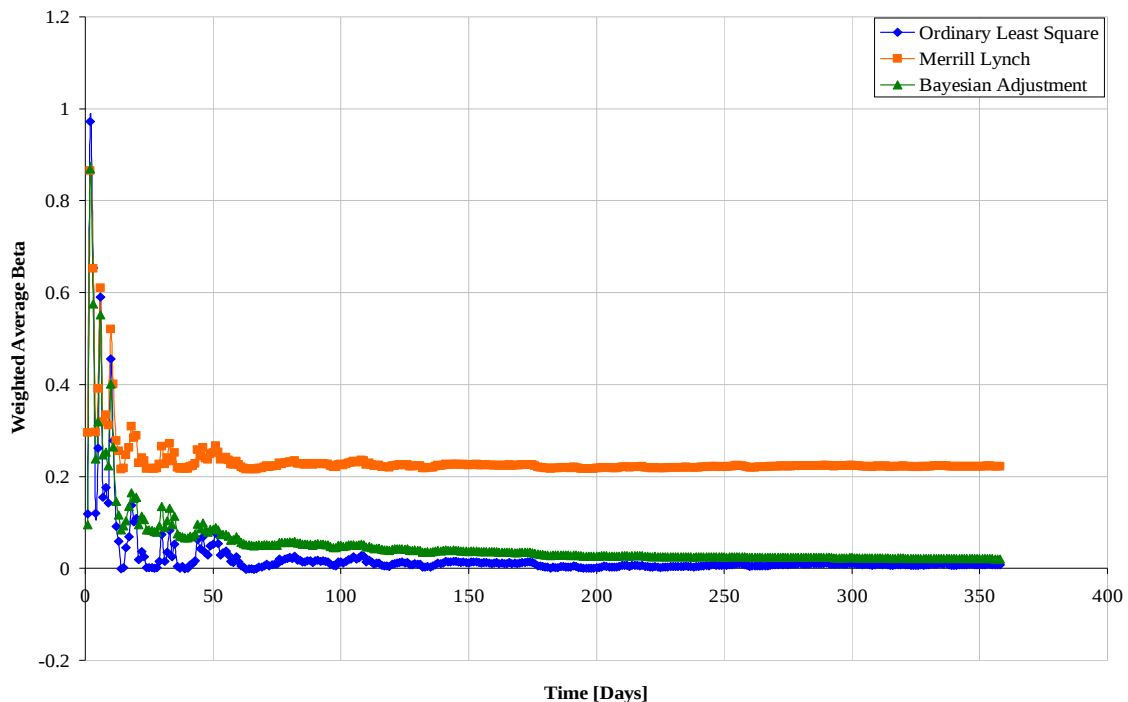


Figure 5.14: Weighted Average Beta for Core Component over Test Period

The low beta values are due to the low covariances between the market and individual shares in this subportfolio, resulting in efficient diversification. The diversification is evident from the dual-listing structure of 3 out of 5 securities in this component.

The beta values of this component are higher than that of the core alternative. This means that the systematic risk of the core is higher than the core alternative component. The core alternative is a component which will complement this one. The reason for higher beta values in core than core alternative is the nature of securities. In this component, the nature of chosen securities is blue chip and commodity related. Commodities depend on various factors which cannot be controlled by individual investors. From recent events occurring in both the local and global environment, it is observed that commodity related securities experience a reasonable amount of volatility.

From Figure 5.15, the trend of increasing alpha values over the test period tends to be associated with a decreasing trend of beta values. This inverse relationship is evident when comparison is done between Figure 5.14 and Figure 5.15. The reason for this has been discussed previously.

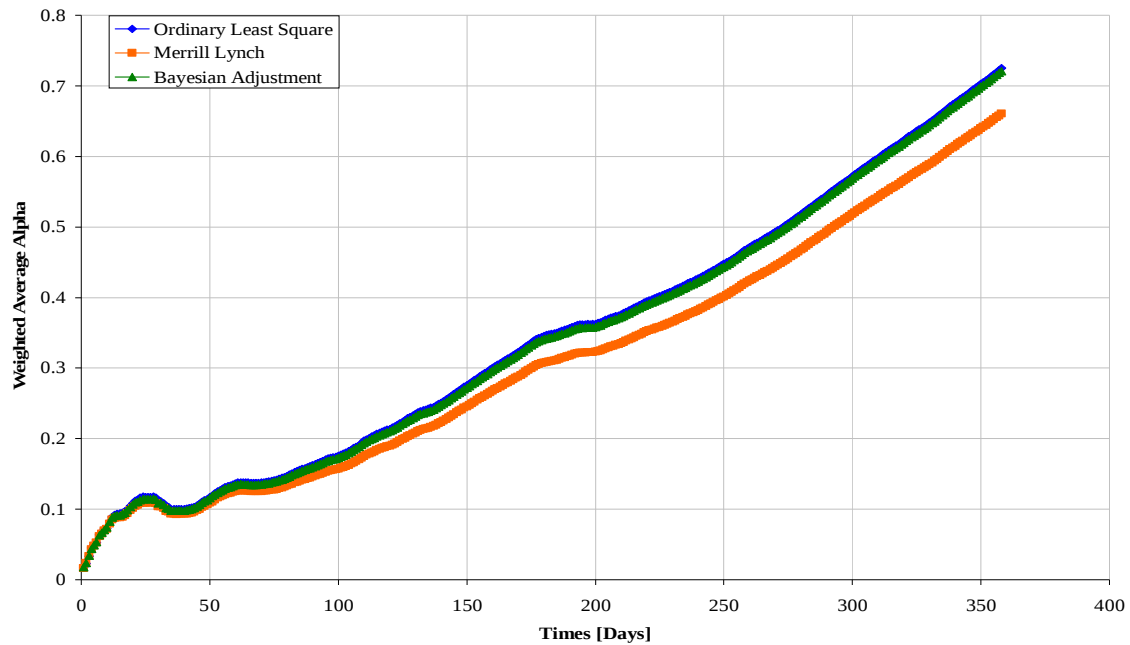


Figure 5.15: Weighted Average Alpha for Core Component over Test Period²⁵

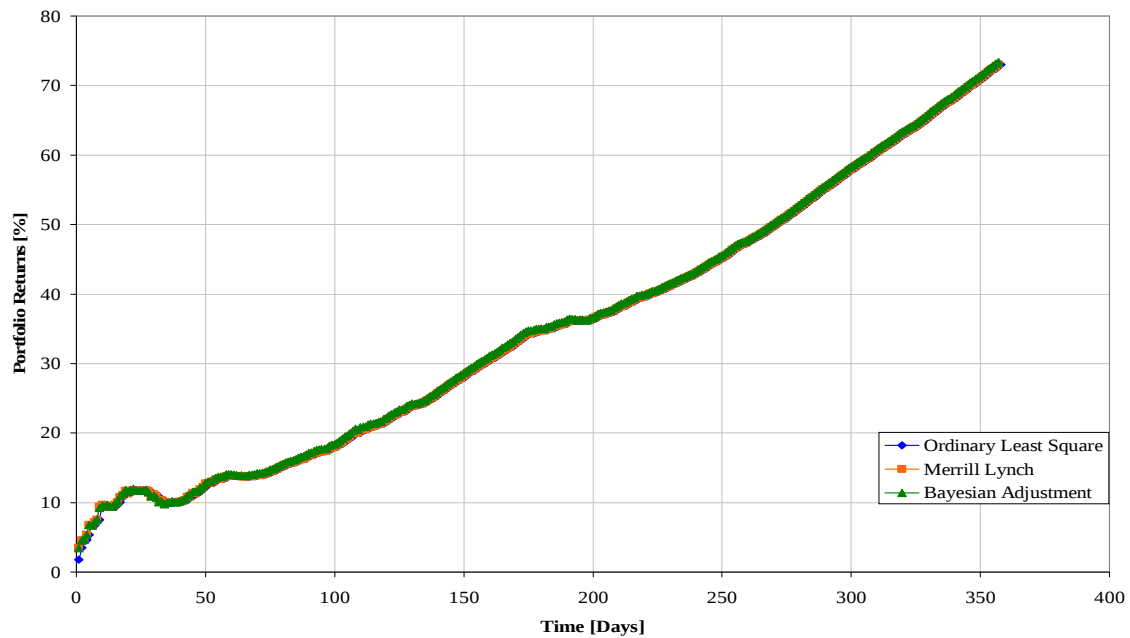


Figure 5.16: Returns Excluding Errors for Core Component over Test Period²⁶

²⁵ OLS and BA series shown in Figure 5.15 coincides. This means that their alpha values are very similar.

²⁶ All three series, BA, OLS and ML series shown in Figure 5.16 coincides. This means that their returns without errors' values are very similar.

Figure 5.16 shows the steady proportion increase of returns over time. The returns have increased from 0% to over 70% from the beginning to the end of the test period. The relationship between returns and alphas was discussed in the previous sections.

Leading from returns excluding errors for the core component, it is relevant to discuss the returns including errors for the same component.

From Figure 5.17, it is seen that the returns move from 5% at $t = 0$ to 35%, shown by ML series, at end of the testing period. The rate of returns shown is reasonable, due to the nature of this component. For a core component, it is important for its constituents to show steady growth over time. The general pattern shown in Figure 5.17 coincides with the pattern of the All Share Index, displayed in Figure 5.26.

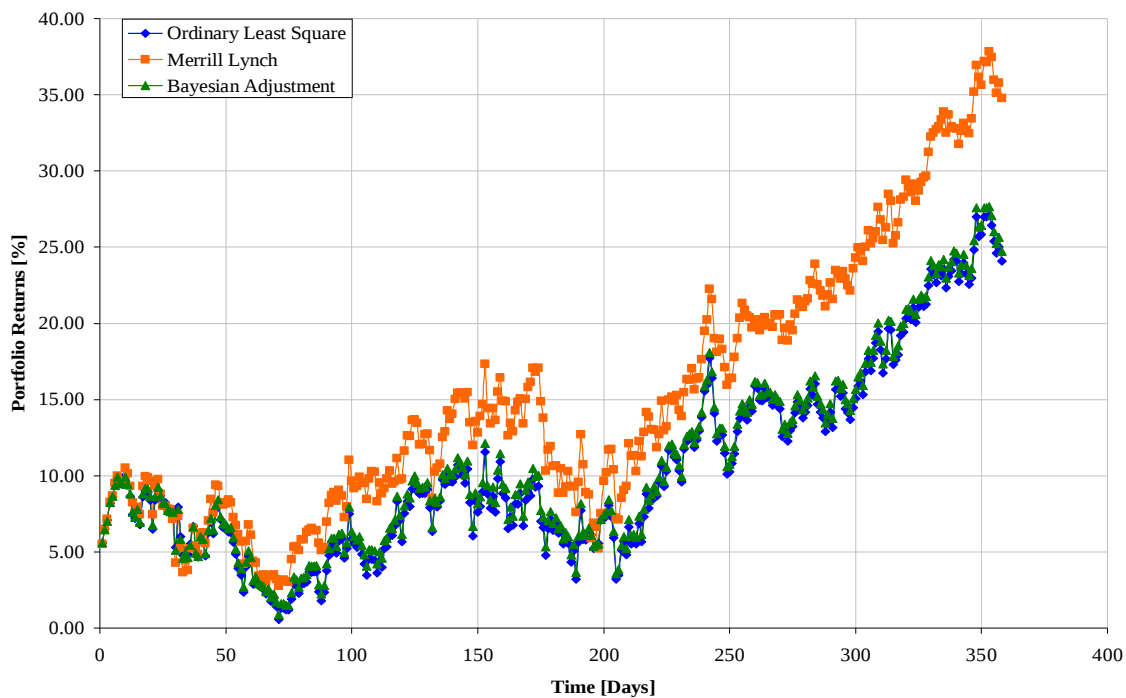


Figure 5.17: Returns Including Errors for Core Component over Test Period

From Table 5.4, the beta values of this component are higher than the core alternative component but lower than both balanced and conservative components. The lower beta

values are due to the high degree of diversification present in this component. This thought is supported by the multi-listing of various securities in this component. The multi-listing securities are AGL, LBT and BAW. Through multi-listing, the risks have been diversified through different economies.

Table 5.4: Summarised Results for Core Component

	Beta	Alpha	Returns Include Error [%]	Returns Exclude Errors [%]	Errors [%]
OLS	0.022915	0.3436701	10.41249866	34.67313681	24.2606381
ML	0.231943	0.3098974	15.13263746	37.74705924	22.6144218
BA	0.050592	0.3403098	10.82066909	34.96655329	24.1458842

5. Mid- Term Portfolio

The outcomes can be found in the file “results_midterm.xls” on the disk provided. This component consists of 11 shares in total.

This component was selected for mid-term investments. This refers to the mid-term time horizon; hence various major sectors on JSE have been selected. Diversification is, thus, achieved. This exposes the investor to different risks in each industry. Thus, by summing up each risk associated with sectors, it is clear that a higher beta value is created. The beta of this component, shown in Figure 5.18, is higher than conservative, core alternative and core subportfolios, but on par with the balanced component.

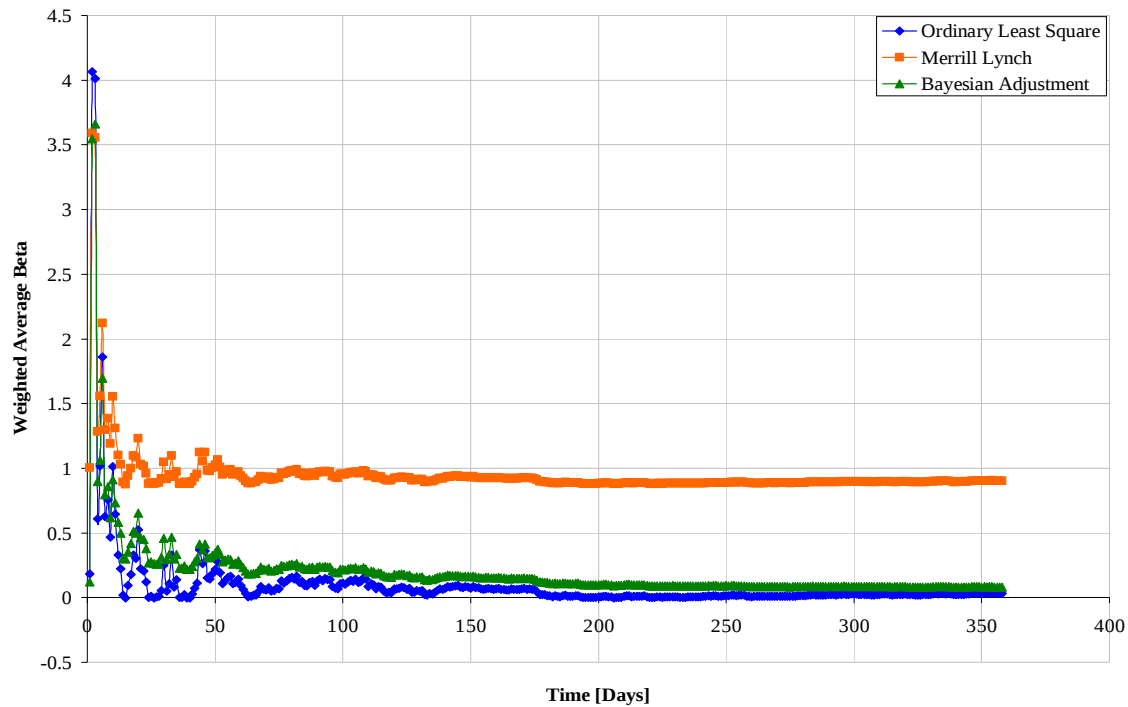


Figure 5.18: Weighted Average Beta for Mid- Term Component over Test Period

It is observed, from Figure 5.18, that the ML series stabilises near 1, while the OLS and BA series stabilise near 0. This suggests the almost total correlation of ML series with the market and almost no correlation of OLS and BA series. The ML series has the highest beta value followed by the BA series then the OLS series. These discussions can be found in the discussion on the balanced component.

It is also noted that the alpha values displayed in Figure 5.19, are generally higher when compared to the other components of the test portfolio. The rationale behind this is that the securities' categories have been included in this component, namely blue-chip, value and cyclical securities. These are usually the securities with solid fundamentals, meaning the possibilities of exceeding general market expectations can be expected.

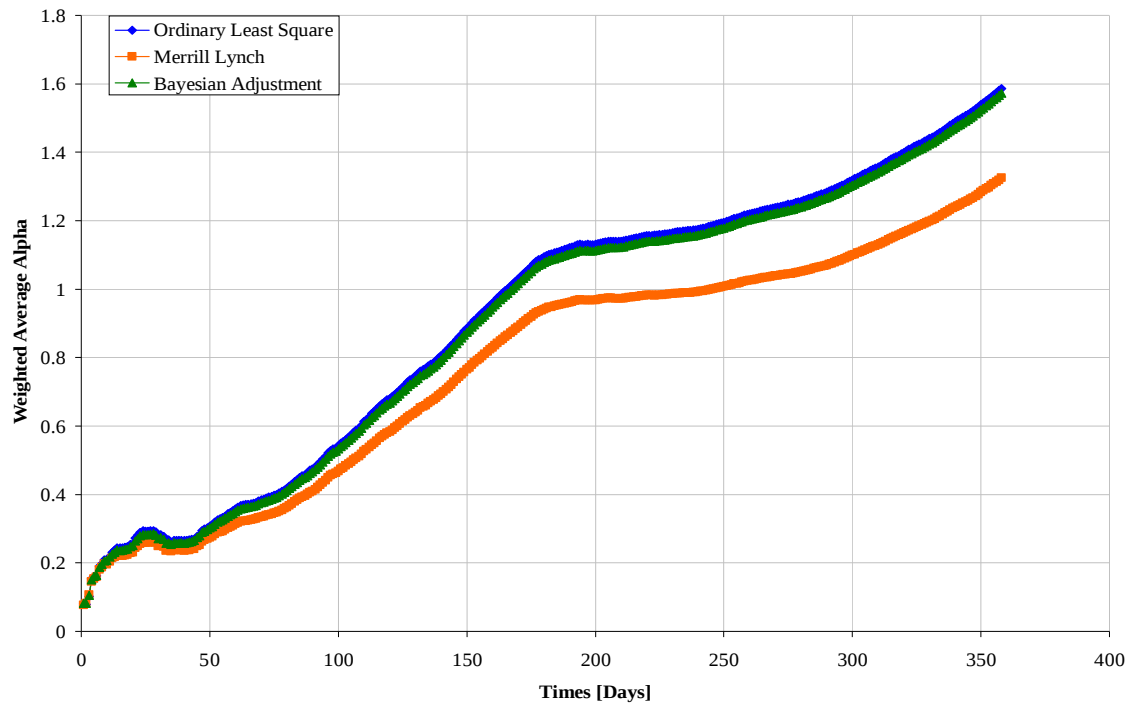


Figure 5.19: Weighted Average Alpha for Mid- Term Component over Test Period²⁷

Shown in Figure 5.20, the rate of returns of this component increased from 0% at $t = 0$ to over 180%, shown by ML series, at end of test period. This is due to the cyclical nature of the securities included. Some of the cyclical securities included in this component are M&R, HLD, PPC and BAW. Currently, the domestic South African economy is preparing for the 2010 Soccer World Cup and various infrastructure needs to be built, therefore construction and cement firms would show rapid growth.

²⁷ OLS and BA series shown in Figure 5.19 coincides. This means that their alpha values are very similar.

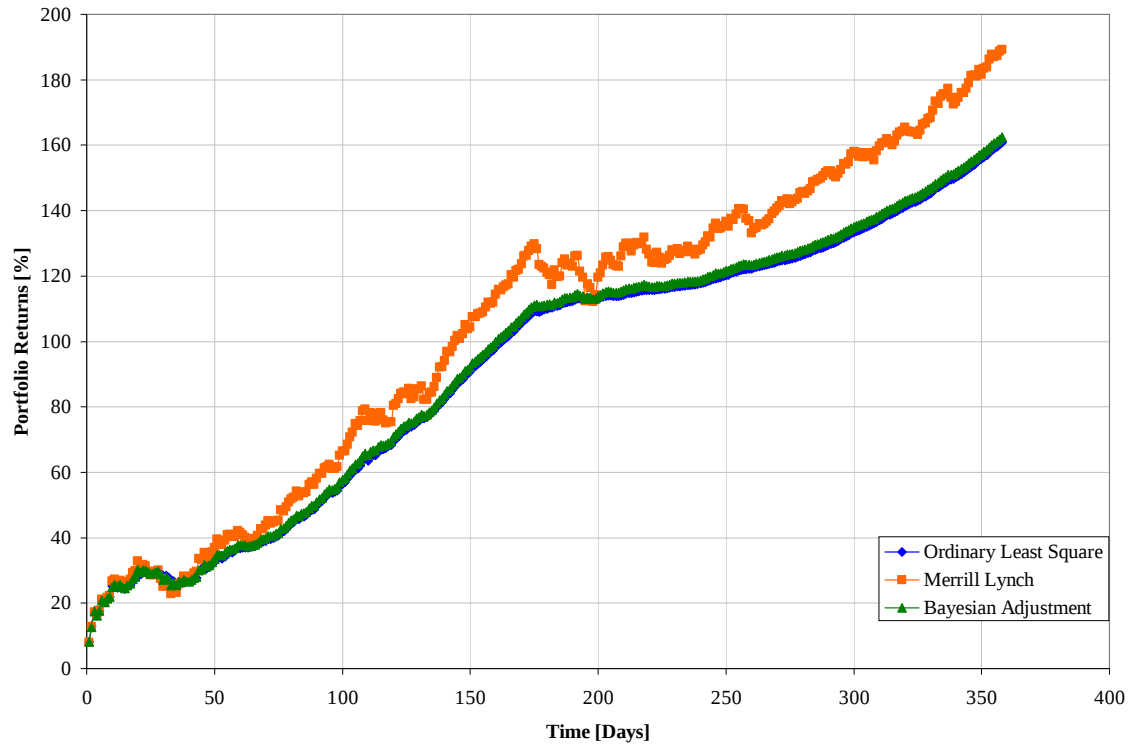


Figure 5.20: Returns Excluding Errors for Mid-Term Component over Test Period²⁸

From Figure 5.21, it is observed that the returns including errors for this component increased from 0% at $t = 0$ to over 50%, shown by ML series, at $t = 350$. The troughs and ridges shown are in close correlation with the local economy.

²⁸ OLS and BA series shown in Figure 5.20 coincides. This means that their returns without errors' values are very similar.

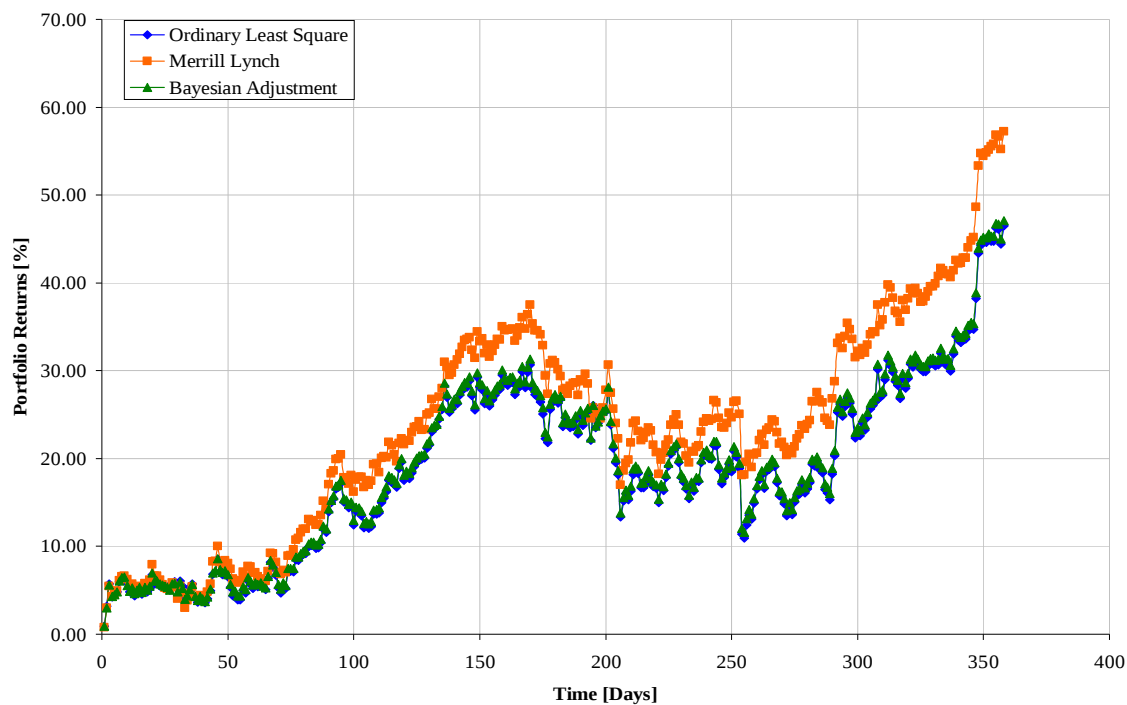


Figure 5.21: Returns Include Errors for Mid-Term Component over Test Period

From Table 5.5, the highest beta value is associated with ML series. The value is 0.944171, which is close to one. This implies almost total correlation, and that a fair amount of return on the portfolio is explained by the return on the market. This view is supported by the cyclical nature of securities.

Table 5.5: Summarised Results for Mid-Term Component

	Beta	Alpha	Returns Include Error [%]	Returns Exclude Errors [%]	Errors [%]
OLS	0.096257	0.9094312	18.90735527	92.17136522	73.2640099
ML	0.944171	0.7721751	23.6266315	104.6525744	81.0259429
BA	0.194819	0.8964564	19.34284848	93.30559812	73.9627496

6. Small Caps Portfolio

The outcome can be found in the file, “results_smallcap.xls” on the disk provided.

From Figure 5.22, beta values stabilise around 0.2 for ML, 0.05 for BA and 0 for OLS. The beta values are low for this component, meaning there is low systematic risk. The low systematic risk can be explained by the low market capitalization held by the securities of this component. Small market capitalization also means the low correlation between the market and the firm.

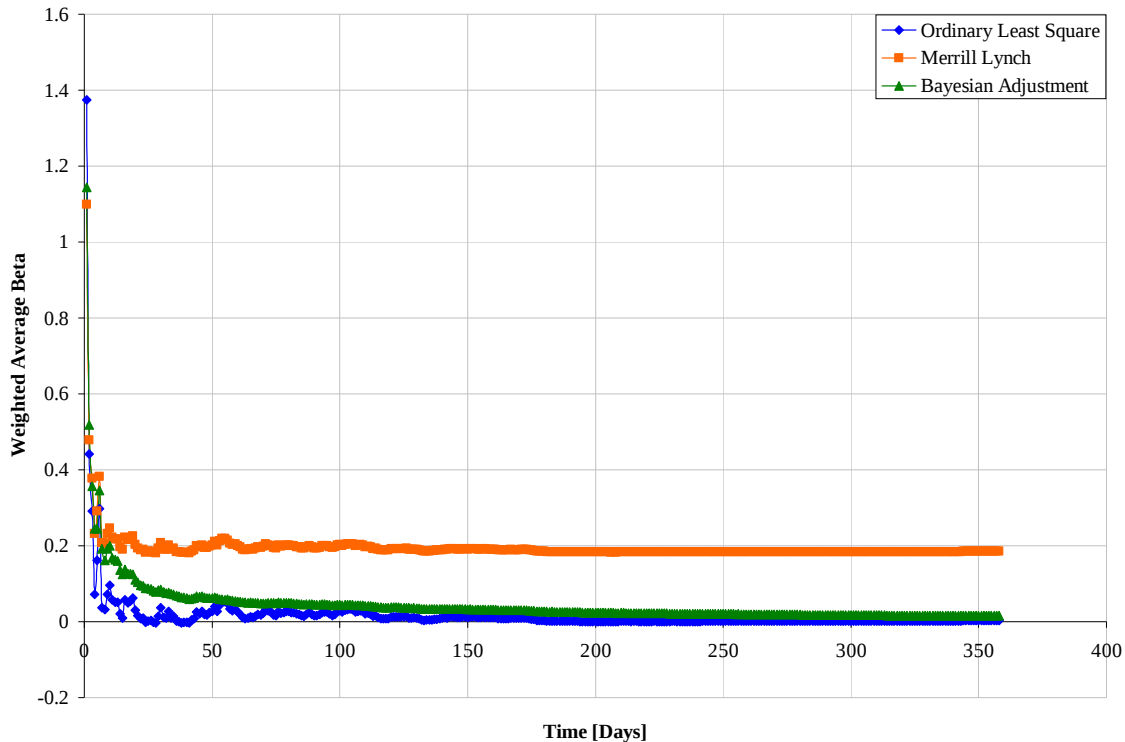


Figure 5.22: Weighted Average Beta for Small Caps Component over Test Period

The securities included in this component are of the small capitalization nature. Securities of this kind are the securities with good potential, that may one day develop into blue-chip firms. The firms included came from four of the major sectors division for the All Share Index. These sectors are consumer goods, consumer services, industrials and technology. These are also the sectors that are closely related to the 2010 Soccer World Cup.

From Figure 5.23, the alpha values increased to 0.45 at $t = 350$ from 0 at $t = 0$. Alphas of this component are generally lower than alphas of the other components. The rationale

behind this is that the securities of this component are small capitalization in nature, meaning the impact of general market expectations on this component is limited.

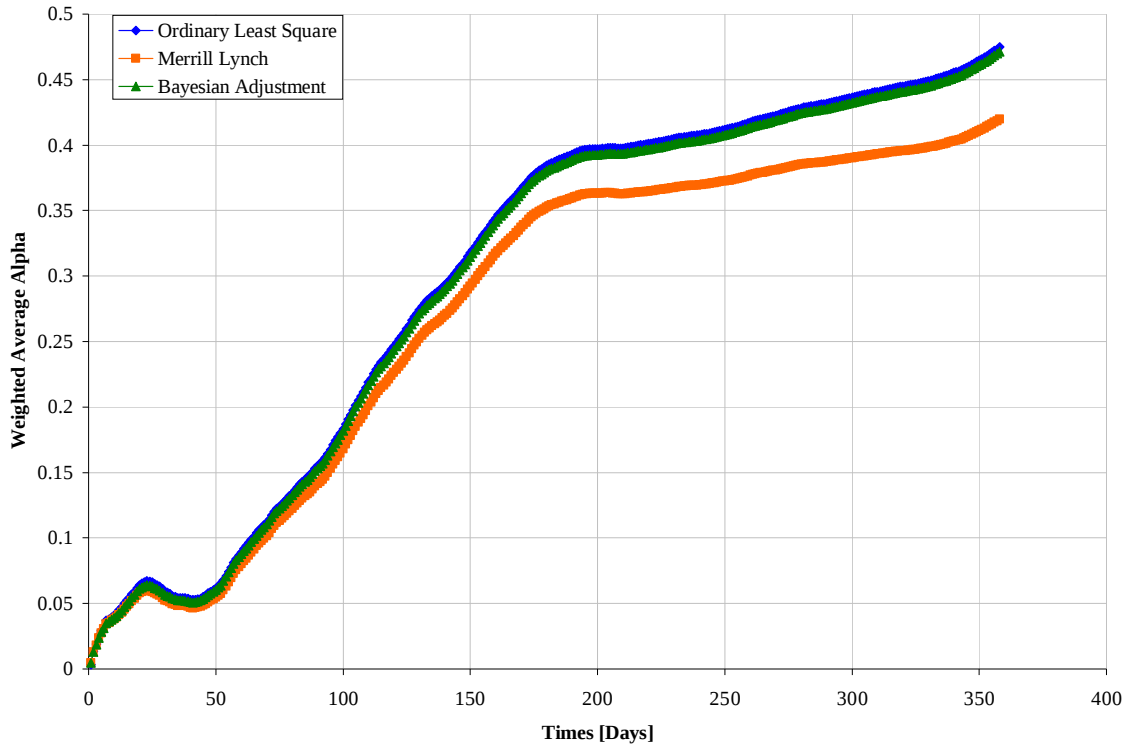


Figure 5.23: Weighted Average Alpha for Small Caps Component over Test Period

Figure 5.24 shows the steady proportion increase of returns over time. The returns have increased from 0% to over 50%, shown by ML series, from the beginning to the end of the test period. The troughs and ridges shown are in close correlation with the local economy. The relationship between returns and alphas was discussed in the previous sections.

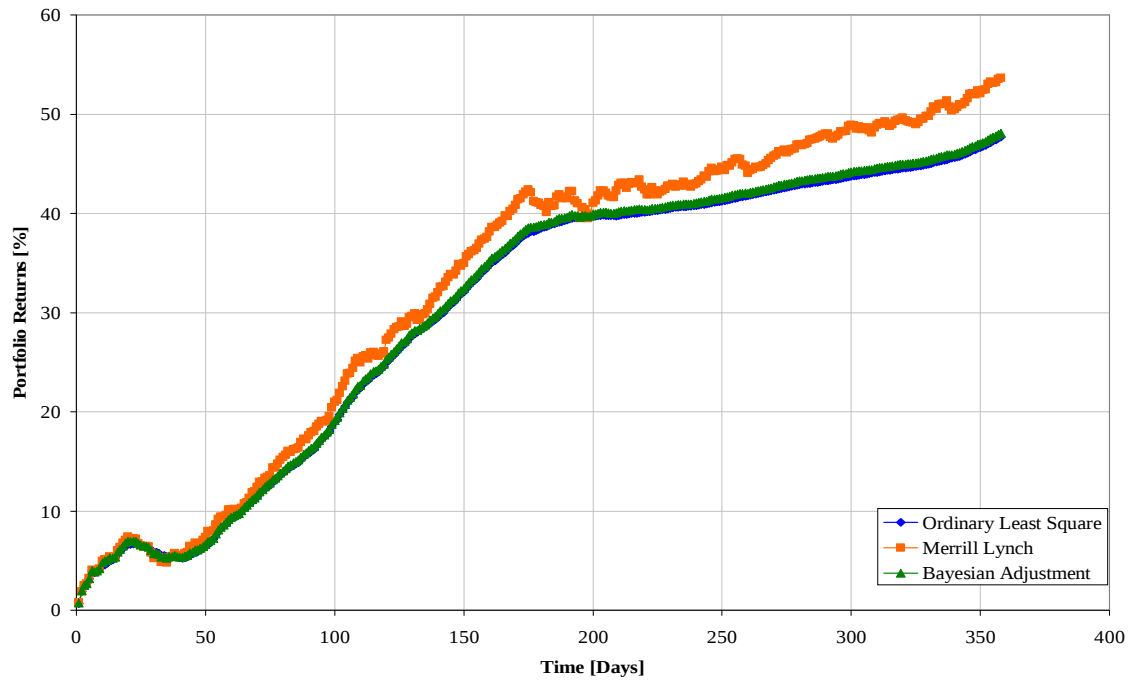


Figure 5.24: Returns Excluding Errors for Small Caps Component over Test Period²⁹

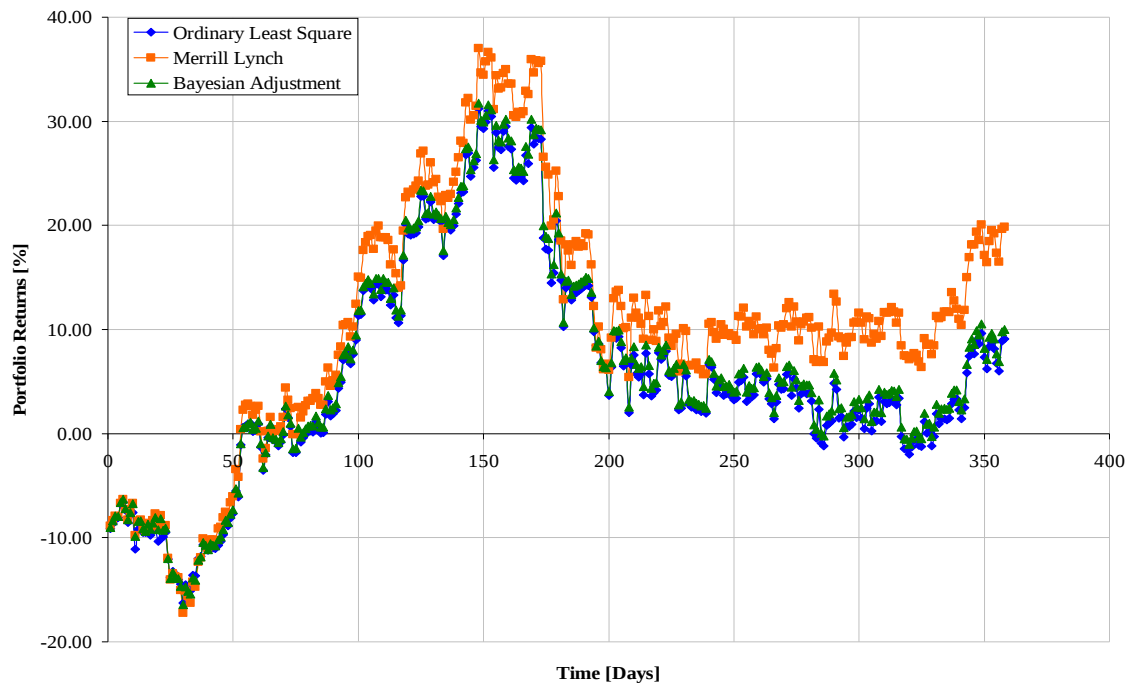


Figure 5.25: Returns Including Errors for Small Caps Component over Test Period

²⁹ OLS and BA series shown in Figure 5.24 coincides. This means that their returns without errors' values are very similar.

From Figure 5.25, it is seen that the returns move from -10% at $t = 0$ to 20% at end of testing period. The general pattern shown in Figure 5.25 coincides with the pattern of the All Share Index, displayed in Figure 5.26.

Table 5.6: Summarised Results for Small Caps Component

	Beta	Alpha	Returns Include Error [%]	Returns Exclude Errors [%]	Errors [%]
OLS	0.016919	0.3010414	5.738617277	30.27626406	24.5376468
ML	0.194612	0.2723105	10.44972671	32.89085395	22.4411272
BA	0.04451	0.2978093	6.343006695	30.55413004	24.2111233

From Table 5.6, the beta values are lower than the other components. This means that there are limited correlations between this component and the market. The returns from this component are low relative to other components in the test portfolio. This is as expected since the positions of the small capitalisation securities are not significant enough to contribute to or make a significant impact on the market.

5.3.2 Results of Overall Test Portfolio

In this section, the outcomes from each of the components have been combined to display the overall results. Below, the overall outcomes have been represented, one to exclude the error from the single index model and the other to include it. Components are combined using weightings. The weightings³⁰ are based on the fractional investment in each component, as shown in Table 4.3.

³⁰ Weightings refer to the percentage invested in each subportfolio. These values can be found in Table 4.3.

Exclude Errors

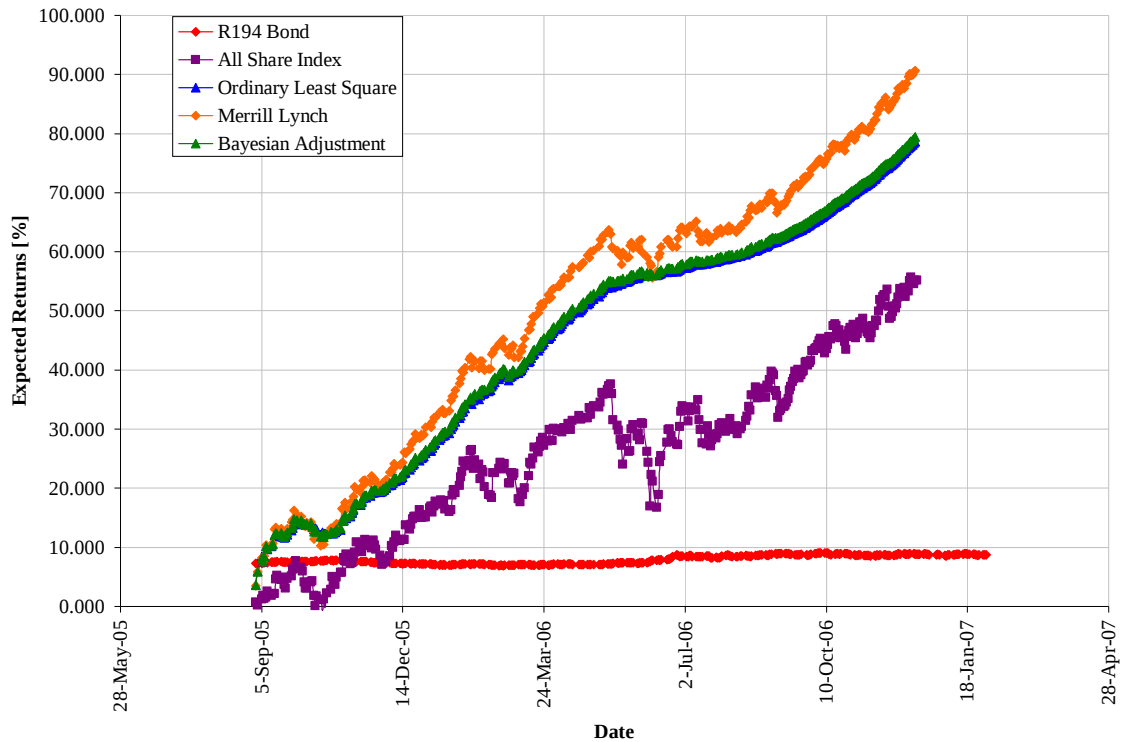


Figure 5.26: Daily Comparison of Expected Returns Excluding Errors of Test Portfolio over Test Period

From Figure 5.26, the R194 Bond acts as a benchmark to which each of the series models is compared. Expected returns of the R194 Bond start off from approximately 7.3% and increase to 8.8% at end of the test period. The determinant of bond return is in close proximity with annual inflation predicted by the government. In comparison with others, the R194 Bond displays a relatively steady trend throughout the test period.

The adjustment models, OLS, ML and BA and the All Share Index, all start off at 0% because the initial share prices are being used as the reference point to which the daily returns are compared. The results fluctuate until November 2005, and then all adjustment models display a reasonably positively proportioned relationship. This implies that the expected returns have accumulated over time, and hence indirectly showed that the test portfolio performed better than the risk-free instrument. If the All Share Index outperforms the risk-free instrument, this immediately suggests that the test portfolio has

also performed better than the risk-free instrument, as there are positive correlations between the test portfolio and the market shown by the beta values. This can be demonstrated by conducting a basic return calculation on the All Share Index between the start and the end of the test period. The data used for this calculation is displayed below.

		All Share Index Value
Start of Test Period	1 st September 2005	15646.47
End of Test Period	31 st January 2007	25481.25

The basic return calculation is based on the following formula:

$$\text{Return [\%]} = \frac{(\text{End Point} - \text{Start Point})}{\text{Start Point}} \times 100$$

Therefore, return of the All Share Index is equal to 62.86% over the test period. This result shows that the ALSI has outperformed the chosen risk-free instrument, the R194 bond, as expected.

Also, the test portfolio generates better returns than that of the market, i.e. the All Share Index, provided that the random error present in the market is not considered. This suggests that an investor could outperform the market if the securities were selected with caution. With every investment comes risks, hence investments should be conducted cautiously, this also refers to process prior to making the decisions.

Include Errors

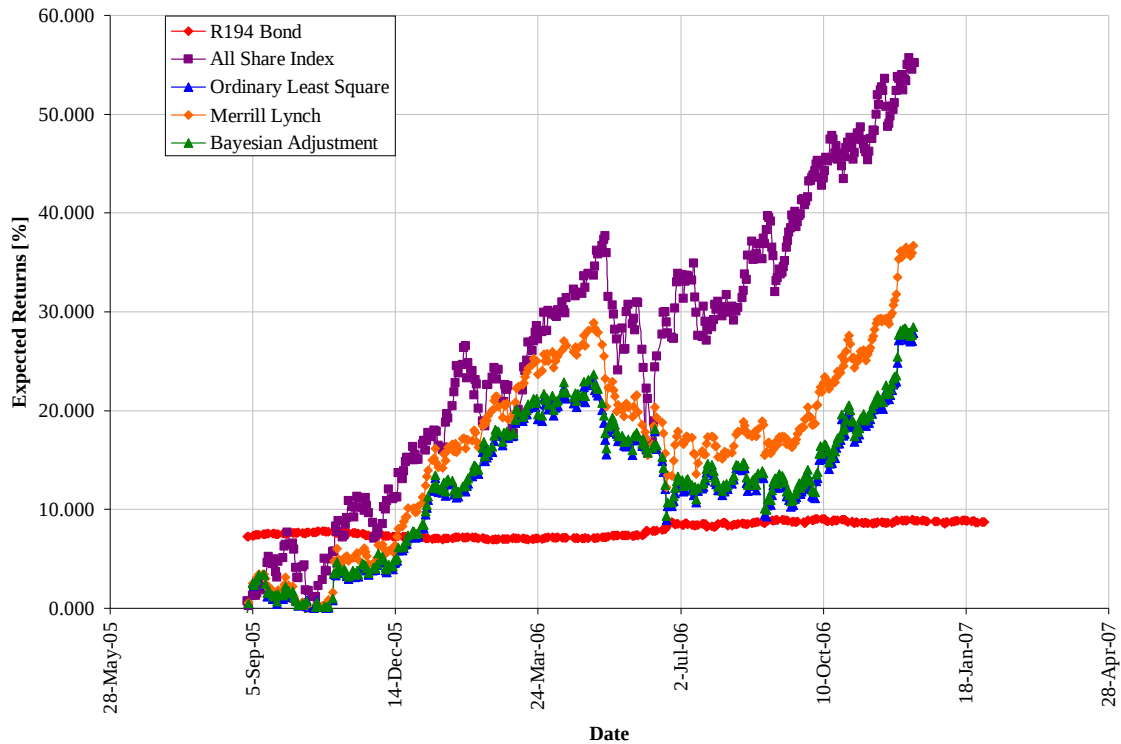


Figure 5.27: Daily Comparison of Expected Returns Including Errors of Test Portfolio over Test Period

When the investor includes the error terms into the expected returns of the portfolio, as shown in Figure 5.27, the test portfolio results are still higher than the government bond R194, but lower than the All Share Index (market benchmark). The different outcome is due to the error term. The error term cannot be ignored in an economic environment, since by excluding it, the results would be distorted. This distortion arises from viewing the results in isolation, without the error terms, instead of in a broad economic environment. This is supported by Gleser (1998: p. 278), who says “...deviations³¹ from measured mean due to imprecisely determined contextual conditions are now of a magnitude that they cannot be ignored.”

³¹ Deviations can be referred to as errors.

Also, Chen et al. (1983) suggest, "...sample estimators are usually treated as if they were true values of unknown parameters." Thus, by treating the estimated error vector, generated by using equation (2.10), as a true value, this will greatly affect the outcome, as seen in Figure 5.27. This idea is emphasised by Fisher et al. (1997: p.43), "...that optimised mean-variance portfolios are extremely sensitive to even subtle changes in the estimation of the parameters." The error term cannot be estimated accurately as it is random in nature. This randomness is parametric in nature and inherent in the market itself. This parametric uncertainty plays a significant role in portfolio returns over time, since this uncertainty should also be considered as a measure of business risks (Israelsen et al. 2007: p. 419).

Uncertainty associated with the error vector can be fundamentally explained by supply and demand. A supply and demand relationship could be altered by various factors, whether it be macro- or micro- economically related. Some of the most common economical reasons are (Standard Bank Group, 2007):

1. The health of the US economy

As the US is the most important economy globally, its performance would directly affect other nations. If the US economy is in a boom phase of the business cycle, this would imply the same goes for the rest of the world. In the context of this design, when the US economy is blossoming, the South African economy would also blossom, thus creating a healthy and active stock exchange. As a direct consequence, the market performs better and there is an increase trend in security prices.

2. Official interest rate dictated by Reserve Bank

Interest rate is part of the monetary policy of a country. It directly affects companies' earnings, because when interest rates increase it would increase cost of debt payments and hence affect earnings.

An increase in interest rates would affect the level of economic activity and consumer spending. It would reduce consumer spending, since debt payments would be higher and less disposable income would be available for investment purposes. This would potentially result in less demand for the securities. Thus security prices would decrease in order to reach a new equilibrium point between supply and demand.

From Figure 5.28, showing repo rate³² changes, the increasing repo rate puts a downward pressure on share prices, since there is less disposable income to be spent on investments.

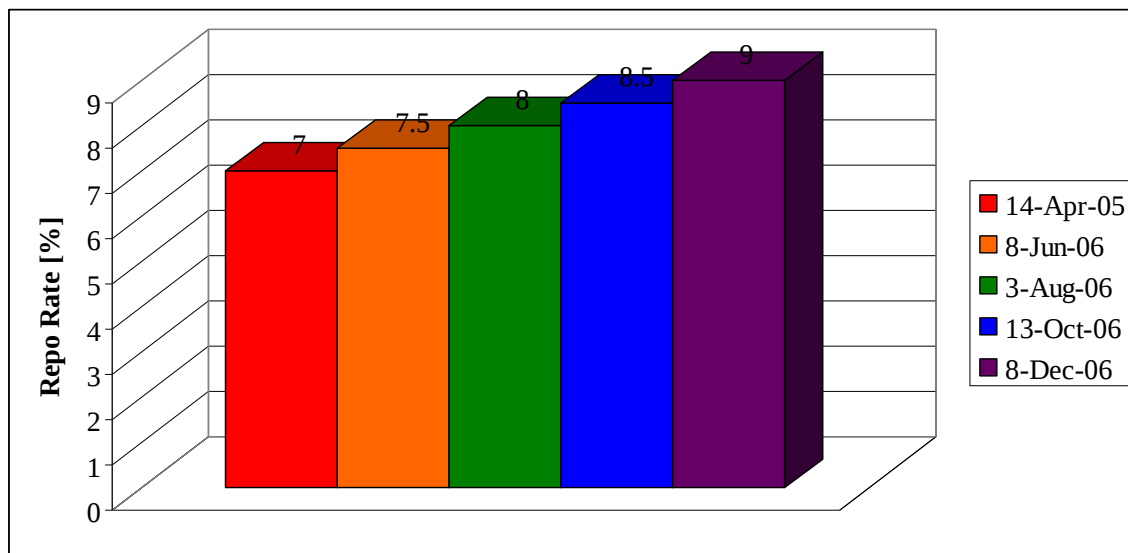


Figure 5.28: Repo Rate Changes over Test Period

(Source: South African Reserve Bank, 2007a)

3. Exchange rate, or how the Rand fares against other currencies

If a firm exports or imports products or services from other countries, or has payments or receipts in other currencies, it is affected by the exchange rate

³² Repo rate is the interest rate at which the Reserve Bank lends money to the financial institutions.

between the Rand and other currencies. A few currencies of particular interest to the Rand are the US Dollar, the British Pound and the Euro.

From Figure 5.29, there is a clear depreciation in South African currency between May and October 2006. This would affect firms which are multi-listed across countries by putting upward pressure on expenses, leading to reduced earnings on their financial statements, thus reducing EPS and potentially reducing share prices.

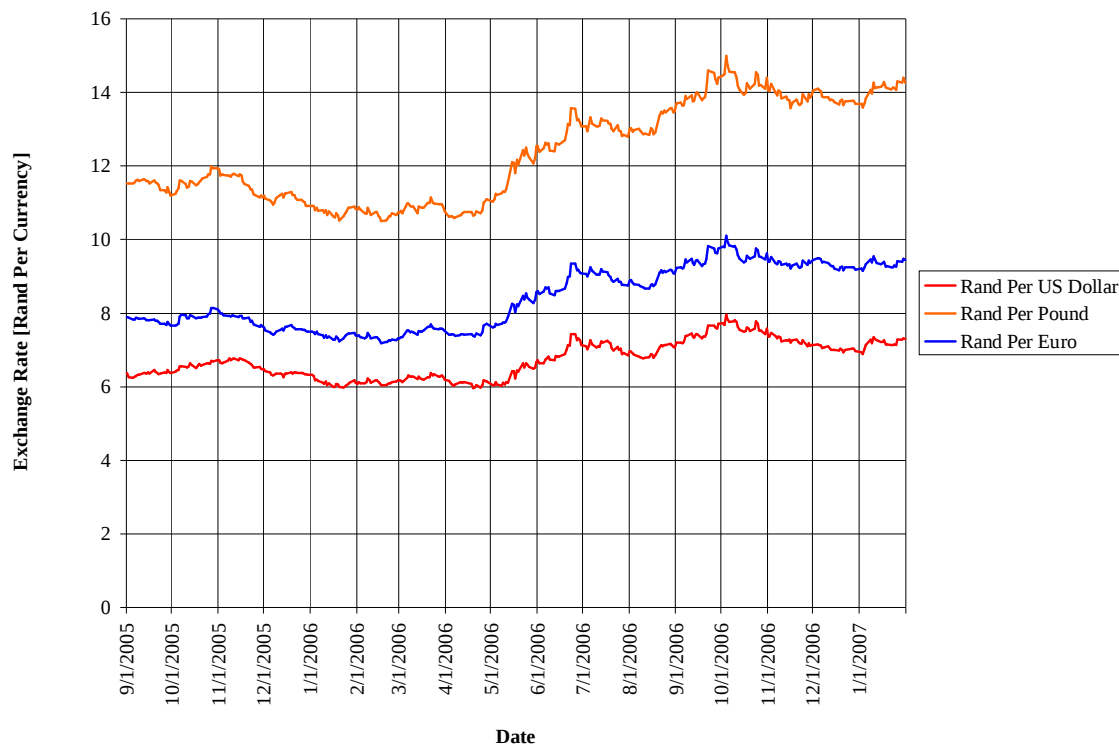


Figure 5.29: Exchange Rate over Test Period

(Source: South African Reserve Bank, 2007b)

4. Inflation rate

The security market dislikes inflation as it pushes up the operating, financial and investing costs for companies. The companies cannot pass the increased

costs to consumers quick enough due to some of the regulations, thus inflation directly affect the company's earnings.

The inflation rate is usually represented by the Consumer Price Index (CPI). An increase in inflation suggests a decrease in the purchasing power of consumers. So, if the consumers want to maintain their current living standards, more money needs to be spent. This action would lead to less disposable income that can be used for investment purposes. Thus, the stock exchange may become less active, since supply is greater than demand i.e. less people are buying shares, leading to the decline in share prices.

5. Rate of growth of South Africa's Gross Domestic Product (GDP)

The GDP is the value of all goods and services produced in an economy. When GDP increases, the economy expands and a firm's earnings will rise and vice versa. When the firm's earnings increase, this leads to a high EPS. Therefore, share prices would increase.

The discrepancies between the expected returns which exclude and include error terms have, thus, been discussed. The averages over the entire test period will now be compared.

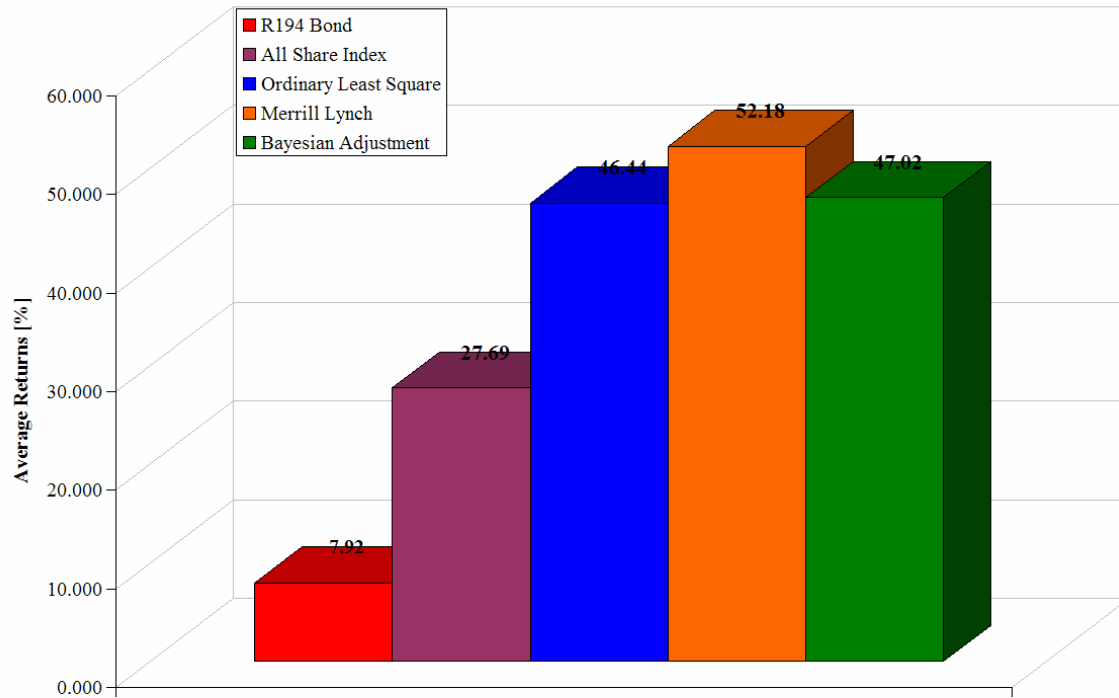


Figure 5.30: Average Returns Excluding Errors Comparisons Over Test Period

From Figure 5.30, the R194 Bond performed at an average of 7.92% over the test period, while the OLS at 46.44%, the ML at 52.18%, the BA at 47.02% and the All Share Index at 27.69%. This suggests that the OLS and the BA can be approximated, thus the BA adjustment model was unnecessary.

The yield of the R194 Bond is 7.92%. This figure is only slightly above the proposed inflation target of 6% by the government. (Statistics South Africa, 2007) This suggests that if an investor doesn't wish to encounter any risk and is satisfied with keeping the present monetary value of the investment, government bonds should be considered.

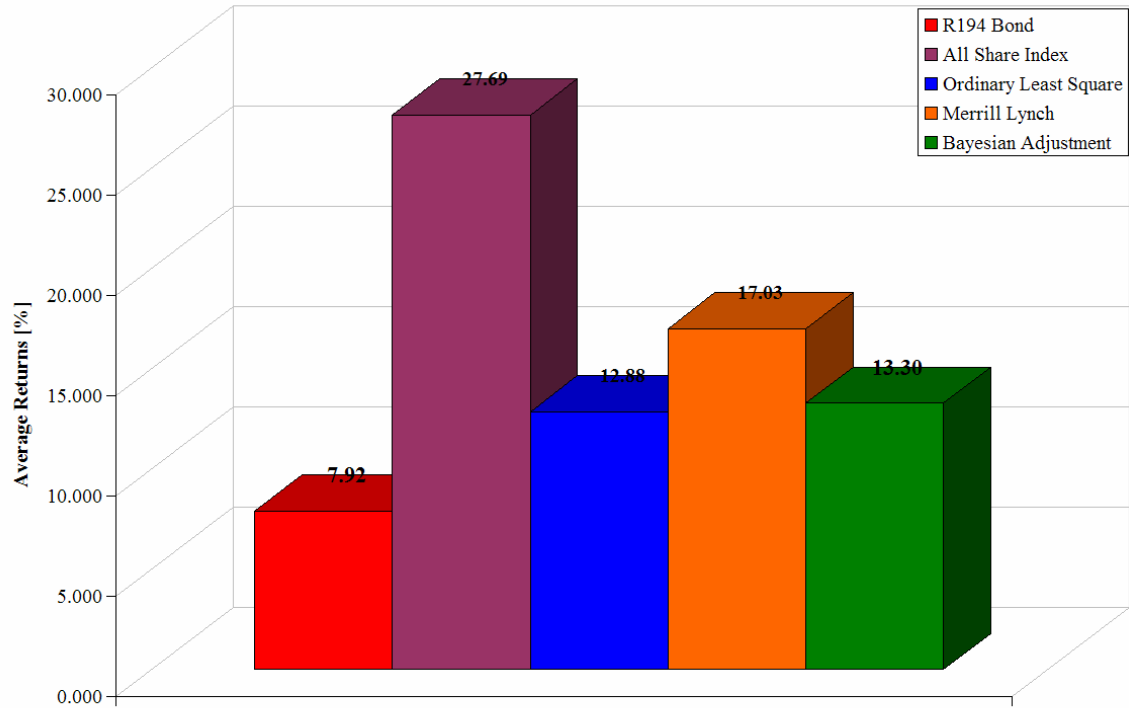


Figure 5.31: Average Returns Including Errors Comparisons Over Test Period

From both Figure 5.30 and Figure 5.31, it is observed that the test portfolio selected has outperformed the R194 bond. This implies the purchasing power of money has been sustained in this design report.

5.4 Summary

From the demonstration, the following was found:

- the computer programme developed, based on the proposed critical literature review as discussed in Chapter 2, can be used to perform calculations on the components (these include the balanced, the core, the core alternative, the conservative, the mid-term and the small cap components)
- over the period analysed:
 - beta values tend to stabilise around $t = 50$, the ML series stabilises above 0.5, the BA and the OLS series stabilise near zero

- o the ML series has the highest beta values, followed by the BA series then the OLS series
- o alpha values tend to rise and show a positive trend
- o alpha and beta values tend to be inversely related,
- o alpha and expected returns display a similar trend
- o expected returns, for both exclusion and inclusion of error terms, are higher than the proposed annual inflation rate.

Chapter 6 Conclusions & Further Work

6.1 Conclusions

For any investor to generate returns on their securities' portfolios, they need to gain the necessary investment-related knowledge. There are many models that can be used; the fundamentals of MPT have been widely used by passive investors and they have been used in this design to serve as the basis for the automated model. With the model developed, the objective is accepted as achieved within the accuracy of this design. However, this design is biased towards a particular type of security, namely shares and selected industries. The details of these are discussed below.

The objectives of this design have been met, namely:

- To develop a model for passive portfolio management using MPT tools via a critical literature review. This is achieved by develop a complete methodology that assists investors in the management of their portfolios. The proposed methodology is represented graphically in Figure 1.1.

The pertinent model was achieved through a critical literature review as outlined in Chapter 2, by using both Markowitz's mean-variance framework and Sharpe's single index model.

- To develop a computer programme where the model is validated through the use of a test portfolio. This is explained by the automation of the above-mentioned passive portfolio management model via a computer programme which was developed as outlined in Chapter 3. The structure of the test portfolio was outlined in Chapter 4. The computer programme developed has achieved its purpose which is to demonstrate the automation of the model. This is shown by the results generated by the computer programme, which was discussed in Chapter 5.

The MATLAB software selected for the development of the model has achieved the stated objectives. Therefore, the model developed in this design has achieved the objectives as stated in Chapter 1. The design questions, as stated in Chapter 1, have also been answered. Firstly, the reasons for portfolio selection have been investigated, namely the macroeconomic factors of an economy, an investors' preferences and profiles and the use of both fundamental and technical analysis. Secondly, the fundamentals and models associated with MPT have been understood, namely Markowitz's Portfolio Theory and Sharpe's Single Index Model. The author has developed fundamental knowledge in the mean-variance framework and the significance of this framework, thus a private investor can do the same based on this design report. Thirdly, a risk-return relationship has been established on the test portfolio. This is achieved by analysing the relationship between beta values with expected returns, which is discussed in Chapter 5 – design outcomes.

The model developed is validating through the use of a selected test portfolio. It is relevant to examine the constituents of the test portfolio, where the selected portfolio has been categorised into different components due to the nature of their constituents. The reasons that were considered for the test portfolio were discussed. Sharpe's Single Index Model was used for determining the portfolio returns. The test portfolio was divided into six components, namely balanced, conservative, core alternative, core, mid-term and small-cap, according to the nature of constituents and investment time horizon.

In more details, the components' results were discussed in Chapter 5. Betas are reasonable measures for risk exposure and they give approximate directions in which the systematic risks will move. If the beta values are positive, they will move in the same direction to that of the market and vice versa. The low beta values generated from the components implied low covariances, thus high levels of diversification. The diversification was mainly achieved through the dual- or multi-listing of the securities on other stock exchanges. It was noted that both beta and alpha values tended to stabilize around time series containing 50 data values, i.e. around $t=50$. This is due to the initial starting up fluctuations, i.e. the use of daily data.

Alphas can be interpreted as the human interventions that can be added to components in an attempt to increase the returns. Alphas and betas have an inversely proportioned relationship.

The patterns of alpha, for each component, are identical to that of the corresponding figures for returns excluding errors. The troughs and ridges of graphs associated with returns including error over the test period, coincide with the All Share Index pattern.

From the discussion in Chapter 5, section 5.3.2, it was observed that there were positive returns generated by the test portfolio. Two sets of outcomes were analyzed, one excludes and the other includes the error term from the single index model respectively. The two sets of results do not coincide. In the set of results that excludes the error term, the test portfolio outperforms both the government R194 bond and the market. While in the set of results that includes the error term, the test portfolio underperforms relative to the market but outperforms the government R194 bond. The reasons for these differences could be due to the state of the US economy, the inflation rate within the domestic economy, interest rates, exchange rates relative to other currencies and GDP growth statistics. Each of the pertinent reasons has been discussed in more detail in section 5.3.2.

The average rate for the R194 bond is 7.57% over the test period. This value is slightly higher than the government-proposed inflation rate. Therefore, bonds may be used as an alternative choice for risk-averse investors. This was discussed in section 5.3.2.

Generally, the returns generated by the OLS and BA adjustments were similar, thus the Bayesian adjustments carried out on the initial OLS results may be unnecessary. It is concluded that OLS is an adequate estimation of BA for this test.

Findings from this design indicate that this design has contributed to enable private investors to make sound investment decisions based on this document.

In conclusion, this design has achieved its objectives by providing some useful information that can be used by private investors to determine what aspects can be investigated prior to their portfolio selections and the relationships between the market and their portfolios can be examined.

6.2 Directions for Further Work

The following areas for further work are identified:

- 1) The models used in this research gave static estimation of beta values. An approach can be taken to estimate beta values dynamically; such an approach could be the use of Kalman filtering.
- 2) Hypothesis formation on the superiority of the Single Index Model over others.
- 3) Hypothesis formation on efficient market, testing for the type of market present.
- 4) Attempts can be made to deal with implications and limitations associated with MPT.
- 5) There are significant discrepancies between the results with the error term from Sharpe's single index model and the results without it. An implication for further research may be a detailed investigation into the error term from the single index model using a neural network. A neural network is a recommended technique to identify the patterns and filter out noise from the errors.
- 6) In this design, the short-selling of securities has not been mentioned. For further work, short-selling cases can be investigated.
- 7) Personalisation of the data set. User interface can be improved from what is proposed in this design report. Currently, an investor needs to insert a new column for a new security in front of the 'All Share Index' in the raw data workbook. He must then open the Excel workbook 'Weight Factors for Calculation – Beta' on the CD provided, insert an additional row for inclusion of new security, enter the actual number of units held and annual dividends; then a new percentage held by each of the portfolio constituents needs to be calculated. Once these are established, the MATLAB codes must be run, the outcomes will

be written into the prescribed Excel workbooks. A direction for further development would be that an Excel model can be developed with user interface. This model can replace the proposed MATLAB one in this design.

- 8) Improvements on Sharpe's single index model. These are mainly related to the assumptions associated with the model; hence their validity could be verified.

Chapter 7 References & Bibliography

References

Barry, C. B. (1974) Portfolio Analysis Under Uncertain Means, Variances and Covariances, *Journal of Finance*, Vol. 29, No. 2 (May 1974), pp. 515- 522

Bernstein, P. (1992) *Capital Ideas: The Improbable Origins of Modern Wall Street*, The Free Press A Division of Macmillan, Inc. New York

Buffet, M. and Clark, D. (2002) *The New Buffettology*, Free Press Business

Bradfield, D. (2003) Investment Basics XLVI. On Estimating The Beta Coefficient, *Investment Analysts Journal*, No. 57, pp.47-53

Brinson, G.P., Hood, R.L. and Beebower, G.L. (1995) Determinants of Portfolio Performance, *Financial Analysts Journal*, Jan/Feb, Vol. 51, No. 1, pp. 133- 138

Carleton College (2007) *Why Use Excel?*

Internet: <http://serc.carleton.edu/introgeo/mathstatmodels/WhyUseXL.html>,

Cited: 7th October 2007

Campbell, H. (2007) *Notes to Advanced Simulation System*, University of the Witwatersrand

Campbell, J.Y. (2002) Strategic Asset Allocation: Portfolio Choice for Long- Term Investor, Address to the American Economic Association and American Finance Association, January

Chen, S.N. and Brown S.J. (1983) Estimation Risk and Simple Rules for Optimal Portfolio Selection, *The Journal of Finance*, Vol. 38, No. 4, September, pp. 1087-1093

Cheng, P.L. and King Deets, M. (1971) Portfolio Returns and the Random Walk Theory, *Journal of Finance*, Vol. 26, No. 1 (Mar. 1971), pp. 11- 30

Cohen, J.B., Zinbarg, E.D. and Zeikel, A. (1987) *Investment Analysis and Portfolio Management*, 5th Edition, Irwin, pp. 82 – 124

Compass Financial Planners Pty Ltd. (2007),

Internet: <http://www.travismorien.com/FAQ/portfolios/practicalmpt.htm>,

Cited: 8th March 2007

Correia, C., Flynn, D., Uliana, E. and Wormald, M. (2003) *Financial Management*, Fifth Edition, Juta & Co. Ltd.

Cuthbertson, K. and Nitzsche, D. (2004) *Quantitative Financial Economics: Stocks, Bonds & Foreign Exchange*, Second Edition, John Wiley & Sons, Ltd.

Daves, P.R., Ehrhardt, M.C. & Kunkel R.A.(2000) Estimating Systematic Risk: The Choice of Return Interval and Estimation Period, *Journal of Financial and Strategic Decisions*, Vol. 13, No. 1, pp. 7-13

Deng, X.T., Wang, S.Y. and Xia, Y.S. (2000) Criteria, Models and Strategies in Portfolio Selection, *Advanced Modelling and Optimization*, Vol. 2, No. 2, pp. 79- 103

Derby Financial Group (2008) *Modern Portfolio Theory*,
Internet: <http://www.derbyfinancial.com>, Cited: 8th March 2008

Elton, E.J., Gruber, M.J. and Padberg, M.W. (1976) Simple Criteria for Optimal Portfolio Selection, *Journal of Finance*, Vol. 31, No. 5 (Dec. 1976), pp. 1341- 1357

Elton, E.J. and Gruber, M.J.
(1977) Risk Reduction and Portfolio Size: An Analytical Solution, *The Journal of Business*, Vol. 50, No. 4, October, pp.415-437
(2000) Rationality of Asset Allocation Recommendations, *The Journal of Financial and Quantitative Analysis*, Vol. 35, No. 1, Mar, pp. 27- 41

Elton, E.J., Gruber, M.J., Brown, S.J. & Goetzmann, W.N. (2003) *Modern Portfolio Theory and Investment Analysis*, Sixth Edition, John Wiley

Evanson Asset Management (2006)
Internet <http://www.evansonasset.com/index.cfm/Page/2.htm>
Cited: 12th March 2006

Feinberg, P. (2005) *Corporate Financial Management and Decision Making*, Second Edition, Peter Feinberg Business Planning Cc, pp.56 – 65

Financial Engineering News (2006).
Internet <http://www.fenews.com/what-is-fe/what-is-fe.html>
Cited: 12th March 2006

Fisher, K.L. and Statman, M. (1997) The Mean- Variance- Optimization Puzzle: Security Portfolios and Food Portfolios, *Financial Analysts Journal*, Vol. 53, No. 4, Jul/Aug, pp. 41- 50

Frankfurter, G. (1990) Is Normative Portfolio Theory Dead? *Journal of Economics and Business*, Vol. 42, No. 2, May, pp. 95- 98

Frank Russell Company (2006).
Internet http://www.russell.com/us/education_center/plan/Active_vs_Passive.asp
Cited: 8th February 2006

Fridson, M. (2007) Behavioural Finance & Wealth Management: How to Build Optimal Portfolios that Accounts for Investors' Biases, *Financial Analysts Journal*, Mar/Apr, Vol. 63, No. 2, pp. 107- 108

Friend I. and Vickers, D. (1965) Portfolio Selection and Investment Performance, *Journal of Finance*, Vol. 20, No. 3 (Sept. 1965), pp. 391- 415

Gallant, C. (2005), *A Guide to Portfolio Construction*, Internet: www.investopedia.com, Cited: 6th March 2007

Graham, B., Dodd, D. and Cottle, S. (1962) *Security Analysis Principles and Techniques*, Fourth Edition, McGraw- Hill Book Company

Gleser, L.J. (1998) Assessing Uncertainty in Measurement, *Statistical Science*, Vol. 13, No. 3 (Aug 1998), pp. 277- 290

Hagin, R. (1979) *The Dow Jones- Irwin Guide To Modern Portfolio Theory*, Dow Jones Irwin

Harvey, C. R, Travers, K.E. and Costa, M.J. (2000) Forecasting Emerging Market Returns Using Neural Networks, *Emerging Markets Quarterly*, Summer Edition, pp. 1- 12

Hobbs, J. (2001) *Can South African Fund Managers Add Enough Active Value to Domestic Investment Portfolios?*, BSc Honours Project in Mathematics of Finance, University of Witwatersrand, Johannesburg

Holton, G.A. (2004) Defining Risk, *Financial Analysts Journal*, Nov/Dec, Vol. 60, No. 6, pp. 19-25

Hultstorm, D. (2007) *Ruminations on Active vs. Passive Management*, Internet: <http://www.financialarchitectsllc.com>, Cited: 8th March 2008

International Marketing Council of South Africa (2007) , *South Africa: Open for Business*, Internet: http://www.safrika.info/doing_business/sa_trade/importing/open.htm, Cited: 19th September 2007

Investopedia Inc.

(2003) Internet: <http://www.investopedia.com/articles/03/032603.asp>, Cited: 7th March 2007

Israelsen, C.L. and Cogwell, G.F. (2007) The Error of Tracking Error, *Journal of Asset Management*, Vol. 7, No. 6, pp. 419 – 424

Jacquier, E. and Marcus, A.J. (2001) Asset Allocation Models and Market Volatility, *Financial Analysts Journal*, Mar/Apr, Vol. 57, No. 2, pp. 16 – 30

Jarnecic, E., M^cCorry, M. & Winn R. (1997) *Periodic Return Time Series, Capitalisation Adjustments and Beta Estimation*, SIRCA

JSE Securities Exchange Limited (JSE) (2007),
Internet: <http://www.jse.co.za>, Cited: 27th February 2007

Kam, K. (2006) *Portfolio Selection Methods: An Empirical Investigation*, MSc Thesis in Statistics, University of California, Los Angeles

Korner, G. (2005) *Share Market Outlook – August 2005*,
Internet: <http://www.smcb.co.za>, Cited: 21st October 2006

Lattmann, J. M. (2006) *Modern Portfolio Theory: A Nobel Prize Winning Approach*,
Internet: <http://www.cyberhaven.com/investors/portfolio.html>
Cited: 12th March 2006

Li, C. (2007) *What Are Emerging Markets?*, The University of IOWA Center for International Finance and Development,
Internet: http://www.uiowa.edu/ifdebook/faq/faq_docs/emerging_markets.shtml,
Cited: 19th September 2007

Lin, W., Kopp, L., Hoffman, P. & Thurston M. (2004) Changing Risks In Global Equity Portfolio, *Financial Analysts Journal*, January/ February, Vol. 60, No. 1, pp. 87-99

Luenberger, D.G. (1998) *Investment Science*, Oxford University Press

Lynu, Y.D. (2002) *Financial Engineering and Computation, Principles, Mathematics, Algorithms*, Cambridge University Press

Malkiel, B.G.
(1999) *The Random Walk Down Wall Street*, W. W. Norton & Company, Inc.
(2003) *The Random Walk Guide To Investing*, W.W. Norton & Company, Inc.

Markowitz, H.
(1952) Portfolio Selection, *Journal of Finance*, vol. 7, pp.77-91
(1959) *Portfolio Selection Efficient Diversification of Investment*, John Wiley & Sons, Inc

Mason, R.D. and Lind, D.A. (1990) *Statistical Techniques in Business & Economics*, Ninth Edition, Irwin

McKnight, W. (2007) *What are the advantages and disadvantages of data mining tools?*
Internet:
http://searchdatamanagement.techtarget.com/expert/KnowledgebaseAnswer/0,289625,sid91_gci1269812,00.html, Cited: 9th October 2007

Mendenhall, W., Beaver, R.J. and Beaver, B.M. (2003) *Introduction to Probability and Statistics*, Thomas Brooks/Cole

Mesirow Financial Holdings, Inc. (2006)

Internet: <http://www.mesirowfinancial.com/institutions/investmentmanagement>

Cited: 28th February 2006

Microsoft Corporation

(2003) *Supporting Documents on Microsoft Excel Help*

(2007) Internet: <http://office.microsoft.com/en-us/excel/HA101641791033.aspx>,

Cited: 7th October 2007

Mitchell, M. N. (2007) *Statistically Using General Purpose Statistics Packages: A Look at Stata, SAS and SPSS*, Statistical Consulting Group, UCLA Academic Technology Services

Muradzikwa, S., Smith, L. and de Villiers, P. (2004) *Economics*, Oxford University Press South Africa

Nagy, Robert A. and Obenberger, Robert W. (1994) Factors Influencing Individual Investor Behaviour, *Financial Analysts Journal*, July/ August, Vol. 50, No. 4, pp.63 -68

Njavro, D., Barac, Z. (2000) *Institutional Investors; Procedures in Selection of Optimal Investment Combination*, Journal of Contemporary Management Issues, Vol. 5 No. 2, pp. 79- 93

Northeastern University: College of Computer and Information Science (2003) *PowerPoint Presentation on Introduction to MATLAB*, Co- op Preparation University (CPU)

Profile Group (Pty) Ltd.

(2006a) *Profile's Stock Exchange Handbook January – June 2006*

(2006b) Internet: <http://www.sharedata.co.za>, Cited: 21st April 2006

Raftery A.E., Madigen, D. and Hoeting J.A. (1997) Bayesian Model Averaging for Linear Regression Model, *Journal of the American Statistical Association*, Vol. 92, No. 437, pp. 179- 191

Reilly, F.K. (1989) *Investment Analysis and Portfolio Management*, Third Edition, The Dryden Press

Renwick, F.B. (1969) Asset Management and Investor Portfolio Behaviour, *Journal of Finance*, Vol. 24, No. 2 (May 1969), pp. 181- 206

Rudd, A. (1980) Optimal Selection of Passive Portfolio, *Financial Management*, Vol. 9, No. 1 (Spring 1980), pp. 57- 66

Ryan, T.M. (1978) *Theory of Portfolio Selection*, The MacMillan Press Ltd.

Schweser Kaplan Financial

(2006a), *Study Notes for the 2006 CFA Exam Level 1, Book 1: Ethics and Quantitative Methods*

(2006b), *Study Notes for the 2006 CFA Exam Level 1, Book4: Corporate Finance, Portfolio Management, Markets, Equity and Alternative Investments*

Sharpe, W. F.

(1964) Capital Asset Prices: A Theory of Market Equilibrium Under Conditions of Risk, *The Journal of Finance*, Vol. 19 No. 3, pp. 425- 442

(1970) *Portfolio Theory and Capital Markets*, McGraw- Hill Series in Finance, McGraw-Hill Book Company

(1995) Risk, Market Sensitivity, and Diversification, *Financial Analysts Journal*, Vol. 51, Jan/Feb, pp. 84 – 88

(2006) *Investors and Markets: Portfolio Choices, Asset Prices and Investment Advice*, Stanford University

Sorensen, E. H., Miler, K. L. and Samak, V. (1998) Allocating Between Active and Passive Management, *Financial Analysts Journal*, Sep/Oct, Vol. 54, No. 5, pp. 18-31

South African Reserve Bank

(2007a) Internet: <http://reservebank.co.za>, Historical Data on Interest Rate,
Cited: 2nd May 2007

(2007b) Internet: <http://reservebank.co.za>, Historical Data on Exchange Rate,
Cited: 2nd May 2007

Standard Bank Group

(2006) Course Notes of Standard Bank Online Share Trading Technical Analysis

Internet: [http:// www.smcg.co.za](http://www.smcg.co.za)

Cited: 14th March 2006

(2007) Notes for Basic Investment Course, Unit 5 – What factors will influence my returns?

Internet: [http:// www.smcg.co.za](http://www.smcg.co.za)

Cited: 2nd May 2007

Statistic South Africa (2007), Statistical Release P0141 Consumer Price Index January 2007, Internet: <http://www.statssa.gov.za>, Cited: 4th March 2007

Statman, M. (1987) How Many Stocks Make A Diversified Portfolio?, *Journal of Finance and Quantitative Analysis*, September, Vol. 22, No. 3, pp. 353- 363

The MathWorks, Inc. (2006) *MATLAB® Supporting Documents: Getting Started help, MATLAB tutorials and Programming tips*

Tobin, J. (1981) Portfolio Theory, *American Association the Advancement of Science*, New Series, Vol. 214, No. 4524 (Nov. 27 1981), p. 974

Topper, J. (2005) *Financial Engineering With Finite Elements*, Wiley Finance, Wiley

Tucker, A.L., Becker, K.G., Isimbabi, M.J. and Ogden J.P. (1994) *Contemporary Portfolio Theory and Risk Management*, West Publishing Company

VenFin Group (2006), Annual Report 2006, p. 10

Internet: http://www.venfin.com/financial_annualreport.asp, Cited: 30th October 2006

Waters Corporation (2007),

Internet: <http://www.waters.com/WaterDivison/ContentD.asp?watersit=JDRS-5LTGMN>, Cited: 7th November 2007

WebFinance Inc.

(2006) Internet: http://www.investorwords.com/3083/modern_portfolio_theory.html, Cited: 12th March 2006

(2007a) Internet: <http://www.investorwords.com/3473/optimization.html>, Cited: 7th March 2007

(2007b) Internet: <http://www.investorwords.com/3665/performance.html>, Cited: 7th March 2007

Welch, G. & Bishop G.

(2001) *Course 8 Notes: An Introduction to Kalman Filter*, Department of Computer Science, University of North Carolina

(2004) *An Introduction to Kalman Filter*, TR 95-041, Department of Computer Science, University of North Carolina

Wellis, C. (1996) *The Kalman Filter in Finance*, Springer

West, G. (2005) *South African Financial Markets: Programme in Advanced Mathematics of Finance*, School of Computational and Applied Mathematics, University of the Witwatersrand, Financial Modelling Agency

Wikimedia Foundation Inc.

(2004) Internet: http://en.wikipedia.org/wiki/2010_FIFA_World_Cup, Cited: 27th February 2007

(2007a) Internet: http://en.wikipedia.org/wiki/Microsoft_Excel, Cited: 7th October 2007

(2007b) Internet: <http://en.wikipedia.org/wiki/Spreadsheet#Shortcomings>, Cited: 7th October 2007

(2007c) Internet: <http://en.wikipedia.org/wiki/MATLAB>, Cited: 7th October 2007

(2007d) Internet: http://en.wikipedia.org/wiki/SAS_System, Cited: 7th October 2007

Winston, W. L. (2004) *Operations Research Applications and Algorithms*, Fourth Edition, Thomson Brooks/ Cole, pp. 680- 686, 1147

Yao, F., Xu, B., Adams, P., Doucet, K. (2002) *Streetsmart Guide to Managing Your Portfolio: An Investor's Guide to Minimizing Risk and Maximizing Returns*, McGraw-Hill

Yates, J. (2006) Department of Political Science, University of Georgia, Internet: http://www.elsborg.org/the_empirical_legal_studi/2006/02/stats_analysis_.html, Cited: 9th October 2007

Bibliography

Achour, D., Harvey, C.R., Hopkins, G. and Lang C. (1999) Stock Selection in Mexico, *Emerging Market Quarterly*, Fall, pp. 1-38

Beller, K.R., Kling, J.L. and Levinson M.J. (1998) Are Industry Stock Returns Predictable?, *Financial Analysts Journal*, Sep/Oct, Vol. 54, No. 5, pp. 42- 57

Bernstein, P.L. (1995) Risk As History of Ideas, *Financial Analysts Journal*, Jan/Feb, Vol. 51, No. 1, pp. 7-11

Best, M.J. and Grauer, R.R. (1991) Sensitivity Analysis for Mean-Variance Portfolio Problems, *Management Science*, August, Vol. 37, No. 8, pp.980-989

Britten-Jones, M. (1999) The Sampling Error In Estimates of Mean-Variance Efficient Portfolio Weights, *The Journal of Finance*, April, Vol. 54, No. 2, pp. 655-671

De Silva, H., Sapra, S. and Thorley S. (2001) Return Dispersion and Active Management, *Financial Analysts Journal*, Sep/Oct, Vol. 57, No. 5, pp. 29-42

Ellis, C.D. (1975) The Loser's Game, *Financial Analysts Journal*, July/ August, pp.19-26

Goldberg, S.R. and Heflin, F.L. (1995) The Association Between The Level of International Diversification and Risk, *Journal of International Financial Management and Accounting*, Vol. 6, No.1, pp. 1-26

Jarrow, R (2001) Default Parameter Estimation Using Market Prices, *Financial Analysts Journal*, September/ October, pp. 1-18

Jarrow, R.A. & Turnbull S.M. (2000) The Intersection of Market and Credit Risk, *Journal of Banking & Finance*, vol. 24, pp. 271- 299

Kwan, C.C.Y. (1984) Portfolio Analysis Using Single-Index, Multi-Index and Constant Correlation Model: A Unified Treatment, *The Journal of Finance*, December, Vol. 39, No. 5, pp. 1469-1483

Lee, S. and Bryne, P. (1998) Diversification By Sector, Region or Function: A Mean Absolute Deviation Optimisation, *Journal of Property Evaluation and Investments*, Vol. 16, No. 1, pp. 38-56

Lo, A.W. (1999) The Three P's of Total Risk Management, *Financial Analysts Journal*, Jan/Feb, Vol. 55, No. 1, pp. 13-26

Phillips, S.D., Estler, W.T., Levenson, M.S. and Eberhardt K.R. (1998) Calculation of Measurement Uncertainty Using Prior Information, *Journal of Research of the National Institute of Standards and Technology*, November- December, Vol. 103, No. 6, pp. 625-632

Raynor, M.E. (2002) Diversification As Real Options and The Implications On Firm-Specific Risk and Performance, *The Engineering Economist*, Vol. 47, No. 4, pp. 371-389

Renshaw, E. (1993) Modeling the Stock Market for Forecasting Purposes, *Journal of Portfolio Management*, Fall, Vol. 20, No. 1, pp. 76-81

Scherer, B. (2002) Portfolio Resampling: Review and Critique, *Financial Analysts Journal*, Nov/Dec, Vol. 58, No. 6, pp. 98-109

Sharpe, W.F. (1998) Morningstar's Risk-Adjusted Rating, *Financial Analysts Journal*, Jul/Aug, Vol. 54, No. 4, pp. 21-33

Stutzer, M. (2004) Asset Allocation Without Unobservable Parameters, *Financial Analysts Journal*, Vol. 60, No. 5, pp. 38-51

Appendices

Appendix A: MATLAB Code for Analysing Components of the Test Portfolio With Error Terms

```
% Final Code: Use Simple Discrete Return With Dividends
% Acknowledgement must be paid to Mr. Randall Paton, who has assisted
in writing of the following code.
% Some components from Ms. Hobbs' code had also been modified for this
% research report
```

```
function Data = FinStats
```

```
format long;
i = 1; % initialise variables
j = 2;
k = 1;
m = 1;
weighttot = 0;

%Select name of file to process
[file, path] = uigetfile('*.xls', ' Original Data File'); % Select file
from which the raw data will be read from
[file2, path2] = uigetfile('*.xls', 'Ouput Data File'); % Select file
from which the results will be written to

% Set up communication with Excel
DDE_Total = xlsread(strcat(path, '/', file)); % Retrive data from a
spreadsheet in an Excel workbook, i.e. read from the first spreadsheet
in the workbook
[a,b] = size(DDE_Total); % a rows by b columns, b essentially
represents the number of securities including the benchmark
ndat = b - 1; % ndat is equal to b securities less one, since 1 refers
to the date column presented in the worksheet
ndatt = b;
DataRows = ones(ndat, 1); % Create arrays of all ones, returns a ndat
by 1 matrix of ones
while i <= ndat % for i is smaller or equal to ndat
    Name{1, i} = ['Data Set' num2str(i) 'Abbreviation']; % Convert
numbers to strings
    i = i + 1; % incrementing
end
i = 1;% reinitialise

Abbcell = inputdlg(Name, strcat('Please specify the portfolio data
abbreviation for data in', file), DataRows);
Allsname{1} = 'Composite Index Abbreviation';
Allscell = inputdlg(Allsname, 'Composite Index Details', 1);

% Create user-interphase for user involvements
% Define company abbreviations
while i <= ndat
    Data(i).name = Abbcell{i};
    i = i + 1;
end
i = 1;
```

```

Data(ndatt).name = Allscell{1};
% The weight assigned to each share in the portfolio
% Ensure the total weights add up to 1 for the portfolio
while weighttot ~= 1
    % Enter predetermined weighting factors for each share - use
weights
    % determined from portfolio optimisation
    while i <= ndat
        NameWeights{i, 1} = ['Data Set' ' ' Abbcell{i} ' ' 'Weight in
percentage or decimal is' file];
        i = i + 1;
    end
    i = 1;
    Weightcell = inputdlg(NameWeights, strcat('Please specify the
weight in', file), DataRows);
    % Define the weight factors for beta calculations - these are the
% individual percentages hold of each securities in the portfolio
    while i <= ndat
        Data(i).weightfactor = str2num(Weightcell{i}); % Convert
strings to numbers
        weighttot = weighttot + Data(i).weightfactor;
        i = i + 1;
    end
    i = 1;
    if weighttot ~= 1
        warnh = warndlg('The specified weightings do not add up to 1.
Please re-enter the desired weightings', 'Improper Weightings');
        weighttot = 0;
        waitfor(warnh); % block execution and wait for event
    end
end
i = 1;

% Time series data for each of the shares in the portfolio
while i <= ndatt
    Data(i).ddedata = DDE_Total(:, i);
    i = i + 1;
end
i = 1;

% Define the number of data points
dpts = 1; % initialise
while dpts <= a-2 % less 2, one is for the first name row, and the
other for unbiased sample variance
    dpts = dpts + 1;
end
A = cumsum(ones(dpts,1)); % create an array that counts the sample size

% Total number of observations possible after calculating returns
N = a-1;

% Total number of shares in the portfolio
numshares = ndat;

% Setting up the matrix for the independent variables

```

```

X = zeros(N, 2); % Create a zero matrix of N by 2, i.e. N rows with 2
columns
X(1:N, 1) = ones(N,1);
% Calculating the returns for each shares in the portfolio
% Enter dividends received per share in cents during period examined,
i.e. dividends
% declaration date have been used as the reference
while i <= ndat
    NameDiv{i, 1} = ['Data Set' ' ' Abbc{cell{i}} ' ' ' Dividend Received
Per Share in Cents over test period', file];
    i = i + 1;
end
i = 1;
Divcell = inputdlg(NameDiv, strcat('Please enter dividends per share
over the test period', file), DataRows);

% Take into accounts of the dividend paid per share in cents for each
of
% the securities
while i <= ndat
    Data(i).dividend = str2num(Divcell{i});
    i = i + 1;
end
i = 1;
% Returns being expressed in percentages
while i <= ndatt
    data = Data(i).ddedata;
    b = length(data);
    if isempty(Data(i).dividend)==1
        div(i) = 0;
    else
        div(i) = Data(i).dividend./length(data); % get dividends into
daily form, thus it is assumed that it will be considered on a dialy
base
    end
    Data(i).returns = ((data(2:b)-data(1)+div(i))./data(1)).*100;%
Equation used here is the holding period yield (HPY), how it differs
daily
    i = i + 1;
end
i = 1;

% Returns on the index - the independent variable
X(:,2) = Data(ndatt).returns;

% Setting up the matrix for the dependent variables
Y = zeros(N, numshares); % create a zero matrix of N by numshares
while i <= numshares
    Y = Data(i).returns;
    Data(i).Y = Y;
    i = i + 1;
end
i = 1;

% Performing the regression
while i <= numshares

```

```

        Data(i).betahat = inv(X'*X)*X'*Data(i).Y;
        Data(i).alphaestimate = Data(i).betahat(1);
        Data(i).betaestimate = Data(i).betahat(2);
        i = i + 1;
    end
    i = 1;

% Calculating the vector of residuals, i.e. the error term
while i <= numshares
    error = Data(i).Y - X*Data(i).betahat;
    Data(i).error = error;
    i = i + 1;
end
i = 1;

% Calculation of arithmetic averages, this is consistent with the
pertaining returns
% calculation, since it was assumed to be discrete simple compounding
returns,
% instead of continuous compounding
while i <= ndatt
    returns = Data(i).returns;
    b = length(returns);% define length for returns vector
    averages(1) = returns(1);
    averagesi(1) = averages(1);
    while j <= b
        averagesi(j) = returns(j) + averagesi(j - 1);
        averages(j) = averagesi(j)./j;
        j = j + 1;
    end
    j = 2;
    Data(i).averages = averages';% transpose into column vector
    i = i + 1;
end
i = 1;

% Calculation of variances i.e. sample variances, they are unbiased,
hence
% the denominator is the number of data points, j, less 1
while i <= ndatt
    returns = Data(i).returns;
    averages = Data(i).averages;
    vard(1) = ((returns(1) - averages(1)).^2);
    var(1) = vard(1);
    while j <= b % use of column vector calculations
        vard(j) = ((returns(j) - averages(j)).^2) + vard(j - 1);% gives
cumulative results
        var(j) = vard(j)./A(j, :);
        j = j + 1;
    end
    j = 2;
    Data(i).var = var';
    i = i + 1;
end
i = 1;

```

```

% Standard Deviations
while i <= ndatt
    Data(i).stddev = sqrt(Data(i).var);
    i = i + 1;
end
i = 1;

% Covariances
while i <= ndatt
    returns = Data(i).returns;
    averages = Data(i).averages;
    b = length(returns);
    while k <= ndatt
        if k ~= i % for k is not equal to i
            ret = Data(k).returns;
            aves = Data(k).averages;
            reti = ret(2:end); % end indicate the last index of array
            avesi = aves(2:end);
            returns = MakeCol(returns); % make returns vector into its
column vector, if it is not already in the column form
            averages = MakeCol(averages);
            ret = MakeCol(ret);
            aves = MakeCol(aves);
            covarii = (returns - averages).*(ret - aves);
            covari(1) = covarii(1);
            while j <= b
                covari(j) = covarii(j)./A(j, :);
                j = j + 1;
            end
            j = 2;
            Names{k} = Data(k).name;
            Index(k) = k;
            CoVars(:,k) = covari;
        end
        k = k + 1;
    end
    Indtake = VecClean(Index);
    Data(i).covarnames = CellClean(Names);
    Data(i).covars = MatClean(Indtake, CoVars);
    Data(i).CoVarInd = Indtake;
    k = 1;
    i = i + 1;
    clear Names Index CoVars % free up the system memory
end
i = 1;

% Correlation coefficients calculations
while i <= ndatt
    indices = Data(i).CoVarInd;
    CoVars = Data(i).covars;
    stddev = Data(i).stddev;
    b = length(stddev);
    while k <= ndat
        covari = CoVars(:,k);
        stddevi = Data(indices(k)).stddev;
        rho(1) = 0;
    end
end

```

```

        while j <= b
            rho(j) = covari(j)./(stddev(j).*stddevi(j));
            j = j + 1;
        end
        Rhos(:,k) = rho;
        j = 2;
        k = k + 1;
    end
    k = 1;
    Data(i).rhos = Rhos;
    i = i + 1;
end
i = 1;

% Coefficient of Variation, this is a measure of risk/ volatility
while i <= ndat
    Data(i).cv = sqrt(Data(i).var)./Data(i).averages;
    i = i + 1;
end
i = 1;

% Calculations of betas - ordinary least squares method (ols)
while i <= ndat
    covars = Data(i).covars;
    covari = covars(:,ndat);
    if Data(ndatt).var ~= 0
        Data(ndatt).var = Data(ndatt).var;
    else if Data(ndatt).var == 0
        Data(i).beta = 0;
    end
    end
    Data(i).betaols = covari./Data(ndatt).var;% Equation of beta
    calculation
    i = i + 1;
end
i = 1;

% Calculations of alphas - ordinary least squares method (ols)
while i <= ndat
    Data(i).averages = MakeCol(Data(i).averages);
    Data(i).betaols= MakeCol(Data(i).betaols);
    Data(ndatt).averages = MakeCol(Data(ndatt).averages);
    Data(i).alphaols = Data(i).averages -
    ((Data(i).betaols).*(Data(ndatt).averages));
    i = i + 1;
end
i = 1;

% Beta Adjustments
% Merrill Lynch (ml)
while i <= ndat
    Data(i).betaml = 2.*Data(i).betaols./3 + 1/3;
    i = i + 1;
end
i = 1;

```

```

% Vasciek's technique: Bayesian's Adjustment (ba)
% Calculations on averages of betas
b = length(Data(i).betaols);
Porto = zeros(b,1); % Returns an b, where b is the length of
Data(i).beta, by 1 matrix of zeros, i.e. a column vector
while i <= ndat
    beta = Data(i).betaols; % Define the length
    betasum(1) = 0; % Assign initial values
    betasumi(1) = 0;
    while j <= b
        betasumi(j) = beta(j) + betasumi(j - 1); % cumulative averages
    of beta
        betasum(j) = betasumi(j)./A(j, :);
        j = j + 1;
    end
    j = 2;
    Data(i).avebeta = betasum';
    Porto = Porto + betasum'; % Ensure the addition is between two
column vectors, i.e. of the same dimension
    i = i + 1;
end
i = 1;
avebetaporto = Porto./ndat; % presume equal-weighted betas for the
securities in the portfolio
while i <= ndat
    Data(i).avebetaporto = avebetaporto;
    i = i + 1;
end
i = 1;

% Variances of individual betas i.e. sample unbiased variances
while i <= ndat
    beta = Data(i).betaols;
    avebeta = Data(i).avebeta;
    varbetai(1) = 0;
    varbeta(1) = 0;
    while j <= b
        varbetai(j) = (beta(j) - avebeta(j)).^2 + varbetai(j - 1);
        varbeta(j) = varbetai(j)./A(j, :);
        j = j + 1;
    end
    Data(i).varbeta = varbeta';
    j = 2;
    i = i + 1;
end
i = 1;

% Cross - sectional variance of all the estimates of beta in portfolio,
% i.e. the average used for calculation is the average of ALL betas of
% individual shares in the portfolio at a particular time
varbetaporto = zeros(b,1);
while i <= ndat
    varbetaporto = varbetaporto + ((Data(i).betaols -
Data(i).avebetaporto).^2);
    i = i + 1;
end

```

```

i = 1;
while i <= ndat
    Data(i).varbetaporto = varbetaporto./A(j, :);
    i = i + 1;
end
i = 1;

%Calculate weight factors for Bayesian adjustments
while i <= ndat
    Data(i).weight = Data(i).varbetaporto./(Data(i).varbetaporto +
Data(i).varbeta);
    i = i + 1;
end
i = 1;

% Calculation of Bayesian adjustments
while i <= ndat
    Data(i).betaba = (Data(i).weight).*(Data(i).betaols) + (1 -
Data(i).weight).*(Data(i).avebetaporto);
    i = i + 1;
end
i = 1;

% Alpha calculations for adjustments
% Merrill Lynch (ml)
while i <= ndat
    Data(i).alphaml = Data(i).averages -
((Data(i).betaml).*(Data(ndatt).averages));
    i = i + 1;
end
i = 1;
% Vasciek's technique: Bayesian's Adjustment (ba)
while i <= ndat
    Data(i).alphaba = Data(i).averages -
((Data(i).betaba).*(Data(ndatt).averages));
    i = i + 1;
end
i = 1;

% Portfolio Betas
betaportools = zeros(b,1);
betaportoml = zeros(b,1);
betaportoba = zeros(b,1);
while i <= ndat
    betaportools = betaportools + Data(i).betaols;
    betaportoml = betaportoml + Data(i).betaml;
    betaportoba = betaportoba + Data(i).betaba;
    i = i + 1;
end
i = 1;
while i <= ndat
    weightfactor = Data(i).weightfactor;
    betaportoolswithweights = betaportools.*weightfactor;
    betaportomlwithweights = betaportoml.*weightfactor;
    betaportobawithweights = betaportoba.*weightfactor;
    i = i + 1;
end

```

```

end;
i = 1;
betaportools = betaportoolswithweights;
betaportoml = betaportomlwithweights;
betaportoba = betaportobawithweights;

while i <= ndat
    Data(i).betaportools = betaportools;
    Data(i).betaportoml = betaportoml;
    Data(i).betaportoba = betaportoba;
    i = i + 1;
end
i = 1;

% Portfolio Alphas
averagesporto = zeros(b,1);
while i <= ndat
    averagesporto = averagesporto + Data(i).averages;
    i = i + 1;
end
i = 1;
while i <= ndat
    Data(i).averagesporto = averagesporto./A(j, :);
    i = i + 1;
end
i = 1;

while i <= ndat
    Data(i).alphaportools = Data(i).averagesporto -
    (Data(i).betaportools).*(Data(ndatt).averages);
    Data(i).alphaportoml = Data(i).averagesporto -
    (Data(i).betaportoml).*(Data(ndatt).averages);
    Data(i).alphaportoba = Data(i).averagesporto -
    (Data(i).betaportoba).*(Data(ndatt).averages);
    i = i + 1;
end
i = 1;

while i <= ndat
    Data(i).alphaportoolsmod = Data(i).alphaportools./100;
    Data(i).alphaportomlmod = Data(i).alphaportoml./100;
    Data(i).alphaportobamod = Data(i).alphaportoba./100;
    i = i + 1;
end
i = 1;

% Expected returns of individual shares
while i <= ndat
    Data(i).returnsols = Data(i).alphaols +
    (Data(i).betaols).*(Data(ndatt).returns) + Data(i).error;
    Data(i).returnsml = Data(i).alphaml +
    (Data(i).betaml).*(Data(ndatt).returns) + Data(i).error;
    Data(i).returnsba = Data(i).alphaba +
    (Data(i).betaba).*(Data(ndatt).returns) + Data(i).error;
    i = i + 1;
end

```

```

i = 1;

Results_returnsols = zeros(N,ndat);% Define the empty matrix, i.e. to
define the matrix size
Results_returnsml = zeros(N,ndat);
Results_returnsba = zeros(N,ndat);

% Define the outcomes
Results_Beta = [Data(1).betaportools, Data(1).betaportoml,
Data(1).betaportoba];
Results_Alpha = [Data(1).alphaportools, Data(1).alphaportoml,
Data(1).alphaportoba];
Results_Alphamod = [Data(1).alphaportoolsmod, Data(1).alphaportomlmod,
Data(1).alphaportobamod];

R_names{1} = 'ols';
R_names{2} = 'ml';
R_names{3} = 'ba';

while i <= ndat
    R_sharenames{i} = Abbcell{i};
    Results_returnsols(:, i) = Data(i).returnsols;
    Results_returnsml(:, i) = Data(i).returnsml;
    Results_returnsba(:, i) = Data(i).returnsba;
    i = i + 1;
end
i = 1;

% Export the results into Excel spreadsheet without opening up the
% worksheet
xlswrite(strcat(path2, '/', file2), R_names,'Beta', 'A1');
xlswrite(strcat(path2, '/', file2), Results_Beta,'Beta', 'A2');
xlswrite(strcat(path2, '/', file2), R_names,'Alpha', 'A1');
xlswrite(strcat(path2, '/', file2), Results_Alphamod,'Alpha', 'A2');
xlswrite(strcat(path2, '/', file2), R_sharenames,'Individual Returns
OLS', 'A1');
xlswrite(strcat(path2, '/', file2), Results_returnsols,'Individual
Returns OLS', 'A2');
xlswrite(strcat(path2, '/', file2), R_sharenames,'Individual Returns
ML', 'A1');
xlswrite(strcat(path2, '/', file2), Results_returnsml,'Individual
Returns ML', 'A2');
xlswrite(strcat(path2, '/', file2), R_sharenames,'Individual Returns
BA', 'A1');
xlswrite(strcat(path2, '/', file2), Results_returnsba,'Individual
Returns BA', 'A2');

function B = MakeCol(A)% Make the data set a column vector if it's not

[a,b] = size(A);

if a == 1
    if b > 1
        B = A';
    else

```

```

        B = A;
    end
else
    B = A;
end

function B = CellClean(A);% Clean the cells

i = 1;
j = 1;

[a,b] = size(A);
pos = b + 1;

while i <= b
    [a2,b2] = size(A{i});
    if a2 == 0
        pos = i;
    end
    i = i + 1;
end
i = 1;

while j <= b - 1
    if j == pos
        i = i + 1;
    end
    B{j} = A{i};
    i = i + 1;
    j = j + 1;
end

function B = MatClean(Ind,A)

i = 1;

[a,b] = size(Ind);

while i <= b
    B(:,i) = A(:,Ind(i));
    i = i + 1;
end

function B = VecClean(A)

i = 1;
j = 1;

[a,b] = size(A);
pos = b + 1;

while i <= b
    if A(i) == 0
        pos = i;
    end
    i = i + 1;
end

```

```
        end
        i = i + 1;
    end
    i = 1;

    while j <= b
        if j == pos
            i = i + 1;
        end
        if i <= b
            B(j) = A(i);
        end
        i = i + 1;
        j = j + 1;
    end
```

Appendix B: MATLAB Code for Analysing Components of the Test Portfolio Without Error Terms

```
% Final Code - Use Simple Discrete Return With Dividends with  
Statistical Analysis  
% Acknowledgement must be paid to Mr. Randall Paton, who has assisted  
in the writing of the following codes  
% Some components from Ms. Hobbs' code had also been modified for this  
% research report
```

```
function Data = FinStats
```

```
i = 1; % assign initial values to variables  
j = 2;  
k = 1;  
weighttot = 0;
```

```
% Select name of file to process  
[file, path] = uigetfile('*.xls', 'Original data file'); % Select file  
from which the raw data will be read from  
[file2, path2] = uigetfile('*.xls', 'Output data file'); % Select file to  
which the results will be written to
```

```
% Setup communication with Excel  
DDE_Total = xlsread(strcat(path, '/', file)); % Retrieve data and text  
from a spreadsheet in an Excel workbook, i.e. read from the first  
spreadsheet in the workbook  
[a,b] = size(DDE_Total); % a rows by b columns, b essentially represents  
the number of securities  
ndat = b - 1; % ndat is equal to b securities less one, since the 1  
refers to the date column presented in the worksheet  
ndatt = b;  
DataRows = ones(ndat,1); % Create arrays of all ones, returns an ndat by  
1 matrix of ones  
while i <= ndat % for i is smaller or equal to ndat  
    Name{1,i} = ['Data Set ' num2str(i) ' Abbreviation']; % convert  
numbers to string  
    i = i + 1; % incrementing  
end  
i = 1; % reinitialise
```

```
Abbcell = inputdlg(Name, strcat('Please specify the portfolio data  
abbreviations for the data in ', file), DataRows);  
Allsname{1} = 'Composite index abbreviation';  
Allscell = inputdlg(Allsname, 'Composite Index Details', 1);
```

```
% Define the number of data points  
dpts = 1; % initialise  
while dpts <= a-2 % less 2, since one is for the first name row, and  
the other is for the unbiased sample variance  
    dpts = dpts + 1;  
end  
A = cumsum(ones(dpts, 1)); % create an array that counts the sample size
```

```

% Create user-interphase for user involvements
% Define company abbreviations
while i <= ndat
    Data(i).name = Abbcell{i};
    i = i + 1;
end
i = 1;
Data(ndatt).name = Allscell{1};

% Time series data for each of the shares in the portfolio
while i <= ndatt
    Data(i).ddedata = DDE_Total(:,i);% read directly from the selected
file without opening the file
    i = i + 1;
end
i = 1;

% Ensure the total weighting factors add up to 1 for the portfolio
while weighttot ~= 1
    % Enter predetermined weighting factors for each share - for beta
calculation for the portfolio
    % in percentages - should use the weighting created from portfolio
optimisation
    while i <= ndat
        Name3{i,1} = ['Data Set '' Abbcell{i} '' Weighting Factor In
Percentage/ Decimal is ' file];
        i = i + 1;
    end
    i = 1;
    Weightcell = inputdlg(Name3, strcat('Please specify the weighting
factor in', file), DataRows);

    %Define the weighting factors for beta calculations - these are the
%individual percentages hold of each securities in the portfolio
    while i <= ndat
        Data(i).weightfactor = str2num(Weightcell{i}); % Convert
strings into numbers
        weighttot = weighttot + Data(i).weightfactor;
        i = i + 1;
    end
    i = 1;
    if weighttot ~= 1
        warnh = warndlg('The specified weightings do not add up to 1.
Please re-enter the desired weightings','Improper Weightings');
        weighttot = 0;
        waitfor(warnh);% Waiting for condition before execution
    end
end
i = 1;

% Enter the annual dividend received per share in cents
while i <= ndat
    Name4{i,1} = ['Data Set'' Abbcell{i} '' Dividend Received Per
Share In Cents over test period', file];
    i = i + 1;
end

```

```

i = 1;
DivCell = inputdlg(Name4, strcat('Please enter dividends per share over
the test period', file), DataRows);

% Take into accounts of the dividend paid per share in cents for each
of
% the securities
while i <= ndat
    Data(i).dividend = str2num(DivCell{i});
    i = i + 1;
end
i = 1;

% Calculation of returns - capital gain returns with dividends, returns
being expressed in decimals - the returns values
% are rather small since it is calculated per share
while i <= ndatt
    data = Data(i).ddedata;
    b = length(data);
    if isempty(Data(i).dividend)== 1 % testing array to see if it is
empty
        div(i) = 0;
    else
        div(i) = Data(i).dividend./length(data);% get dividends into
daily form, thus it is assumed that it will be considered on a daily
base
    end
    Data(i).returns = ((data(2:b)-data(1)+div(i))./data(1)).*100;%
equation used here is the holding period yield (HPY), how it differs
daily
    i = i + 1;
end
i = 1;

% Calculation of arithmetic averages, this is consistent with the
pertaining returns
% calculation, since it was assumed to be discrete simple compounding
returns,
% instead of continuous compounding
while i <= ndatt
    returns = Data(i).returns;
    b = length(returns);% define length for returns vector
    averages(1) = returns(1);
    averagesi(1) = averages(1);
    while j <= b
        averagesi(j) = returns(j) + averagesi(j - 1);
        averages(j) = averagesi(j)./j;
        j = j + 1;
    end
    j = 2;
    Data(i).averages = averages';% transpose into column vector
    i = i + 1;
end
i = 1;

```

```

% Calculation of variances i.e. sample variances, they are unbiased,
hence
% the denominator is the number of data points, j, less 1
while i <= ndatt
    returns = Data(i).returns;
    averages = Data(i).averages;
    vard(1) = ((returns(1) - averages(1)).^2);
    var(1) = vard(1);
    while j <= b % use of column vector calculations
        vard(j) = ((returns(j) - averages(j)).^2) + vard(j - 1); % gives
cumulative results
        var(j) = vard(j)./A(j, :);
        j = j + 1;
    end
    j = 2;
    Data(i).var = var';
    i = i + 1;
end
i = 1;

% Standard Deviations
while i <= ndatt
    Data(i).stddev = sqrt(Data(i).var);
    i = i + 1;
end
i = 1;

% Covariances
while i <= ndatt
    returns = Data(i).returns;
    averages = Data(i).averages;
    b = length(returns);
    while k <= ndatt
        if k ~= i % for k is not equal to i
            ret = Data(k).returns;
            aves = Data(k).averages;
            reti = ret(2:end); % end indicate the last index of array
            avesi = aves(2:end);
            returns = MakeCol(returns); % make returns vector into its
column vector, if it is not already in the column form
            averages = MakeCol(averages);
            ret = MakeCol(ret);
            aves = MakeCol(aves);
            covarii = (returns - averages).*(ret - aves);
            covari(1) = covarii(1);
            while j <= b
                covari(j) = covarii(j)./A(j, :);
                j = j + 1;
            end
            j = 2;
            Names{k} = Data(k).name;
            Index(k) = k;
            CoVars(:,k) = covari;
        end
        k = k + 1;
    end
end

```

```

    Indtake = VecClean(Index);
    Data(i).covarnames = CellClean(Names);
    Data(i).covars = MatClean(Indtake, CoVars);
    Data(i).CoVarInd = Indtake;
    k = 1;
    i = i + 1;
    clear Names Index CoVars % free up the system memory
end
i = 1;

% Correlation coefficients calculations
while i <= ndatt
    indices = Data(i).CoVarInd;
    CoVars = Data(i).covars;
    stddev = Data(i).stddev;
    b = length(stddev);
    while k <= ndat
        covari = CoVars(:,k);
        stddevi = Data(indices(k)).stddev;
        rho(1) = 0;
        while j <= b
            rho(j) = covari(j)./(stddev(j).*stddevi(j));
            j = j + 1;
        end
        Rhos(:,k) = rho;
        j = 2;
        k = k + 1;
    end
    k = 1;
    Data(i).rhos = Rhos;
    i = i + 1;
end
i = 1;

% Coefficient of Variation, this is a measure of risk/ volatility
while i <= ndat
    Data(i).cv = sqrt(Data(i).var)./Data(i).averages;
    i = i + 1;
end
i = 1;

% Calculations of betas - ordinary least squares method (ols)
while i <= ndat
    covars = Data(i).covars;
    covari = covars(:,ndat);
    if Data(ndatt).var ~= 0
        Data(ndatt).var = Data(ndatt).var;
    else if Data(ndatt).var == 0
        Data(i).beta = 0;
    end
    end
    Data(i).beta = covari./Data(ndatt).var;% Equation of beta
    calculation
    i = i + 1;
end
i = 1;

```

```

% Calculations of alphas - ordinary least squares method (ols)
while i <= ndat
    Data(i).averages = MakeCol(Data(i).averages);
    Data(i).beta= MakeCol(Data(i).beta);
    Data(ndatt).averages = MakeCol(Data(ndatt).averages);
    Data(i).alpha = Data(i).averages -
    ((Data(i).beta).*(Data(ndatt).averages));
    i = i + 1;
end
i = 1;

% Beta Adjustments
% Merrill Lynch (ml)
while i <= ndat
    Data(i).betaml = 2.*Data(i).beta./3 + 1/3;
    i = i + 1;
end
i = 1;

% Vasciek's technique: Bayesian's Adjustment (ba)
% Calculations on averages of betas
b = length(Data(i).beta);
Porto = zeros(b,1);% Returns an b, where b is the length of
Data(i).beta, by 1 matrix of zeros, i.e. a column vector
while i <= ndat
    beta = Data(i).beta; % Define the length
    betasum(1) = 0; % Assign initial values
    betasumi(1) = 0;
    while j <= b
        betasumi(j) = beta(j) + betasumi(j - 1);% cumulative averages
    of beta
        betasum(j) = betasumi(j)./A(j, :);
        j = j + 1;
    end
    j = 2;
    Data(i).avebeta = betasum';
    Porto = Porto + betasum'; % Ensure the addition is between two
column vectors, i.e. of the same dimension
    i = i + 1;
end
i = 1;
avebetaporto = Porto./ndat;% presume equal-weighted betas for the
securities in the portfolio
while i <= ndat
    Data(i).avebetaporto = avebetaporto;
    i = i + 1;
end
i = 1;

% Variances of individual betas i.e. sample unbiased variances
while i <= ndat
    beta = Data(i).beta;
    avebeta = Data(i).avebeta;
    varbetai(1) = 0;
    varbeta(1) = 0;

```

```

        while j <= b
            varbetai(j) = (beta(j) - avebeta(j)).^2 + varbetai(j - 1);
            varbeta(j) = varbetai(j)./A(j, :);
            j = j + 1;
        end
        Data(i).varbeta = varbeta';
        j = 2;
        i = i + 1;
    end
    i = 1;

% Cross - sectional variance of all the estimates of beta in portfolio,
% i.e. the average used for calculation is the average of ALL betas of
% individual shares in the portfolio at a particular time
varbetaporto = zeros(b,1);
while i <= ndat
    varbetaporto = varbetaporto + ((Data(i).beta -
Data(i).avebetaporto).^2);
    i = i + 1;
end
i = 1;
while i <= ndat
    Data(i).varbetaporto = varbetaporto./A(j, :);
    i = i + 1;
end
i = 1;

%Calculate weight factors for Bayesian adjustments
while i <= ndat
    Data(i).weight = Data(i).varbetaporto./(Data(i).varbetaporto +
Data(i).varbeta);
    i = i + 1;
end
i = 1;

% Calculation of Bayesian adjustments
while i <= ndat
    Data(i).betaba = (Data(i).weight).*(Data(i).beta) + (1 -
Data(i).weight).*(Data(i).avebetaporto);
    i = i + 1;
end
i = 1;

% Alpha calculations for adjustments
% Merrill Lynch (ml)
while i <= ndat
    Data(i).alphaml = Data(i).averages -
((Data(i).betaml).*(Data(ndatt).averages));
    i = i + 1;
end
i = 1;
% Vasciek's technique: Bayesian's Adjustment (ba)
while i <= ndat
    Data(i).alphaba = Data(i).averages -
((Data(i).betaba).*(Data(ndatt).averages));
    i = i + 1;
end

```

```

end
i = 1;

% Portfolio Betas
betaportools = zeros(b,1);
betaportoml = zeros(b,1);
betaportoba = zeros(b,1);
while i <= ndat
    betaportools = betaportools + Data(i).beta;
    betaportoml = betaportoml + Data(i).betaml;
    betaportoba = betaportoba + Data(i).betaba;
    i = i + 1;
end
i = 1;
while i <= ndat
    weightfactor = Data(i).weightfactor;
    betaportoolswithweights = betaportools.*weightfactor;
    betaportomlwithweights = betaportoml.*weightfactor;
    betaportobawithweights = betaportoba.*weightfactor;
    i = i + 1;
end;
i = 1;
betaportools = betaportoolswithweights;
betaportoml = betaportomlwithweights;
betaportoba = betaportobawithweights;

while i <= ndat
    Data(i).betaportools = betaportools;
    Data(i).betaportoml = betaportoml;
    Data(i).betaportoba = betaportoba;
    i = i + 1;
end
i = 1;

% Portfolio Alphas
averagesporto = zeros(b,1);
while i <= ndat
    averagesporto = averagesporto + Data(i).averages;
    i = i + 1;
end
i = 1;
while i <= ndat
    Data(i).averagesporto = averagesporto./A(j, :);
    i = i + 1;
end
i = 1;

while i <= ndat
    Data(i).alphaportools = Data(i).averagesporto -
    (Data(i).betaportools).*(Data(ndatt).averages);
    Data(i).alphaportoml = Data(i).averagesporto -
    (Data(i).betaportoml).*(Data(ndatt).averages);
    Data(i).alphaportoba = Data(i).averagesporto -
    (Data(i).betaportoba).*(Data(ndatt).averages);
    i = i + 1;
end

```

```

i = 1;

while i <= ndat
    Data(i).alphaporttoolsmod = Data(i).alphaporttools./100;
    Data(i).alphaportomlmod = Data(i).alphaportoml./100;
    Data(i).alphaportobamod = Data(i).alphaportoba./100;
    i = i + 1;
end
i = 1;

% Expected portfolio returns
while i <= ndat
    Data(i).returnsportools = Data(i).alphaporttools +
(Data(i).betaportools).*(Data(ndatt).returns);
    Data(i).returnsportoml = Data(i).alphaportoml +
(Data(i).betaportoml).*(Data(ndatt).returns);
    Data(i).returnsportoba = Data(i).alphaportoba +
(Data(i).betaportoba).*(Data(ndatt).returns);
    i = i + 1;
end
i = 1;

% Statistical Analysis

% Confidence interval is a range of values around the expected outcome
% within which we expect the actual outcome to be some specified
percentage
% of the time. A 95 percent confidence interval is a range that we
expect
% the random variable to be in 95% of the time. For a normal
distribution,
% this interval is based on the expected value (sometimes called a
point
% estimate) of the random variable and on its variability, which we
measure
% with standard deviation - Determine the range in which the outcome
would
% lie using different level of confidence

% Before confidence interval for portfolio returns can be calculated,
its
% averages and variances need to be established in order for the
% calculation on its standard deviation

% Calculation of Portfolio Averages
while i <= ndat
    returnsportools = Data(i).returnsportools;
    returnsportoml = Data(i).returnsportoml;
    returnsportoba = Data(i).returnsportoba;
    b = length(returnsportools);
    while j <= b
        B = cumsum(returnsportools(2:j)./A(j));
        C = cumsum(returnsportoml(2:j)./A(j));
        D = cumsum(returnsportoba(2:j)./A(j));
        averetportoolssum(j) = B(j - 1);
        averetportomlsum(j) = C(j - 1);
    end
end

```

```

        averetportobasum(j) = D(j - 1);
        j = j + 1;
    end
    j = 2;
    Data(i).averetportools = averetportoolssum';
    Data(i).averetportoml = averetportomlsum';
    Data(i).averetportoba = averetportobasum';
    i = i + 1;
end
i = 1;

% Calculation of Portfolio Variances
while i <= ndat
    Data(i).varportools = ((Data(i).returnsportools -
Data(i).averetportools).^2)./A(j);
    Data(i).varportoml = ((Data(i).returnsportoml -
Data(i).averetportoml).^2)./A(j);
    Data(i).varportoba = ((Data(i).returnsportoba -
Data(i).averetportoba).^2)./A(j);
    i = i + 1;
end
i = 1;

% Calculation of Portfolio Standard Deviations
while i <= ndat
    Data(i).stddevportools = sqrt(Data(i).varportools);
    Data(i).stddevportoml = sqrt(Data(i).varportoml);
    Data(i).stddevportoba = sqrt(Data(i).varportoba);
    i = i + 1;
end
i = 1;

% 90% Percent Confidence Interval for point estimates on portfolio
returns
while i <= ndat
    % Ordinary Least Squares
    Data(i).returnsols_upper90 = Data(i).averetportools +
1.65*Data(i).stddevportools;
    Data(i).returnsols_lower90 = Data(i).averetportools -
1.65*Data(i).stddevportools;
    % Merrill Lynch
    Data(i).returnsml_upper90 = Data(i).averetportoml +
1.65*Data(i).stddevportoml;
    Data(i).returnsml_lower90 = Data(i).averetportoml -
1.65*Data(i).stddevportoml;
    % Bayesian Adjustments
    Data(i).returnsba_upper90 = Data(i).averetportoba +
1.65*Data(i).stddevportoba;
    Data(i).returnsba_lower90 = Data(i).averetportoba -
1.65*Data(i).stddevportoba;
    i = i + 1;
end
i = 1;

% 95% Percent Confidence Interval for point estimates on portfolio
returns

```

```

while i <= ndat
    % Ordinary Least Squares
    Data(i).returnsols_upper95 = Data(i).averetportools +
1.96*Data(i).stddevportools;
    Data(i).returnsols_lower95 = Data(i).averetportools -
1.96*Data(i).stddevportools;
    % Merrill Lynch
    Data(i).returnsml_upper95 = Data(i).averetportoml +
1.96*Data(i).stddevportoml;
    Data(i).returnsml_lower95 = Data(i).averetportoml -
1.96*Data(i).stddevportoml;
    % Bayesian Adjustments
    Data(i).returnsba_upper95 = Data(i).averetportoba +
1.96*Data(i).stddevportoba;
    Data(i).returnsba_lower95 = Data(i).averetportoba -
1.96*Data(i).stddevportoba;
    i = i + 1;
end
i = 1;

% 99% Percent Confidence Interval for point estimates on portfolio
returns
while i <= ndat
    % Ordinary Least Squares
    Data(i).returnsols_upper99 = Data(i).averetportools +
2.58*Data(i).stddevportools;
    Data(i).returnsols_lower99 = Data(i).averetportools -
2.58*Data(i).stddevportools;
    % Merrill Lynch
    Data(i).returnsml_upper99 = Data(i).averetportoml +
2.58*Data(i).stddevportoml;
    Data(i).returnsml_lower99 = Data(i).averetportoml -
2.58*Data(i).stddevportoml;
    % Bayesian Adjustments
    Data(i).returnsba_upper99 = Data(i).averetportoba +
2.58*Data(i).stddevportoba;
    Data(i).returnsba_lower99 = Data(i).averetportoba -
2.58*Data(i).stddevportoba;
    i = i + 1;
end
i = 1;

% Plotting the statistical results
% Plotting 90% Confidence interval results
% Ordinary Least Square
fid1 = figure(1);
subplot(2,2,1);
plot(Data(1).returnsols_upper90', 'b'), grid
hold on
plot(Data(1).returnsols_lower90', 'g'), grid
hold on
plot(Data(1).returnsportools', 'r'), grid
hold off
title('Expected Returns Over Time - OLS [90% Confidence]')
xlabel('t = 0 to 360')

```

```

ylabel('Expected Returns in %')
% Merrill Lynch
subplot(2,2,2);
plot(Data(1).returnsml_upper90', 'b'), grid
hold on
plot(Data(1).returnsml_lower90', 'g'), grid
hold on
plot(Data(1).returnsportoml', 'r'), grid
hold off
title('Expected Returns Over Time - ML [90% Confidence]')
xlabel('t = 0 to 360')
ylabel('Expected Returns in %')
% Bayesian Adjustments
subplot(2,2,3);
plot(Data(1).returnsba_upper90', 'b'), grid
hold on
plot(Data(1).returnsba_lower90', 'g'), grid
hold on
plot(Data(1).returnsportoba', 'r'), grid
hold off
title('Expected Returns Over Time - BA [90% Confidence]')
xlabel('t = 0 to 360')
ylabel('Expected Returns in %')
legend('Upper Bound', 'Lower Bound', 'Expected Return');

% Plotting 95% Confidence interval results
% Ordinary Least Square
fid2 = figure(2);
subplot(2,2,1);
plot(Data(1).returnsols_upper95', 'b'), grid
hold on
plot(Data(1).returnsols_lower95', 'g'), grid
hold on
plot(Data(1).returnsportools', 'r'), grid
hold off
title('Expected Returns Over Time - OLS [95% Confidence]')
xlabel('t = 0 to 360')
ylabel('Expected Returns in %')
% Merrill Lynch
subplot(2,2,2);
plot(Data(1).returnsml_upper95', 'b'), grid
hold on
plot(Data(1).returnsml_lower95', 'g'), grid
hold on
plot(Data(1).returnsportoml', 'r'), grid
hold off
title('Expected Returns Over Time - ML [95% Confidence]')
xlabel('t = 0 to 360')
ylabel('Expected Returns in %')
% Bayesian Adjustments
subplot(2,2,3);
plot(Data(1).returnsba_upper95', 'b'), grid
hold on
plot(Data(1).returnsba_lower95', 'g'), grid
hold on
plot(Data(1).returnsportoba', 'r'), grid
hold off

```

```

title('Expected Returns Over Time - BA [95% Confidence]')
xlabel('t = 0 to 360')
ylabel('Expected Returns in %')
legend('Upper Bound', 'Lower Bound', 'Expected Return');

% Plotting 99% Confidence interval results
% Ordinary Least Square
fid3 = figure(3);
subplot(2,2,1);
plot(Data(1).returnsols_upper99', 'b'), grid
hold on
plot(Data(1).returnsols_lower99', 'g'), grid
hold on
plot(Data(1).returnsportools', 'r'), grid
hold off
title('Expected Returns Over Time - OLS [99% Confidence]')
xlabel('t = 0 to 360')
ylabel('Expected Returns in %')
% Merrill Lynch
subplot(2,2,2);
plot(Data(1).returnsml_upper99', 'b'), grid
hold on
plot(Data(1).returnsml_lower99', 'g'), grid
hold on
plot(Data(1).returnsportoml', 'r'), grid
hold off
title('Expected Returns Over Time - ML [99% Confidence]')
xlabel('t = 0 to 360')
ylabel('Expected Returns in %')
% Bayesian Adjustments
subplot(2,2,3);
plot(Data(1).returnsba_upper99', 'b'), grid
hold on
plot(Data(1).returnsba_lower99', 'g'), grid
hold on
plot(Data(1).returnsportoba', 'r'), grid
hold off
title('Expected Returns Over Time - BA [99% Confidence]')
xlabel('t = 0 to 360')
ylabel('Expected Returns in %')
legend('Upper Bound', 'Lower Bound', 'Expected Return');

% Define the portfolio results
Data_Outbeta(:,1) = Data(1).betaportools;
Data_Outbeta(:,2) = Data(1).betaportoml;
Data_Outbeta(:,3) = Data(1).betaportoba;
Data_Outalpha(:,4) = Data(1).alphaportoolsmod;
Data_Outalpha(:,5) = Data(1).alphaportomlmod;
Data_Outalpha(:,6) = Data(1).alphaportobamod;
Data_Outreturn(:,7) = Data(1).returnsportools;
Data_Outreturn(:,8) = Data(1).returnsportoml;
Data_Outreturn(:,9) = Data(1).returnsportoba;

% Export the results into Excel spreadsheet without opening up the
% worksheet
xlswrite(strcat(path2, '/', file2),Data_Outbeta,'Beta', 'A2');

```

```

xlswrite(strcat(path2, '/', file2),Data_Outalpha, 'Alpha', 'A2');
xlswrite(strcat(path2, '/', file2),Data_Outreturn, 'Return', 'A2');

```

```

function B = MakeCol(A)% Make the data set a column vector if it's not

```

```

[a,b] = size(A);

```

```

if a == 1
    if b > 1
        B = A';
    else
        B = A;
    end
else
    B = A;
end

```

```

function B = CellClean(A);% Clean the cells

```

```

i = 1;
j = 1;

[a,b] = size(A);
pos = b + 1;

while i <= b
    [a2,b2] = size(A{i});
    if a2 == 0
        pos = i;
    end
    i = i + 1;
end
i = 1;

while j <= b - 1
    if j == pos
        i = i + 1;
    end
    B{j} = A{i};
    i = i + 1;
    j = j + 1;
end

```

```

function B = MatClean(Ind,A)

```

```

i = 1;

[a,b] = size(Ind);

while i <= b
    B(:,i) = A(:,Ind(i));
    i = i + 1;
end

```

```
function B = VecClean(A)
```

```
i = 1;  
j = 1;
```

```
[a,b] = size(A);  
pos = b + 1;
```

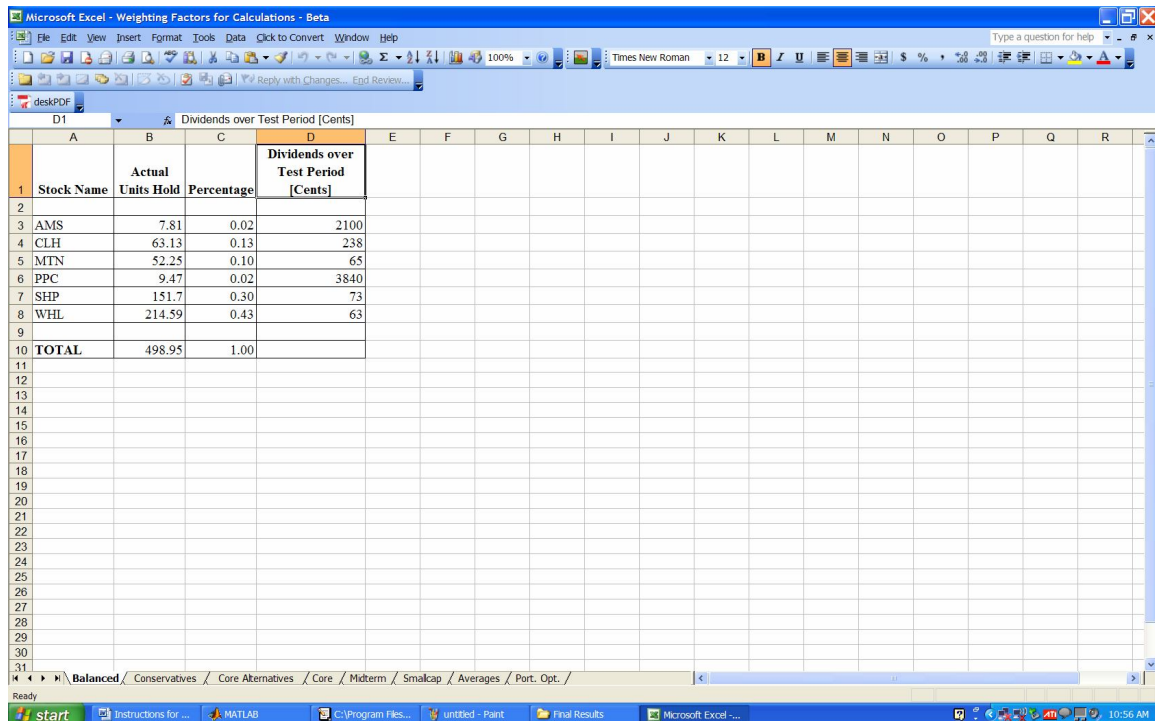
```
while i <= b  
    if A(i) == 0  
        pos = i;  
    end  
    i = i + 1;  
end  
i = 1;
```

```
while j <= b  
    if j == pos  
        i = i + 1;  
    end  
    if i <= b  
        B(j) = A(i);  
    end  
    i = i + 1;  
    j = j + 1;  
end
```

Appendix C: Instructions for Running MATLAB Codes

It is important to note that MATLAB is needed to be installed on the computer, prior to the running of the codes. **Also, It is extremely important to enter the asked information, as it appears in the excel workbook ‘Weighting Factors for Calculations – Beta’, in the correct order. Otherwise the results will be altered.**

- 1) Put the CD, that accompanied this report, into the CD- RAM.
- 2) Run the CD and view the files that are on the CD. This is done by firstly, double click on ‘My Computer’ icon on the desktop. Secondly double click on ‘CD-RAM’. The files on the CD are now visible.
- 3) Select MATLAB Codes and Final Results folders. Copy and Paste these onto the desktop. In MATLAB Codes folder, there are two sets of codes present, one set to include error terms and the other exclude the errors. In Final Results folder, there are two folders present namely, ‘FINAL PORTFOLIO Exclude Error Terms’ and ‘FINAL PORTFOLIO Include Error Terms’. Also present is an excel workbook named, ‘Weighting Factors for Calculations – Beta’.
- 4) Double click on the workbook, ‘Weighting Factors for Calculations – Beta’. The following screen should appear:



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
	Stock Name	Actual Units Hold	Percentage	Dividends over Test Period [Cents]														
1																		
2																		
3	AMS	7.81	0.02	2100														
4	CLH	63.13	0.13	238														
5	MTN	52.25	0.10	65														
6	PPC	9.47	0.02	3840														
7	SHP	151.7	0.30	73														
8	WHL	214.59	0.43	63														
9																		
10	TOTAL	498.95	1.00															
11																		
12																		
13																		
14																		
15																		
16																		
17																		
18																		
19																		
20																		
21																		
22																		
23																		
24																		
25																		
26																		
27																		
28																		
29																		
30																		
31																		

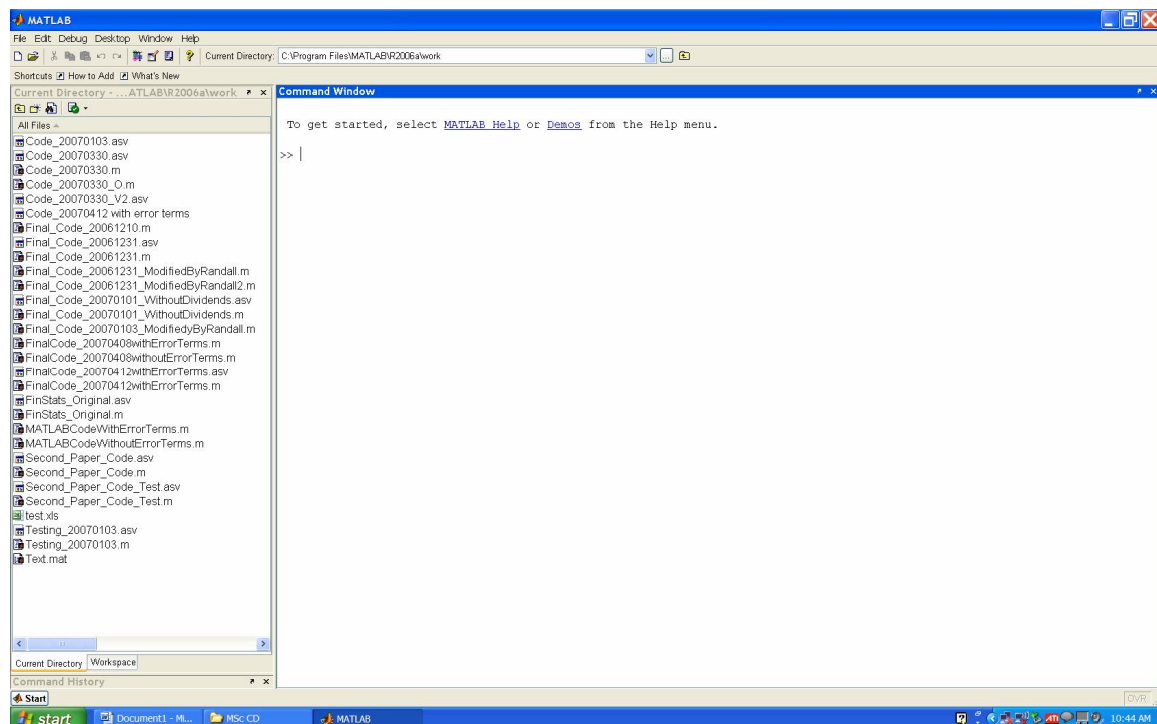
In the workbook, there are eight worksheets present. The first six worksheets are associated with the corresponding component in the overall test portfolio. These

are namely 'Balanced', 'Conservatives', 'Core Alternatives', 'Core', 'Midterm' and 'Smallcap'. In each of these worksheets, the following information are found:

- i. Stock names that are the constituents of each subportfolio.
- ii. Percentage. This refers to the weighting factors that are used for beta calculation in the MATLAB Code.
- iii. Dividends over Test Period in Cents. These refer to the dividends paid to the investor over the test period.

Keep this workbook open, since the pertinent excel information is needed for running the codes.

- 5) Now, open MATLAB programme. This may be done by either double clicking on the MATLAB shortcut on the desktop, or by clicking just once on 'start', at the bottom left hand corner of the screen, select 'all programs', then click on 'MATLAB'. When MATLAB is opened, the following screen is observed:



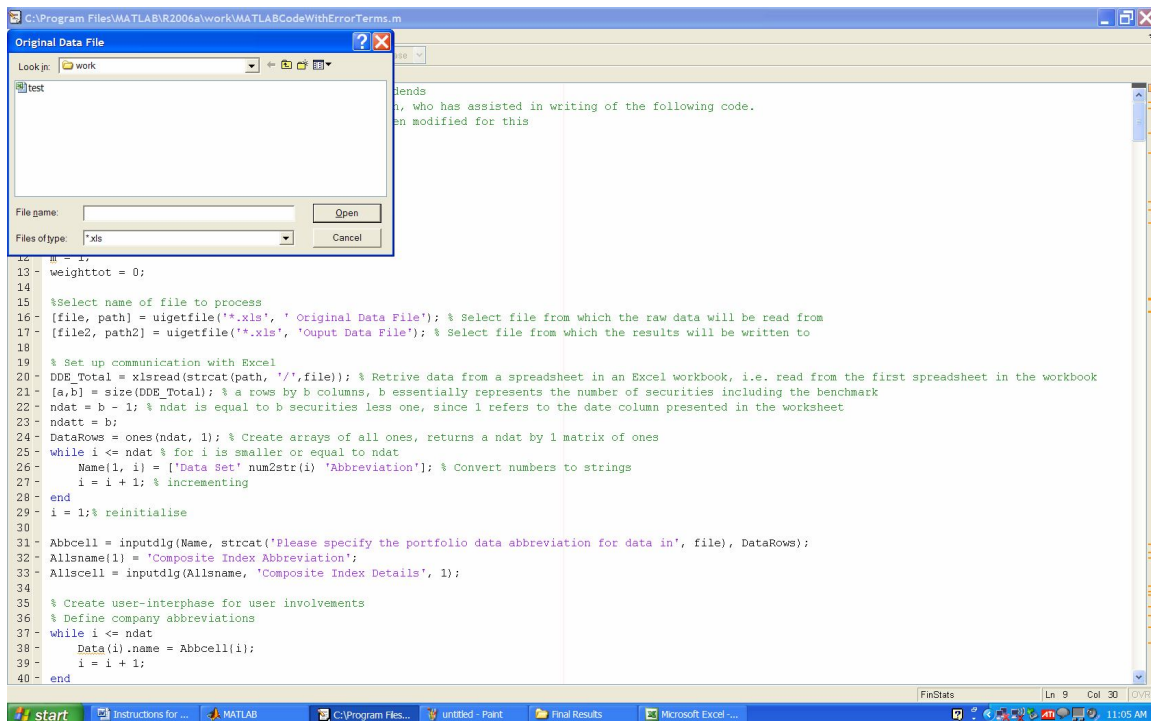
- 6) Copy and paste the two sets of codes found in MATLAB Codes folder into the 'Current Directory' on the left hand side of the above screen.
- 7) Decided on which sets of codes that you want to run first. Then double click on the file. For demonstration purpose, the author has decided to run the codes that include error terms. (The similar method is used for running the other sets.) If the user now double clicks on 'MATLABCodeWithErrorTerm.m'. The following screen should appear:

```

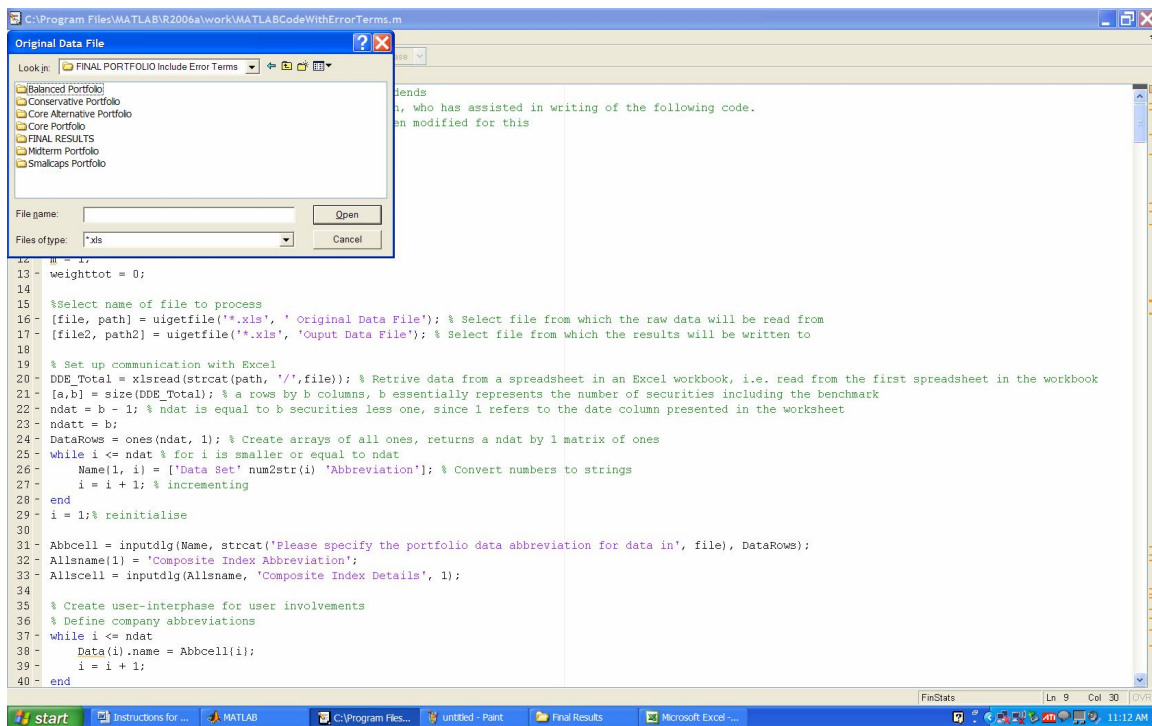
1 % Final Code: Use Simple Discrete Return With Dividends
2 % Acknowledgement must be paid to Mr. Randall Paton, who has assisted in writing of the following code.
3 % Some components from Ms. Hobbs' code had also been modified for this
4 % research report
5
6 function Data = FinStats
7
8 format long;
9 i = 1; % initialise variables
10 j = 2;
11 k = 1;
12 m = 1;
13 weighttot = 0;
14
15 %Select name of file to process
16 [file, path] = uigetfile('*.xls', ' Original Data File'); % Select file from which the raw data will be read from
17 [file2, path2] = uigetfile('*.xls', 'Output Data File'); % Select file from which the results will be written to
18
19 % Set up communication with Excel
20 DDE_Total = xlsread(strcat(path, '/', file)); % Retrive data from a spreadsheet in an Excel workbook, i.e. read from the first spreadsheet in the workbook
21 [a,b] = size(DDE_Total); % a rows by b columns, b essentially represents the number of securities including the benchmark
22 ndat = b - 1; % ndat is equal to b securities less one, since 1 refers to the date column presented in the worksheet
23 ndatt = b;
24 DataRows = ones(ndat, 1); % Create arrays of all ones, returns a ndat by 1 matrix of ones
25 while i <= ndat % for i is smaller or equal to ndat
26     Name(1, i) = ['Data Set' num2str(i) 'Abbreviation']; % Convert numbers to strings
27     i = i + 1; % incrementing
28 end
29 i = 1; % reinitialise
30
31 Abbcell = inputdlg(Name, strcat('Please specify the portfolio data abbreviation for data in', file), DataRows);
32 Allsname(1) = 'Composite Index Abbreviation';
33 Allscell = inputdlg(Allsname, 'Composite Index Details', 1);
34
35 % Create user-interphase for user involvements
36 % Define company abbreviations
37 while i <= ndat
38     Data(i).name = Abbcell(i);
39     i = i + 1;
40 end

```

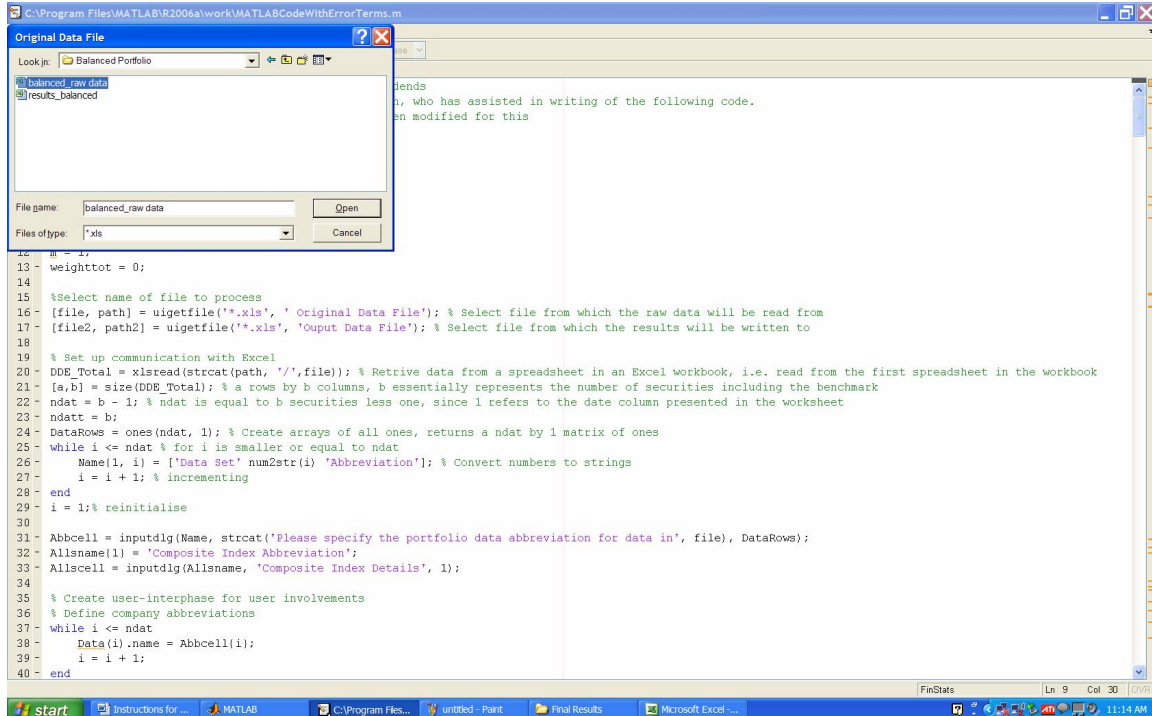
- 8) Once the above screen has appeared, the user is now ready to run the codes. The codes may be run by either pressing 'F5' or pressing the 'run icon', as it appears so:  on the top toolbar.
- 9) By pressing 'F5' or pressing run icon. The following screen appears:



The window that appears on the left hand side of the above screen reads ‘Original Data File’. This refers to the raw data associated with each of the components in the test portfolio. For demonstration purpose, the author has decided to run ‘Balanced’ component. It is important to find the ‘Balanced’ component on the desktop. Go to ‘Look In’ on top of the window, go to desktop, and double click on ‘Final Results’ folder, then double click on ‘FINAL PORTFOLIO Include Error Terms’ The following screen appears:

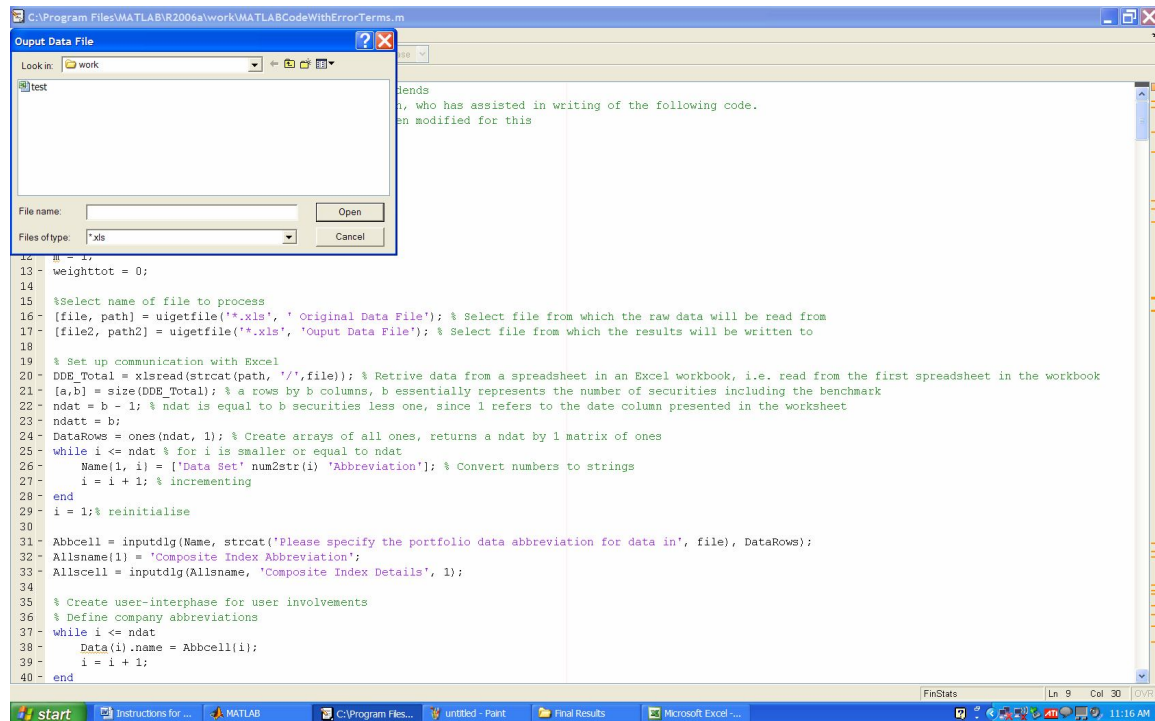


Double click on 'Balanced Portfolio' folder. There are two excel workbook present, one refers to as the raw data and the other results. This is shown below:



Select the excel workbook named, 'balanced_raw data', since this is associated with 'Original Data File'.

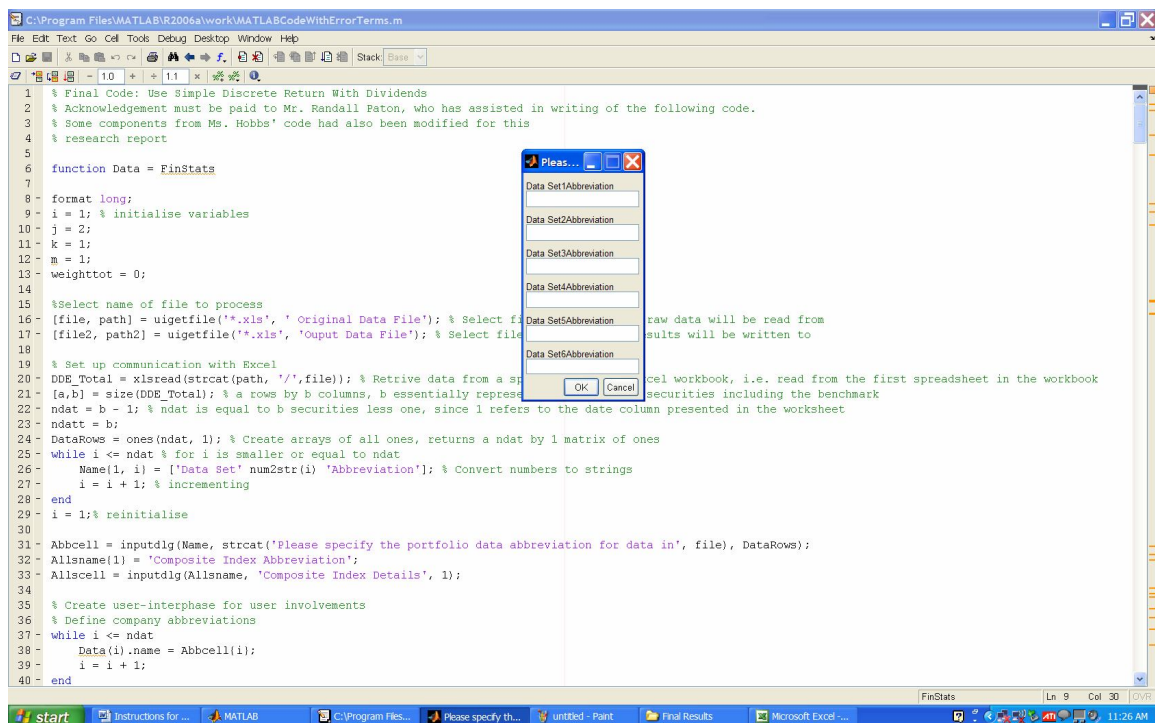
10) Once Step (9) is done. The following screen appears:



This time, the window that appears on the left hand side of the above screen reads 'Output Data File'. This refers to the file, to which the results from MATLAB, are to be written to. It is important to select the results' workbook which corresponds to the above component, in this case, 'Balanced'.

11) Go to 'Look In' on top of the window, go to desktop, and double click on 'Final Results' folder, then double click on 'FINAL PORTFOLIO Include Error Terms'. A similar screen to the one under step (9) appears. Double click on 'Balanced Portfolio' folder. There are two excel workbooks present, select the excel workbook named, 'results_balanced', since this is associated with 'Output Data File'.

12) Wait, while MATLAB processes the code, then the following screen appears:



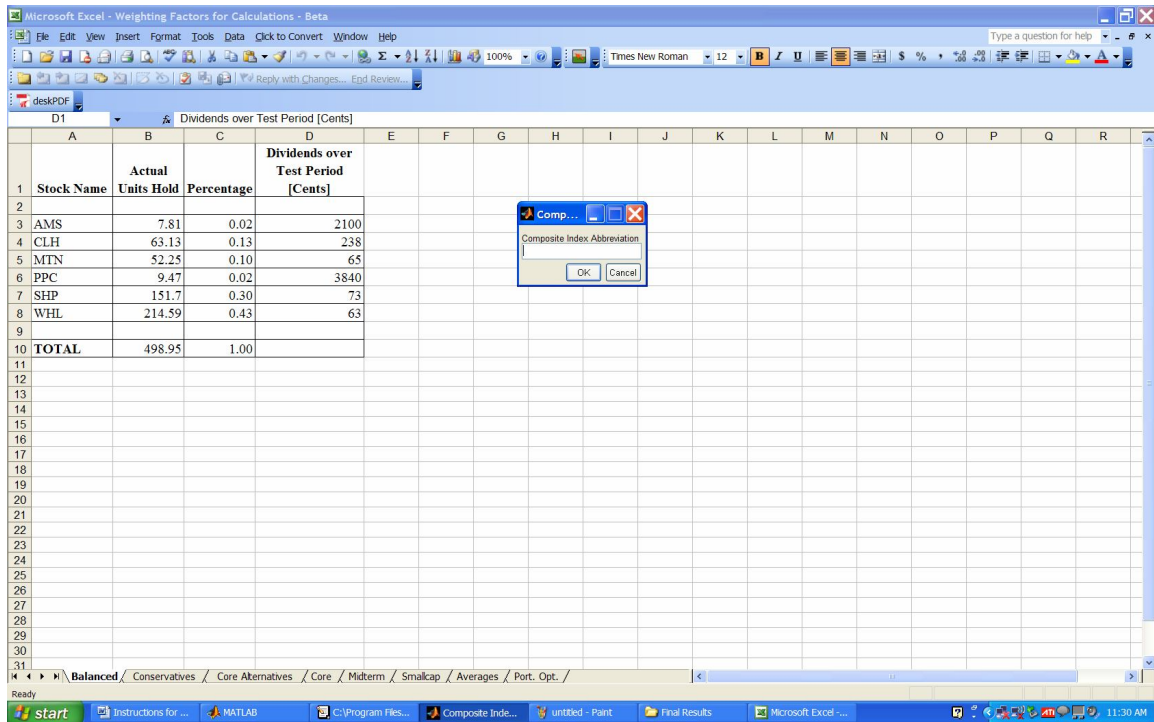
There are 6 shares present in 'Balanced', therefore there are 6 abbreviations that need to be entered. These abbreviations are found under 'Stock names' as described in step (4i). Data set 1 refers to the first stock, as it appears in (4i), in the subportfolio. Once the required information are entered, it looks as below:

The image shows a Microsoft Excel spreadsheet titled "Weighting Factors for Calculations - Beta". The spreadsheet contains data for six stocks: AMS, CLH, MTN, PPC, SHP, and WHL. A dialog box titled "Please specify the portfolio data abbreviation for data in" is overlaid on the spreadsheet. The dialog box has six input fields for "Data Set 1 Abbreviation" through "Data Set 6 Abbreviation". The spreadsheet data is as follows:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
	Stock Name	Actual Units Hold	Percentage	Dividends over Test Period [Cents]														
1	AMS	7.81	0.02	2100														
2	CLH	63.13	0.13	238														
3	MTN	52.25	0.10	65														
4	PPC	9.47	0.02	3840														
5	SHP	151.7	0.30	73														
6	WHL	214.59	0.43	63														
7	TOTAL	498.95	1.00															

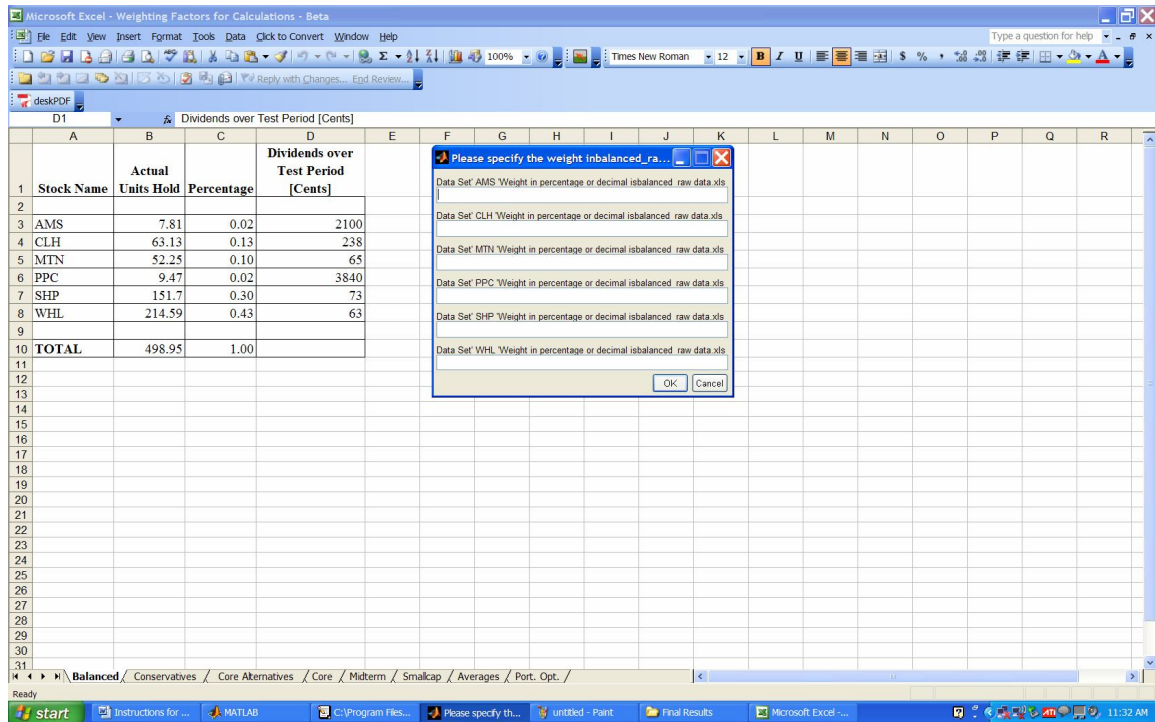
Click on 'OK'.

13) The following screen appears:

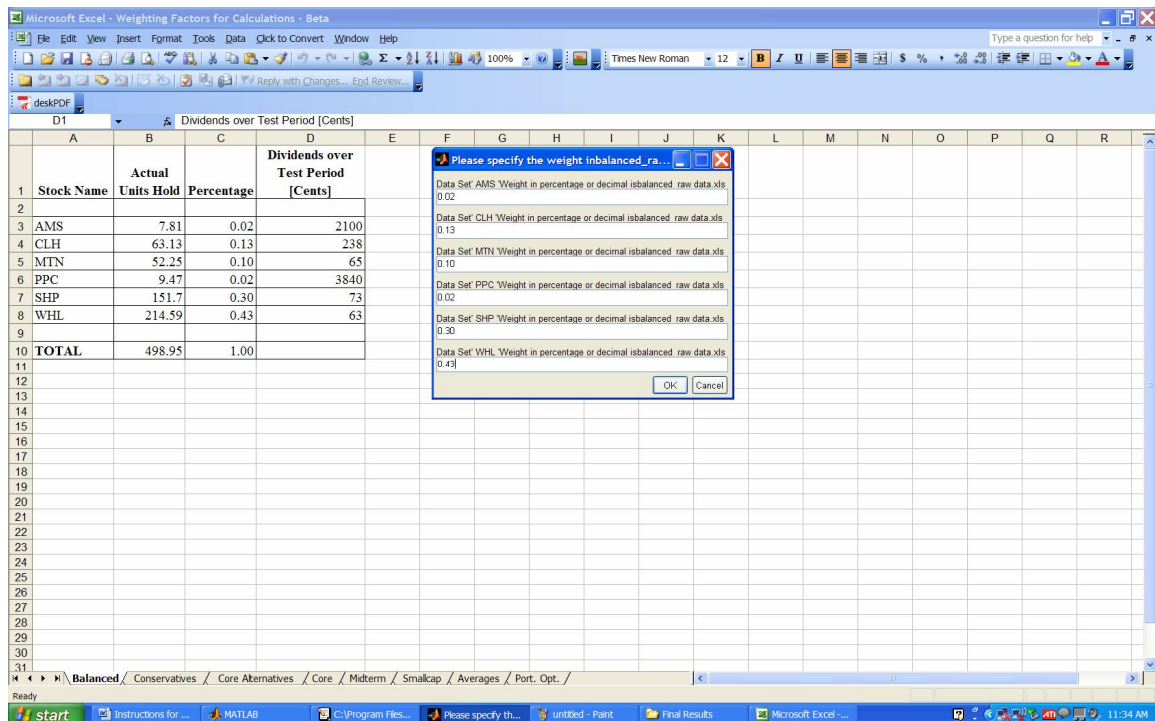


The composite index abbreviation refers to the benchmark chosen in this research. It is the 'ALL SHARE' index. Type 'ALSI' in. Click on 'OK'.

14) Then the following screen appears:

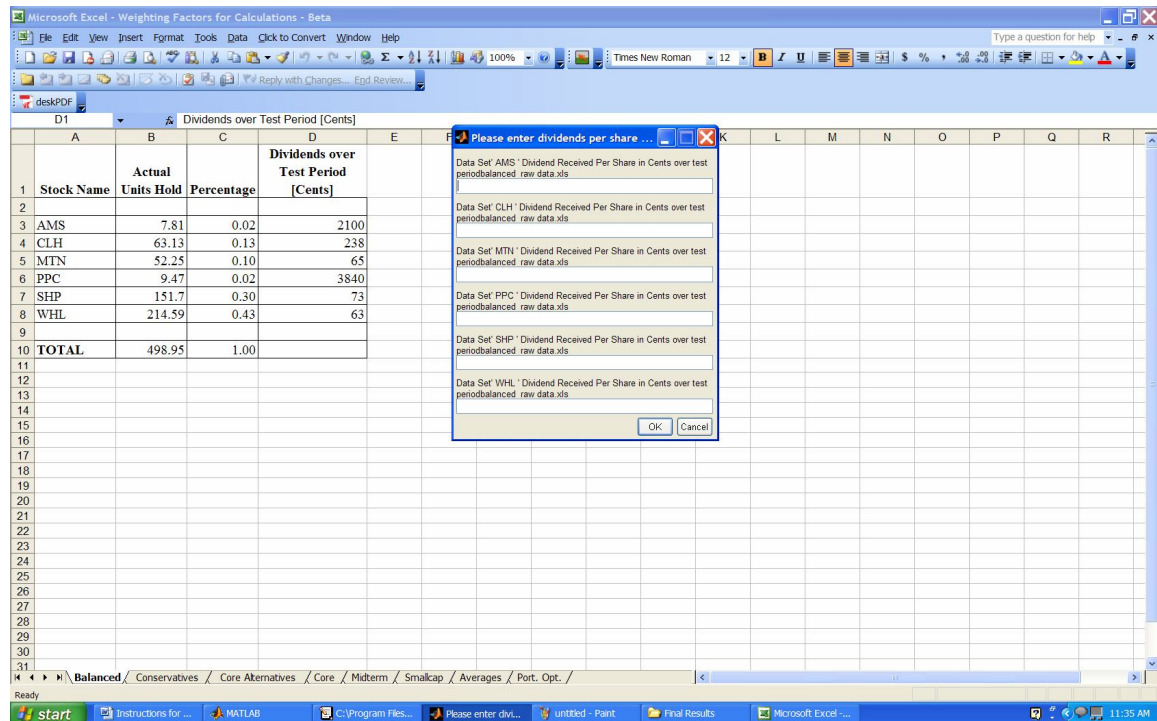


The computer is now asking for the weight factors that are associated with each of the components. These are found in 'Percentage', as described in step (4ii). Enter the weight. The screen will now appear as below:

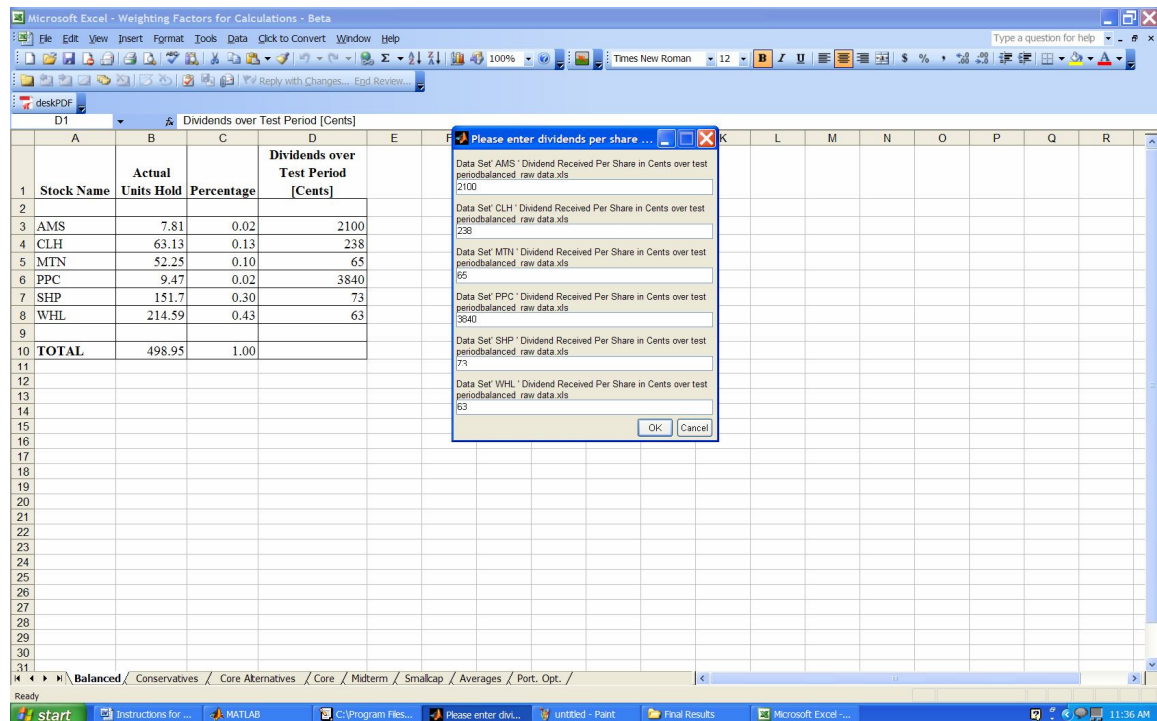


Click on 'OK'.

15) The following screen appears:

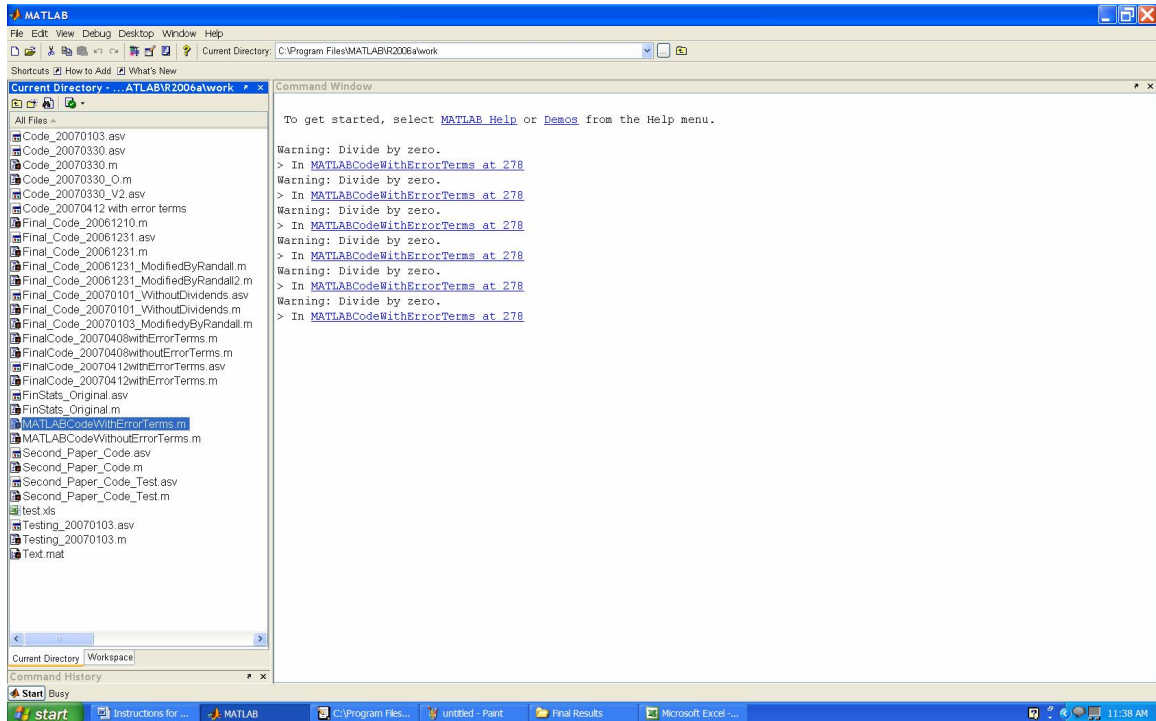


The computer is now requesting for the dividend information associated with the corresponding shares. These information are found under 'Dividends over Test Period' as discussed in step (4iii). Enter the information, the following then appears:

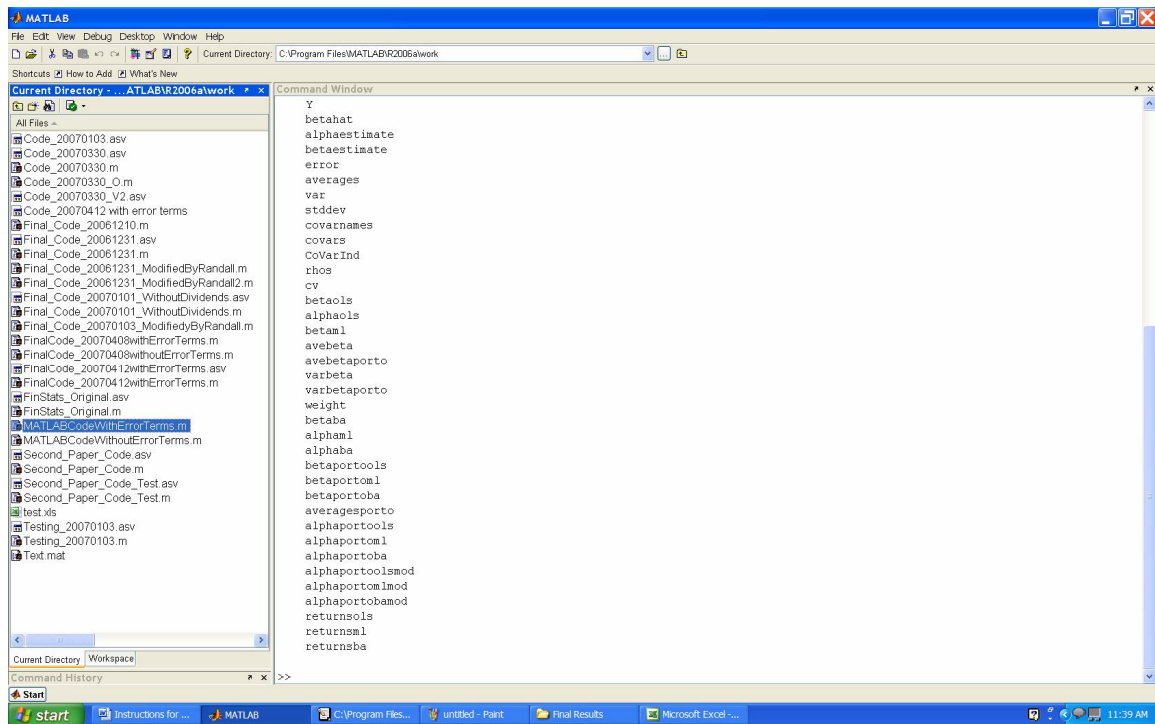


Click on 'OK'.

16) Wait, while MATLAB processes the entered information. Ignore the warning messages in the MATLAB window, shown below:



17) When the processing is complete, the following screen appears:



- 18) Repeat the above mentioned steps for all 6 subportfolios in the overall test portfolio. Remember separate codes are used for the final portfolio folders whether it is to exclude or include the error terms.
- 19) After step (18), one can open the 'FINAL RESULTS' folder. Double click on the workbook present. The graphs present are identical to that of the main body of report.

Appendix D: MATLAB Code for Validating The Computer Programmes

```
% The following codes were used to validate the computer programme
% written. The computer programme were validated in parts. The
% following codes were then modified to give rise to the general
% computer programme as seen in Appendix A and B

% Select the file to which the results will be exported to.
[file, path] = uigetfile('*.xls', 'Output File');

% Let A be refer to as the P1 (Data value/ price of a security)
A = [12, 13, 10, 9, 20, 7, 4, 22, 15, 23]';
% Let B be refer to as the PM (Data value/ price of the market)
B = [50, 54, 48, 47, 70, 20, 15, 40, 35, 37]';
% Define the number of observations
dpts = 1;
b = length(A);
while dpts <= b - 2
    dpts = dpts + 1;
end
C = cumsum(ones(dpts, 1)); % Create an array that counts the sample
size

% Calculate the returns of each of the pertinent time- series (A and
B).
% The returns are being expressed in percentages
returnsofA = ((A(2:end)-A(1))./A(1)).*100;
returnsofB = ((B(2:end)-B(1))./B(1)).*100;

% Calculate the arithmetic averages of A and B
averagesofA = mean(returnsofA);
averagesofB = mean(returnsofB);

% Calculate the variances of A and B
vardofA = ((returnsofA - averagesofA).^2);
vardofB = ((returnsofB - averagesofB).^2);
varianceofA = vardofA./C;
varianceofB = vardofB./C;

% Calculate the covariances of A and B
covarii = (returnsofA - averagesofA).*(returnsofB - averagesofB);
cov = covarii./C;

% Calculation of OLS beta for A
betaofA = cov./varianceofB;

% Calculation of OLS alpha for A
alphaofA = averagesofA - (betaofA*averagesofB);

% Adjustments done to Beta
% Merrill Lynch's Adjustment
betaofAml = 2.*betaofA./3 + 1/3;
```

```

% Bayesian's adjustments: there are a few parameters need to be
calculated
% prior to the adjustment. The following parameters need to be
established,
% the average of OLS beta, variance of beta estimate and cross-
% sectional standard deviation of all beta estimate in the portfolio.
In
% this demonstration, there are only two securities.
% Calculate the average of OLS beta
averagebetaofA = mean(betaofA);

% Calculation of variance of OLS beta estimate
vardofAbetaestimate = ((betaofA - averagebetaofA).^2);
varianceofAbetaestimate = vardofAbetaestimate./C;

% Calculation of cross- sectional standard deviation of all beta
estimate
averagebetaporttoofA = averagebetaofA; % In this demonstration, there is
only one security in the portfolio, the other security is the benchmark
used, i.e. the market index
varbetaofA = ((betaofA - averagebetaporttoofA).^2);
variancebetaporttoofA = varbetaofA./C;

% Weight factor calculation
weight = variancebetaporttoofA./(variancebetaporttoofA +
varianceofAbetaestimate);

% Beta calculation based on Bayesian's adjustment
betaofAba = (weight.*betaofA) + (1-weight).*averagebetaofA;

% Modified alpha values based on Merrill Lynch's adjustments done to
beta
alphaofAml = averagesofA - (betaofAml*averagesofB);

% Modified alpha values based on Bayesian's adjustments done to beta
alphaofAba = averagesofA - (betaofAba*averagesofB);

% Export results to Excel
% Define the headings for each column
Results_names{1} = 'Number of Observations';
Results_names{2} = 'A'; % data value for individual security
Results_names{3} = 'B'; % data value for the benchmark
Results_names{4} = 'Returns of A';
Results_names{5} = 'Returns of B';
Results_names{6} = 'Average of A';
Results_names{7} = 'Average of B';
Results_names{8} = 'Variance of A';
Results_names{9} = 'Variance of B';
Results_names{10} = 'Covariance';
Results_names{11} = 'OLS beta';
Results_names{12} = 'BA beta';
Results_names{13} = 'ML beta';
Results_names{14} = 'OLS alpha';
Results_names{15} = 'BA alpha';

```

```

Results_names{16} = 'ML alpha';

% Write the outcomes to the chosen excel workbook
xlswrite(strcat(path, '/', file), Results_names, 'MATLAB Outputs',
'B2');
xlswrite(strcat(path, '/', file), C, 'MATLAB Outputs', 'B3');
xlswrite(strcat(path, '/', file), A, 'MATLAB Outputs', 'C3');
xlswrite(strcat(path, '/', file), B, 'MATLAB Outputs', 'D3');
xlswrite(strcat(path, '/', file), returnsofA, 'MATLAB Outputs', 'E3');
xlswrite(strcat(path, '/', file), returnsofB, 'MATLAB Outputs', 'F3');
xlswrite(strcat(path, '/', file), averagesofA, 'MATLAB Outputs', 'G3');
xlswrite(strcat(path, '/', file), averagesofB, 'MATLAB Outputs', 'H3');
xlswrite(strcat(path, '/', file), varianceofA, 'MATLAB Outputs', 'I3');
xlswrite(strcat(path, '/', file), varianceofB, 'MATLAB Outputs', 'J3');
xlswrite(strcat(path, '/', file), cov, 'MATLAB Outputs', 'K3');
xlswrite(strcat(path, '/', file), betaofA, 'MATLAB Outputs', 'L3');
xlswrite(strcat(path, '/', file), betaofAba, 'MATLAB Outputs', 'M3');
xlswrite(strcat(path, '/', file), betaofAml, 'MATLAB Outputs', 'N3');
xlswrite(strcat(path, '/', file), alphaofA, 'MATLAB Outputs', 'O3');
xlswrite(strcat(path, '/', file), alphaofAba, 'MATLAB Outputs', 'P3');
xlswrite(strcat(path, '/', file), alphaofAml, 'MATLAB Outputs', 'Q3');

```

Appendix E: Validation Results

The following results are found in this section:

- Table E1 represents the results that were obtained by running the validating computer programme. This computer programme can be found in Appendix D.
- Table E2 represents the results that were obtained by manually calculating the results using the equations found in Chapter 2.
- Table E3 represents the error by comparing Table E1 and Table E2.

Table E1: Outcomes from Validating Computer Programme

Data #	A	B	Returns of A	Returns of B	Variance of A	Variance of B	Covariance	OLS beta	BA beta	ML beta	OLS alpha	BA alpha	ML alpha
1	12	50	8.33	8.00	30.86	711.11	-148.15	-0.21	-3.73	0.19	10.00	-55.69	17.52
2	13	54	-16.67	-4.00	466.82	107.56	-224.07	-2.08	-4.66	-1.06	-25.00	-73.19	-5.81
3	10	48	-25.00	-6.00	504.12	53.48	-164.20	-3.07	-5.16	-1.71	-43.42	-82.40	-18.10
4	9	47	66.67	40.00	696.37	860.44	774.07	0.90	-3.17	0.93	30.68	-45.35	31.31
5	20	70	-41.67	-60.00	617.28	341.69	459.26	1.34	-2.95	1.23	38.98	-41.20	36.84
6	7	20	-66.67	-70.00	1081.53	439.19	689.20	1.57	-2.84	1.38	43.18	-39.10	39.64
7	4	15	83.33	-20.00	688.93	0.25	-13.23	-52.08	-29.66	-34.39	958.33	539.86	628.04
8	22	40	25.00	-30.00	15.43	16.06	-15.74	-0.98	-4.11	-0.32	-4.41	-62.90	7.91
9	15	35	91.67	-26.00	672.15	5.98	-63.37	-10.61	-8.93	-6.74	184.09	152.74	111.88
	23	37											
Ave.	14	-19											

Table E2: Outcomes from Manual Calculations

Data #	A	B	Returns of A	Returns of B	Variance of A	Variance of B	Covariance	OLS beta	BA beta	ML beta	OLS alpha	BA alpha	ML alpha
1	12	50	8.33	8.00	30.86	711.11	-148.15	-0.21	-3.73	0.19	10.00	-55.69	17.52
2	13	54	-16.67	-4.00	466.82	107.56	-224.07	-2.08	-4.66	-1.06	-25.00	-73.19	-5.81
3	10	48	-25.00	-6.00	504.12	53.48	-164.20	-3.07	-5.16	-1.71	-43.42	-82.40	-18.10
4	9	47	66.67	40.00	696.37	860.44	774.07	0.90	-3.17	0.93	30.68	-45.35	31.31
5	20	70	-41.67	-60.00	617.28	341.69	459.26	1.34	-2.95	1.23	38.98	-41.20	36.84
6	7	20	-66.67	-70.00	1081.53	439.19	689.20	1.57	-2.84	1.38	43.18	-39.10	39.64
7	4	15	83.33	-20.00	688.93	0.25	-13.23	-52.08	-29.66	-34.39	958.33	539.86	628.04
8	22	40	25.00	-30.00	15.43	16.06	-15.74	-0.98	-4.11	-0.32	-4.41	-62.90	7.91
9	15	35	91.67	-26.00	672.15	5.98	-63.37	-10.61	-8.93	-6.74	184.09	152.74	111.88
	23	37											
Ave.	14	-19											

Table E3: Errors Comparison Between Table E1 and Table E2

Returns of A	Returns of B	Average of A	Average of B	Variance of A	Variance of B	Covariance	OLS beta	BA beta	ML beta	OLS alpha	BA alpha	ML alpha
8.53E-16	-8.9E-16	0	0	-2.65E-15	-4.8E-16	-1.53477E-15	-1.07E-15	-2.3E-15	8.6E-16	5.3E-16	-3E-15	2E-16
0	-8.9E-16			0	5.29E-16	2.53681E-16	-2.13E-16	-1.9E-15	-4.2E-16	-1E-16	-2E-15	-1E-15
0	-8.9E-16			0	9.3E-16	5.19284E-16	-4.34E-16	-1.7E-15	-5.2E-16	-3E-16	-2E-15	-8E-16
-2.1E-16	1.78E-16			-4.9E-16	5.29E-16	0	-4.94E-16	-2.4E-15	-2.4E-16	-2E-16	-3E-15	-1E-16
1.71E-16	0			0	0	0	0	-2.7E-15	0	0	-3E-15	0
-2.1E-16	0			-4.2E-16	0	-3.29911E-16	-2.83E-16	-2.8E-15	-1.6E-16	-2E-16	-4E-15	0
1.71E-16	1.78E-16			3.3E-16	5.25E-15	2.68585E-15	-2.59E-15	-2.5E-15	-2.7E-15	-3E-15	-3E-15	-3E-15
0	-1.2E-16			0	-4.43E-16	-3.38553E-16	1.132E-16	-1.9E-15	3.5E-16	0	-2E-15	-3E-16
-1.6E-16	0			-3.38E-16	0	-2.24236E-16	-3.35E-16	-1E-15	-4E-16	-3E-16	-1E-15	-4E-16

Appendix F: Sample Size of Test Portfolio

It is important to establish whether the sample size chosen is good representation of the population.

Total Sample Size	n	250 securities × 166 data points per security	41500
	$\sqrt{n}$		203.7155
Standard Deviation of Sample	s		5676.55
Standard Error of Sample Means	s_x^{33}	$\frac{s}{\sqrt{n}}$	27.86509

The following equation is then used to determine the sample size:

$$n = \left(\frac{z \times s}{E} \right)^2 \dots\dots\dots (F1)^{34}$$

Where

E is the allowable error

Z is the z score associated with the degree of confidence selected

s is the sample deviation of the pilot survey, in this case mean value of the standard deviation had been used

From equation (F1), it is seen that sample size is dependent of E. There are two unknowns in the equation, so the standard error of sample means is used as the allowable error in the sample, thus remove one unknown.

From Table F1: Calculation of Sample Size in Terms of Confidence Intervals, for the E = 28, the sample size ranges from 9 to 21, depending on the degree of confidence selected. Thus the number of securities included in portfolio being 27, without repeating any securities, it is a decent representation of the equity market.

Also, the securities chosen are the constituents of headline indices; this implies the meritocracy of these firms. The firms chosen also account for more than 1/3 of the stock exchange market capitalisation. These reinforces the sample chosen is a good representation of the market as a whole.

³³ Mason, R.D. and Lind D.A, 1996, Statistical Techniques in Business & Economics, Ninth Edition, Irwin, p.329, Equation (8-11)

³⁴ Mason, R.D. and Lind D.A, 1996, Statistical Techniques in Business & Economics, Ninth Edition, Irwin, p.330, Equation (8-12)

Table F1: Calculation of Sample Size in Terms of Confidence Intervals

90% Confidence Interval			95% Confidence Interval			99% Confidence Interval		
z	1.65		z	1.96		z	2.58	
s	49.60		s	49.60		s	49.60	
E	n		E	n		E	n	
1	6697.786		1	9450.951		1	16375.81	
2	1674.446		2	2362.738		2	4093.952	
3	744.1984		3	1050.106		3	1819.534	
4	418.6116		4	590.6844		4	1023.488	
5	267.9114		5	378.038		5	655.0324	
6	186.0496		6	262.5264		6	454.8836	
7	136.6895		7	192.8765		7	334.2002	
8	104.6529		8	147.6711		8	255.872	
9	82.68871		9	116.6784		9	202.1705	
10	66.97786		10	94.50951		10	163.7581	
11	55.3536		11	78.10703		11	135.3373	
12	46.5124		12	65.6316		12	113.7209	
13	39.63187		13	55.92278		13	96.89828	
14	34.17238		14	48.21914		14	83.55005	
15	29.76794		15	42.00423		15	72.78137	
16	26.16323		16	36.91778		16	63.968	
17	23.17573		17	32.70225		17	56.6637	
18	20.67218		18	29.1696		18	50.54262	
19	18.55342		19	26.17992		19	45.36235	
20	16.74446		20	23.62738		20	40.93952	
21	15.18772		21	21.43073		21	37.13335	
22	13.8384		22	19.52676		22	33.83432	
23	12.66122		23	17.86569		23	30.95616	
24	11.6281		24	16.4079		24	28.43022	
25	10.71646		25	15.12152		25	26.20129	
26	9.907967		26	13.9807		26	24.22457	
27	9.187635		27	12.96427		27	22.46339	
28	8.543094		28	12.05478		28	20.88751	
29	7.964073		29	11.23775		29	19.47183	
30	7.441984		30	10.50106		30	18.19534	
31	6.9696		31	9.834496		31	17.04038	
32	6.540806		32	9.229444		32	15.992	
33	6.1504		33	8.678559		33	15.03747	
34	5.793932		34	8.175563		34	14.16592	
35	5.46758		35	7.715062		35	13.36801	

Appendix G: Rationale for Shares' Inclusions in the Test Portfolio

The most commonly used ratios such as Price Earning Ratio, Earnings Per Share, Dividend Per Share have been considered for shares inclusions. The shares chosen have displayed either consistent or an increasing trend in their PE, EPS and DPS per share. (Profile Group (Pty) Ltd., 2006b)

Table G1: Rationale for Shares Inclusions

Code	Name	Sector	Subsector	Rationale
AFB	Alexander Forbes Limited	Financial	Insurance	International financial & risk services provider
				Major shareholder in VenFin Ltd. with 24.7% shares
AGL	Anglo American plc	Basic Materials	Mining - General Mining	Global leader in mining and natural resource sector
				Primarily listed on London Stock Exchange; various listing on other stock exchanges
AMS	Anglo Platinum Ltd.	Basic Materials	Mining - Platinum	World's largest platinum produce, thus can effectively affect commodity price
				Gold, Copper, Nickel and Cobalt are recovered as by-products
				Dual listed on London Stock Exchange
ASA	Absa Group Ltd.	Financial	Banks	Foreign investor, Barclays plc, is the major shareholder, holds 56.4% of the firm
BAW	Barloworld Limited	Industrials	Industrial Goods and Services - General	Diversified industrial brand management
				Also listed on both London and Namibian Stock Exchange
BCX	Business Connexion Group Limited	Technology	Software and Computer Services	Africa's leading integrator of competitive, innovative and practical business solutions based on information and communication technology

BDE	BIDBEE	Other Securities - Industrial	Industrial Goods and Services - Business Support Services	
BVT	The Bidvest Group Ltd.	Industrials	Industrial Goods and Services - Business Support Services	Good corporate governance
				International services, trading and distributions
CLH	City Lodge	Consumer Services	Leisure and Hotels	High quality affordable hotels targeted at business community & leisure travelers; however doesn't offer 5 star services
				2010 Soccer World Cup, spectators & tourists need accommodation
DST	Distell Group Limited	Consumer Goods	Food & Beverages	Leading SA producer in wine & spirits
ERP	ERP.com Holdings Ltd.	Technology	Software and Computer Services	Principal business activity is to act as an investment holding company, with subsidiaries
FBR	Famous Brand Limited	Consumer Services	Leisure and Hotels	Operate in all major segments of quick service restaurant
FSR	FirstRand Limited	Financial	Banks	Blurring of boundaries in financial services industry and convergence of products and services
				Differentiated by its de-centralized structure and owner-manager culture
				Dual listed on Namibian Stock Exchange
IPL	Imperial Holdings Ltd.	Industrials	Industrial Goods and Services - Transportation	Subsidiaries and associates in banking, life assurance, short-term insurance, leasing and fleet management, aviation leasing, logistics and transport, etc

LBT	Liberty International plc	Financial	Real Estate	Major UK property group
				Property market started to regress since 1997 economic depression
				Dual listed on London Stock Exchange
MTN	MTN Group Ltd.	Telecommunications	Tele. Services	African- focused holding, providing telecommunication infrastructure
				Aid SA transition from developing to developed country
MUR	Murray and Roberts Holdings Limited	Industrials	Construction & Building Materials	Industrial holding company and multi-faceted global character
PIK	Pick n Pay Stores Limited	Consumer Services	Food & Drug Retailers	
PPC	Pretoria Portland Cement Company Ltd.	Industrials	Construction & Building Materials	PPC Cement is the leading supplier of cement in southern Africa
				Cement is an important raw material for all constructions/ infrastructure
REM	Remgro Limited	Industrials	Industrial Goods and Services - General	Interests in luxurious goods among other economic sectors in SA
RLO	Reunert Limited	Industrials	Industrial Goods and Services - Electrical	Played a major role in SA economy development
				Holds shares in African Cables and Siemens Telecommunication
SAB	SABMiller plc	Consumer Goods	Food & Beverages	One of the world's largest brewers
				SA have been experiencing healthy economy, thus steady increasing demands for luxurious goods/ drinks
				Dual listed on London Stock Exchange

SBK	Standard Bank Group Ltd.	Financial	Banks	Wide representation in Africa and emerging markets internationally
				In 2005, undergoes internal restructuring to increase the firm's competitiveness
				Dual listed on Namibian Stock Exchange
SHP	Shoprite Holdings Ltd.	Consumer Services	Food & Drug Retailers	Investment holding company with investments in supermarket chain, property, fresh produce and furniture, therefore diversification
				Dual listed on Namibian Stock Exchange
TBS	Tiger Brands Limited	Consumer Goods	Food & Beverages	Balanced spread of African & selected international operations in manufacturing, processing & distribution of branded food and healthcare products
VNF	VenFin Ltd.	Financial	Investment Companies	Hold USD 100 million worth of Dimension Data Convertible Bond
				Operating activities have spread over telecommunications, technology and media interests
WHL	Woolworths Holdings Ltd.	Consumer Services	General Retailers	Focus on quality, value and customer service.
				e.g. First retail store without stocks, well managed queues, etc

(Source: Profile Group (Pty) Ltd., 2006a)

Appendix H: Ordinary Shares Listed Based on Market Capitalization

The fundamental reason for selecting shares based on its market capitalisation is that this would include all the ordinary shares listed on JSE, thus this gives a better representation of market.

The overall market value of ordinary shares on JSE is R 2,566,352,039,068.

Table H1: Ordinary Shares Listed Based on Market Capitalization

ALPHA CODE	EQUITY_NAME	EQUITY STATUS	DATE	MARKET_CAP	%
AGL	ANGLO AMERICAN PLC	C	20041231	199,373,508,019	7.7688
BIL	BHP BILLITON PLC	C	20041231	162,897,702,132	6.3474
RCH	RICHEMONT SECURITIES DR	C	20041231	98,136,000,000	3.8239
SAB	SABMILLER PLC	C	20041231	95,875,522,495	3.7359
SBK	STANDARD BANK GROUP LTD	C	20041231	88,968,730,548	3.4667
SOL	SASOL LTD	C	20041231	81,546,428,425	3.1775
FSR	FIRSTRAND LTD	C	20041231	73,108,938,523	2.8487
MTN	MTN GROUP LTD	C	20041231	72,291,401,202	2.8169
OML	OLD MUTUAL PLC	C	20041231	55,084,404,818	2.1464
TKG	TELKOM SA LTD	C	20041231	54,589,118,262	2.1271
ANG	ANGLOGOLD ASHANTI LTD	C	20041231	52,630,760,534	2.0508
ASA	ABSA GROUP LIMITED	C	20041231	49,777,635,073	1.9396
REM	REMGRO LTD	C	20041231	45,905,540,814	1.7887
AMS	ANGLO PLATINUM LTD	C	20041231	45,002,937,672	1.7536
SLM	SANLAM LTD	C	20041231	35,978,418,671	1.4019
GFI	GOLD FIELDS LTD	C	20041231	34,193,508,843	1.3324
LBT	LIBERTY INTERNATIONAL PLC	C	20041231	33,937,587,939	1.3224
IMP	IMPALA PLATINUM HLGS LD	C	20041231	31,957,627,894	1.2453
NED	NEDBANK GROUP LTD	C	20041231	30,667,368,936	1.1950

MLA	MITTAL STEEL SA LTD	C	20041231	29,196,764,646	1.1377
RMH	RMB HOLDINGS LTD	C	20041231	25,846,714,483	1.0071
BVT	BIDVEST LTD ORD	C	20041231	25,518,679,284	0.9944
BAW	BARLOWORLD LTD	C	20041231	23,696,729,250	0.9234
NPN	NASPERS LTD -N-	C	20041231	23,591,152,500	0.9192
IPL	IMPERIAL HOLDINGS LTD	C	20041231	22,829,130,584	0.8896
HAR	HARMONY G M CO LTD	C	20041231	20,224,049,561	0.7880
SAP	SAPPI LTD	C	20041231	19,842,967,036	0.7732
LGL	LIBERTY GROUP LTD	C	20041231	18,421,087,606	0.7178
ECO	EDGARS CONS STORES LTD	C	20041231	16,476,202,431	0.6420
TBS	TIGER BRANDS LTD ORD	C	20041231	16,353,199,623	0.6372
PPC	PRETORIA PORT CEMNT	C	20041231	15,321,953,115	0.5970
SHF	STEINHOFF INTERNTL HLDGS	C	20041231	14,297,163,741	0.5571
LON	LONMIN P L C	C	20041231	14,020,343,469	0.5463
INP	INVESTEC PLC	C	20041231	13,538,561,524	0.5275
KMB	KUMBA RESOURCES LTD	C	20041231	13,281,585,284	0.5175
JDG	JD GROUP LTD	C	20041231	11,729,400,000	0.4570
PIK	PIK N PAY STORES LTD	C	20041231	11,278,306,062	0.4395
WHL	WOOLWORTHS HOLDINGS LTD	C	20041231	10,936,382,144	0.4261
DSY	DISCOVERY HOLDINGS LTD	C	20041231	10,185,632,145	0.3969
NPK	NAMPAK LTD ORD	C	20041231	10,046,317,039	0.3915
FOS	FOSCHINI LTD ORD	C	20041231	9,619,929,640	0.3748
MSM	MASSMART HOLDINGS LTD	C	20041231	9,021,346,667	0.3515
ABL	AFRICAN BANK INVESTMENTS	C	20041231	8,731,946,839	0.3402
LBH	LIBERTY HOLDINGS LTD ORD	C	20041231	8,693,928,778	0.3388
AFX	AFRICAN OXYGEN LTD ORD	C	20041231	8,588,469,754	0.3347
NTC	NETWORK HEALTHCARE HLDGS	C	20041231	8,518,187,676	0.3319

TRU	TRUWORTHS INTERNATIONAL	C	20041231	8,302,632,768	0.3235
SNT	SANTAM LTD	C	20041231	8,179,528,517	0.3187
INL	INVESTEC LTD	C	20041231	7,963,914,387	0.3103
AVI	AVI LTD	C	20041231	7,836,719,942	0.3054
RLO	REUNERT ORD	C	20041231	7,202,231,850	0.2806
SHP	SHOPRITE HLDGS LTD ORD	C	20041231	7,010,885,034	0.2732
MET	METROPOLITAN HLDGS LTD	C	20041231	6,993,381,259	0.2725
APN	ASPEN PHARMACARE HLDGS.	C	20041231	6,870,953,611	0.2677
SUI	SUN INTERNATIONAL LTD	C	20041231	6,634,395,471	0.2585
MAF	MUTUAL AND FEDERAL INS	C	20041231	6,061,653,388	0.2362
PWK	PIK N PAY HOLDINGS LTD	C	20041231	5,799,739,902	0.2260
DDT	DIMENSION DATA HLDGS PLC	C	20041231	5,638,727,346	0.2197
TNT	TONGAAT-HULETT GROUP ORD	C	20041231	5,525,478,731	0.2153
ARI	AFRICAN RAINBOW MINERALS	C	20041231	5,416,368,231	0.2111
SPG	SUPER GROUP LTD	C	20041231	5,181,991,795	0.2019
GRT	GROWTHPOINT PROP LTD	C	20041231	5,067,604,510	0.1975
AFB	ALEXANDER FORBES LTD	C	20041231	4,997,609,233	0.1947
MDC	MEDI-CLINIC CORP LTD ORD	C	20041231	4,988,440,386	0.1944
ALT	ALLIED TECHNOLOGIES	C	20041231	4,909,116,915	0.1913
DST	DISTELL GROUP LTD	C	20041231	4,908,915,900	0.1913
AEG	AVENG LTD	C	20041231	4,753,750,896	0.1852
HVL	HIVELD STEEL AND VANADUM	C	20041231	4,730,284,704	0.1843
AFE	A E C I LTD ORD	C	20041231	4,584,283,002	0.1786
MUR	MURRAY AND ROBERTS H ORD	C	20041231	4,563,523,511	0.1778
CAT	CAXTON CTP PUBLISH PRINT	C	20041231	4,467,529,659	0.1741
ELH	ELLERINE HOLDINGS LTD	C	20041231	4,399,035,200	0.1714
GRY	ALLAN GRAY PROPERTY TRST	C	20041231	4,103,697,493	0.1599

LEW	LEWIS GROUP LTD	C	20041231	3,900,000,000	0.1520
SPP	THE SPAR GROUP LTD	C	20041231	3,629,438,349	0.1414
JNC	JOHNNIC HOLDINGS LTD	C	20041231	3,620,731,156	0.1411
GND	GRINDROD LTD	C	20041231	3,591,401,304	0.1399
JCM	JOHNNIC COMMUNICATIONS	C	20041231	3,542,436,676	0.1380
NCL	NEW CLICKS HLDGS LTD	C	20041231	3,476,071,204	0.1354
WAR	WESTERN AREAS LTD	C	20041231	2,963,709,475	0.1155
UTR	UNITRANS LTD	C	20041231	2,939,375,604	0.1145
MVG	MVELAPHANDA GROUP LTD	C	20041231	2,863,721,245	0.1116
MPC	MR PRICE GROUP LTD	C	20041231	2,803,249,491	0.1092
GDF	GOLD REEF CASINO RESORTS	C	20041231	2,783,033,636	0.1084
ARL	ASTRAL FOODS LTD	C	20041231	2,676,038,280	0.1043
HCI	HOSKEN CONS INVEST LTD	C	20041231	2,628,378,170	0.1024
ILV	ILLOVO SUGAR LTD	C	20041231	2,600,617,900	0.1013
ITE	ITALTILE LTD	C	20041231	2,521,433,205	0.0982
AFR	AFGRI LTD	C	20041231	2,516,605,000	0.0981
SYC	SYCOM PROPERTY FUND	C	20041231	2,484,477,038	0.0968
MVL	MVELAPHANDA RESOURCES LD	C	20041231	2,412,845,530	0.0940
PTG	PEERMONT GLOBAL LTD	C	20041231	2,326,500,000	0.0907
HYP	HYPROP INVESTMENTS LTD	C	20041231	2,303,460,729	0.0898
TRE	TRENCOR LTD	C	20041231	2,235,005,654	0.0871
OMN	OMNIA HOLDINGS LTD	C	20041231	2,167,614,578	0.0845
AQP	AQUARIUS PLATINUM LTD	C	20041231	2,151,601,192	0.0838
DRD	DRDGOLD LTD	C	20041231	2,093,598,539	0.0816
ASR	ASSORE LTD	C	20041231	2,058,000,000	0.0802
RBW	RAINBOW CHICKEN LTD	C	20041231	2,056,499,775	0.0801
NHM	NORTHAM PLATINUM LTD	C	20041231	2,049,425,475	0.0799

PMN	PRIMEDIA LTD -N-	C	20041231	2,030,228,043	0.0791
MTP	MARTPROP PROPERTY FUND	C	20041231	1,957,996,184	0.0763
APA	APEXHI PROPERTIES -A-	C	20041231	1,888,215,030	0.0736
APB	APEXHI PROPERTIES -B-	C	20041231	1,869,142,151	0.0728
EMI	EMIRA PROPERTY FUND	C	20041231	1,868,673,630	0.0728
SAE	SA EAGLE INSURANCE CO	C	20041231	1,802,566,000	0.0702
TSX	TRANS HEX GROUP LTD	C	20041231	1,725,960,207	0.0673
DEL	DELTA ELECRICAL IN	C	20041231	1,686,378,467	0.0657
VKE	VUKILE PROPERTY FUND LTD	C	20041231	1,679,333,328	0.0654
OCE	OCEANA GROUP LTD	C	20041231	1,667,040,310	0.0650
CRM	CERAMIC INDUSTRIES LTD	C	20041231	1,661,982,413	0.0648
WES	WESCO INVESTMENTS LTD	C	20041231	1,646,151,000	0.0641
ATN	ALLIED ELECTRONICS CORP	C	20041231	1,613,090,309	0.0629
PAP	PANGBOURNE PROP LTD	C	20041231	1,591,714,958	0.0620
RDF	REDEFINE INCOME FUND LTD	C	20041231	1,585,886,270	0.0618
SRL	SA RETAIL PROPERTIES LTD	C	20041231	1,559,605,650	0.0608
KGM	KAGISO MEDIA LTD	C	20041231	1,542,101,454	0.0601
ILA	ILIAD AFRICA LTD	C	20041231	1,537,522,693	0.0599
TIW	TIGER WHEELS LTD	C	20041231	1,534,592,175	0.0598
CML	CORONATION FUND MNGRS LD	C	20041231	1,529,099,720	0.0596
CLH	CITY LODGE HTLS LTD ORD	C	20041231	1,487,333,318	0.0580
WBO	WILSON BAYLY HLM-OVC ORD	C	20041231	1,470,498,250	0.0573
RAH	REAL AFRICA HLDGS LTD	C	20041231	1,412,678,975	0.0550
DTC	DATATEC LTD	C	20041231	1,398,281,430	0.0545
BTG	BYTES TECHNOLOGY GRP LTD	C	20041231	1,313,168,953	0.0512
CPL	CAPITAL PROPERTY FUND	C	20041231	1,288,389,264	0.0502
PAM	PALABORA MINING CO ORD	C	20041231	1,274,197,500	0.0497

APK	ASTRAPAK LTD	C	20041231	1,259,423,250	0.0491
KAP	KAP INTERNATIONAL HLDGS	C	20041231	1,256,160,000	0.0489
AMA	AMALGAMATED APPL HLD LTD	C	20041231	1,241,309,680	0.0484
RES	RESILIENT PROP INC FD LD	C	20041231	1,211,731,082	0.0472
IFR	IFOUR PROPERTIES LTD	C	20041231	1,206,119,392	0.0470
KWV	KWV BELEGGINGS BEPERK	C	20041231	1,197,000,000	0.0466
BPL	BARPLATS INVESTMENTS ORD	C	20041231	1,168,336,806	0.0455
TRT	TOURISM INV CORP LTD	C	20041231	1,162,490,424	0.0453
BCX	BUSINESS CONNEXION GROUP	C	20041231	1,158,228,781	0.0451
GRF	GROUP FIVE LTD ORD	C	20041231	1,114,631,298	0.0434
MPL	METBOARD PROPERTIES LTD	C	20041231	1,081,484,727	0.0421
MTA	METAIR INVESTMENTS ORD	C	20041231	1,058,905,980	0.0413
HDC	HUDACO INDUSTRIES LTD	C	20041231	1,044,627,725	0.0407
TDH	TRADEHOLD LTD	C	20041231	1,041,991,323	0.0406
BAT	BRAIT S.A.	C	20041231	986,767,813	0.0385
MST	MUSTEK LTD	C	20041231	984,817,395	0.0384
GMB	GLENRAND M.I.B. LTD	C	20041231	982,106,446	0.0383
MRF	MERAFA RESOURCES LTD	C	20041231	940,817,313	0.0367
DAW	DISTRIBUTION AND WAREHSG	C	20041231	929,570,862	0.0362
CPI	CAPITEC BANK HLDGS LTD	C	20041231	917,087,253	0.0357
IVT	INVICTA HOLDINGS LTD	C	20041231	913,884,356	0.0356
CLE	CLIENTELE LIFE ASSURANCE	C	20041231	905,800,000	0.0353
ACP	ACUCAP PROPERTIES LTD	C	20041231	869,441,051	0.0339
PSG	PSG GROUP LIMITED	C	20041231	850,465,000	0.0331
RNG	RANDGOLD AND EXP CO	S	20041231	822,944,408	0.0321
CDZ	CADIZ HOLDINGS LTD	C	20041231	812,954,286	0.0317
DLV	DORBYL LTD ORD	C	20041231	795,834,144	0.0310

CMH	COMBINED MOTOR HLDGS LTD	C	20041231	790,964,375	0.0308
CSB	CASHBUILD LTD	C	20041231	783,837,405	0.0305
NWL	NU-WORLD HOLDINGS LTD	C	20041231	748,276,587	0.0292
PGR	PEREGRINE HOLDINGS LTD	C	20041231	744,985,504	0.0290
ATS	ATLAS PROPERTIES LTD	C	20041231	739,905,095	0.0288
MBN	MOBILE INDUSTRIES -N-	C	20041231	721,471,600	0.0281
MTL	MERCANTILE BANK HLDGS LD	C	20041231	709,005,334	0.0276
ADR	ADCORP HLDGS LTD ORD	C	20041231	697,264,458	0.0272
ART	ARGENT INDUSTRIAL LTD	C	20041231	670,229,609	0.0261
BRC	BRANDCORP HOLDINGS LTD	C	20041231	656,326,983	0.0256
COM	COMAIR LTD	C	20041231	630,000,000	0.0245
PMA	PRIMEDIA LTD	C	20041231	625,035,312	0.0244
FBR	FAMOUS BRANDS LTD	C	20041231	618,369,132	0.0241
FSP	FREESTONE PROPERTY HLDGS	C	20041231	611,034,370	0.0238
SUR	SPUR CORPORATION LTD	C	20041231	590,678,639	0.0230
BEL	BELL EQUIPMENT LTD	C	20041231	584,327,680	0.0228
SFN	SASFIN HOLDINGS LTD	C	20041231	574,265,714	0.0224
JCD	JCI LTD	S	20041231	567,621,986	0.0221
PMM	PREMIUM PROPERTIES LTD	C	20041231	545,313,787	0.0212
AGI	AG INDUSTRIES LTD	C	20041231	543,428,767	0.0212
PHM	PHUMELELA GAME LEISURE	C	20041231	532,629,637	0.0208
DCT	DATACENTRIX HOLDINGS LTD	C	20041231	530,738,231	0.0207
ZCI	ZAMBIA COPPER INV LD ORD	C	20041231	530,028,920	0.0207
OCT	OCTODEC INVEST LTD	C	20041231	509,239,698	0.0198
PRA	PARAMOUNT PROP FUND LTD	C	20041231	508,968,333	0.0198
MTX	METOREX LTD	C	20041231	498,459,374	0.0194
BCF	BOWLER METCALF LTD	C	20041231	486,797,169	0.0190

MCP	MICC PROPERTY INCOME FND	S	20041231	481,007,571	0.0187
ADH	ADVTECH LTD	C	20041231	472,397,863	0.0184
ENV	ENVIROSERV HOLDINGS LTD	C	20041231	459,673,975	0.0179
SPE	SPEARHEAD PROP HLDGS LTD	C	20041231	452,407,728	0.0176
BDEO	BIDVEST CALL OPTIONS	C	20041231	432,000,000	0.0168
CUL	CULLINAN HOLDINGS ORD	C	20041231	430,913,122	0.0168
TGN	TIGON LTD	S	20041231	404,837,161	0.0158
PCN	PARACON HOLDINGS LTD	C	20041231	397,096,378	0.0155
VLE	VALUE GROUP LTD	C	20041231	396,514,166	0.0155
MOB	MOBILE INDUSTRIES ORD	C	20041231	367,827,080	0.0143
MCU	M CUBED HLDGS LTD	C	20041231	367,500,000	0.0143
ABT	AMBIT PROPERTIES LTD	C	20041231	357,820,127	0.0139
SBO	SAAMBOU HOLDINGS LTD	S	20041231	338,958,403	0.0132
BJM	BARNARD JACOBS MELLET	C	20041231	333,484,003	0.0130
ACH	ARCH EQUITY LTD	C	20041231	330,345,552	0.0129
DGC	DIGICORE HOLDINGS LTD	C	20041231	313,650,989	0.0122
UCS	UCS GROUP LTD	C	20041231	311,394,474	0.0121
SRN	SEARDEL INVST CORP -N-	C	20041231	310,852,296	0.0121
GDH	GOODHOPE DIAM (KIM) LTD	S	20041231	305,000,000	0.0119
ERP	ERP.COM HOLDINGS LTD	C	20041231	292,801,869	0.0114
CNL	CONTROL INSTRUMENTS GRP	C	20041231	261,232,120	0.0102
SCN	SCHARRIG MINING LTD	C	20041231	256,187,318	0.0100
YBA	YOMHLABA RESOURCES LTD	S	20041231	240,000,102	0.0094
LAF	LONRHO AFRICA PLC	C	20041231	236,358,132	0.0092
PIM	PRISM HOLDINGS LTD	C	20041231	225,032,509	0.0088
BSB	THE HOUSE OF BUSBY LTD	C	20041231	219,922,039	0.0086
EOH	EOH HOLDINGS LTD	C	20041231	215,322,895	0.0084

CKS	CROOKES BROS LTD	C	20041231	214,385,600	0.0084
CNC	CONCOR LTD RCON	C	20041231	206,887,707	0.0081
LAN	LA GROUP LTD -N-	C	20041231	200,451,750	0.0078
IDI	IDION TECHNOLOGY HLDGS	C	20041231	194,997,127	0.0076
DTP	DATAPRO GROUP LTD	C	20041231	192,342,886	0.0075
WNH	WINHOLD LTD ORD	C	20041231	178,974,877	0.0070
MMG	MICROMEGA HOLDINGS LTD	C	20041231	177,489,530	0.0069
SOV	SOVEREIGN FOOD INVEST LD	C	20041231	172,114,394	0.0067
TPC	TRANSPACO LTD	C	20041231	168,808,354	0.0066
BRN	BRIMSTONE INVESTMENT -N-	C	20041231	159,179,372	0.0062
SKJ	SEKUNJALO INVESTMENTS LD	C	20041231	155,536,073	0.0061
LAR	LA GROUP LTD ORD	C	20041231	154,473,965	0.0060
ELR	ELB GROUP LTD ORD	C	20041231	145,598,000	0.0057
HWN	HOWDEN AFRICA HLDGS LTD	C	20041231	144,604,039	0.0056
PPR	PUTPROP LTD	C	20041231	143,964,805	0.0056
EXL	EXCELLERATE HLDGS LTD	C	20041231	129,333,485	0.0050
STO	SETPOINT TECHNOLOGY HLDG	C	20041231	127,596,004	0.0050
SPS	SPESCOM LTD	C	20041231	126,028,886	0.0049
JSC	JASCO ELECTRONICS HLDGS	C	20041231	125,515,945	0.0049
GIJ	GIJIMA AST GROUP LTD	C	20041231	107,332,928	0.0042
SBL	SABLE HLDGS LTD ORD	C	20041231	101,040,000	0.0039
CRG	CARGO CARRIERS LTD	C	20041231	100,000,000	0.0039
MTZ	MATODZI RESOURCES LTD	C	20041231	96,458,678	0.0038
SER	SEARDEL INVEST CORP LTD	C	20041231	96,196,987	0.0037
MAS	MASONITE AFRICA LTD ORD	C	20041231	94,243,242	0.0037
AFG	AFGEM LTD	C	20041231	93,468,516	0.0036
PET	PETMIN LTD	C	20041231	93,155,555	0.0036

AME	AFRICAN MEDIA ENTERTAIN	C	20041231	90,597,234	0.0035
SWL	SHAWCELL TELECOMM LTD	S	20041231	90,000,000	0.0035
MTE	MONTEAGLE SOCIETE ANONYM	C	20041231	88,200,000	0.0034
RAG	RETAIL APPAREL GROUP LTD	S	20041231	84,750,000	0.0033
KIR	KAIROS INDUSTRIAL HLDGS	C	20041231	83,188,181	0.0032
RTN	REX TRUEFORM CL CO -N-	C	20041231	79,813,570	0.0031
SUM	SPECTRUM SHIPPING LTD	C	20041231	76,500,000	0.0030
PSC	PASDEC RESOURCES SA LTD	C	20041231	75,551,340	0.0029
PNC	PINNACLE TECH HLDGS LTD	C	20041231	74,563,293	0.0029
SAL	SALLIES LTD	C	20041231	71,962,492	0.0028
LNF	LONDON FIN INV GRP PLC	C	20041231	71,829,321	0.0028
WLN	WOOLTRU LTD-N-	C	20041231	71,784,095	0.0028
DEC	DECILLION LTD	C	20041231	71,294,647	0.0028
CCL	COMPU CLEARING OUTS LTD	C	20041231	69,666,894	0.0027
OLG	ONELOGIX GROUP LTD	C	20041231	69,160,830	0.0027
SVN	SABVEST LTD -N-	C	20041231	65,204,664	0.0025
BRT	BRIMSTONE INVESTMNT CORP	C	20041231	61,689,917	0.0024
SBG	SIMEKA BSG LTD	C	20041231	60,750,000	0.0024
SCH	STOCKS HOTELS AND RESORT	S	20041231	59,000,000	0.0023
FVT	FAIRVEST PROPERTY HLDGS	C	20041231	58,705,802	0.0023
JDH	JOHN DANIEL HOLDINGS LTD	C	20041231	58,019,759	0.0023
CNX	CONAFEX HLDGS SOCIE ANON	C	20041231	56,911,596	0.0022
BSR	BASIL READ HLDGS LTD	C	20041231	56,202,000	0.0022
WLO	WOOLTRU LTD ORD	C	20041231	54,534,832	0.0021
ERM	ENTERPRISE RISK MNGMENT	C	20041231	52,504,061	0.0020
PPE	PURPLE CAPITAL LTD	C	20041231	52,267,500	0.0020
AON	AFRICAN AND OVERSEAS - N-	C	20041231	50,687,205	0.0020

AFO	AFLEASE GOLD LTD	C	20041231	50,589,573	0.0020
ABO	ABSOLUTE HOLDINGS LTD	C	20041231	50,287,767	0.0020
LAB	LABAT AFRICA LTD	C	20041231	46,103,637	0.0018
VKG	VIKING INV AND ASSET MAN	S	20041231	45,458,051	0.0018
SIM	SIMMER AND JACK MINES	C	20041231	44,964,749	0.0018
HWA	HWANGE COLLIERY LD ORD	C	20041231	41,546,920	0.0016
TMT	TREMATON CAPITAL INV LTD	C	20041231	39,312,000	0.0015
DMR	DIAMOND CORE RESOURCES	C	20041231	38,876,357	0.0015
SBV	SABVEST LTD	C	20041231	38,118,407	0.0015
STA	STRATCORP LTD	C	20041231	37,407,499	0.0015
YRK	YORK TIMBER ORG	C	20041231	34,225,540	0.0013
KNG	KING CONSOLIDATED HLDGS	C	20041231	32,634,877	0.0013
NCS	NICTUS BEPERK	C	20041231	32,066,100	0.0012
IFW	INFOWAVE HOLDINGS LTD	C	20041231	31,051,188	0.0012
MKX	MILKWORX LTD	C	20041231	29,442,124	0.0011
FRT	FARITEC HOLDINGS LTD	C	20041231	28,977,378	0.0011
HAL	HALOGEN HLDGS SOC ANON	C	20041231	27,960,390	0.0011
ALX	ALEX WHITE HOLDINGS LTD	C	20041231	27,186,921	0.0011
ICC	INDUS CREDIT CO AFRICA H	C	20041231	26,833,352	0.0010
ALJ	ALL JOY FOODS LTD	C	20041231	26,565,000	0.0010
PMV	PRIMESERV GROUP LTD	C	20041231	26,412,548	0.0010
CAE	CAPE EMPOWERMENT TRUST	C	20041231	26,014,586	0.0010
NMS	NAMIBIAN SEA PRODUCTS LD	C	20041231	25,571,817	0.0010
VTL	VENTER LEISURE AND COMM	C	20041231	25,247,547	0.0010
EUR	EUREKA IND LTD ORD	C	20041231	25,224,000	0.0010
DON	DON GROUP LTD	C	20041231	23,558,824	0.0009
ITR	INTERTRADING LTD	C	20041231	23,000,000	0.0009

BDM	BUILDMAX LTD	C	20041231	22,993,098	0.0009
MNY	MONEY WEB HOLDINGS LTD	C	20041231	22,950,000	0.0009
MSS	MARSHALLS LTD	C	20041231	20,029,152	0.0008
SLO	SOUTHERN ELECTRICITY CO	C	20041231	19,231,860	0.0007
EXO	EXXOTEQ LTD	S	20041231	19,200,000	0.0007
NAN	NEW AFRICA INVESTMNT-N-	C	20041231	18,388,758	0.0007
BIC	BICC CAFCA LTD	C	20041231	18,360,000	0.0007
BEG	BEIGE HOLDINGS LTD	C	20041231	16,925,931	0.0007
ISA	ISA HOLDINGS LTD	C	20041231	16,721,079	0.0007
KLK	KELGRAN LTD	C	20041231	15,045,470	0.0006
IDQ	INDEQUITY GROUP LTD	C	20041231	14,604,000	0.0006
TOT	TOP INFO TECHNOLOGY HLDG	S	20041231	13,767,055	0.0005
RCO	RARE EARTH EXTRACTION CO	S	20041231	13,662,000	0.0005
IND	INDEPENDENT FINANCIAL SE	C	20041231	13,600,000	0.0005
SPA	SPANJAARD LTD	C	20041231	13,395,000	0.0005
RTO	REX TRUEFORM CLOTH ORD	C	20041231	13,221,412	0.0005
PAL	PALS HOLDING LTD	C	20041231	12,000,000	0.0005
ADW	AFRICAN DAWN CAPITAL LTD	C	20041231	10,604,953	0.0004
SJL	S AND J LAND HOLDINGS	C	20041231	10,520,000	0.0004
CRW	CORWIL INVESTMENTS LTD	S	20041231	9,749,580	0.0004
CND	CONDUIT CAPITAL LTD	C	20041231	9,522,751	0.0004
GLL	GLOBAL VILLAGE HLDGS LTD	C	20041231	9,409,783	0.0004
CMA	COMMAND HOLDINGS LTD	C	20041231	9,000,000	0.0004
QUY	QUYN HOLDINGS LTD	C	20041231	8,400,894	0.0003
ICT	INCENTIVE HOLDINGS LTD	S	20041231	8,243,973	0.0003
ALC	AMLAC LTD	S	20041231	8,190,000	0.0003
RNT	RENTSURE HOLDINGS LTD	S	20041231	8,087,586	0.0003

SQE	SQUARE ONE SOLUTIONS GRP	C	20041231	7,920,000	0.0003
ILT	INTERCONNECTIVE SOLUTION	C	20041231	7,847,000	0.0003
TBX	THABEX EXPLORATION LTD	C	20041231	7,653,099	0.0003
MFL	METROFILE HOLDINGS LTD	C	20041231	7,407,741	0.0003
HCL	HERITAGE COLLECTION HLDG	C	20041231	7,113,030	0.0003
SNG	SYNERGY HOLDINGS LTD	C	20041231	7,073,287	0.0003
NEI	NORTHERN ENG IND AFR LTD	S	20041231	6,721,449	0.0003
APE	APS TECHNOLOGIES LTD	S	20041231	6,575,000	0.0003
ITG	INTEGREAR LTD	S	20041231	6,282,095	0.0002
AOO	AFR AND OSEAS ENTER ORD	C	20041231	5,937,500	0.0002
VST	VESTA TECHNOLOGY HOLDNGS	C	20041231	5,922,000	0.0002
ZPT	ZAPTRONIX LTD	C	20041231	5,792,221	0.0002
SFA	SHOPS FOR AFRICA LTD	S	20041231	5,769,177	0.0002
VIL	VILLAGE MAIN REEF G M CO	C	20041231	4,854,756	0.0002
DYM	DYNAMIC CABLES RSA LTD	C	20041231	4,673,425	0.0002
STI	STILFONTEIN G M CO LTD	S	20041231	4,572,022	0.0002
SLL	STELLA VISTA TECHNOL LTD	C	20041231	4,200,000	0.0002
SMR	SAMRAND DEVELOP HLDGS LD	S	20041231	4,084,897	0.0002
SAM	SA MINERAL RESOURCES COR	C	20041231	3,742,749	0.0001
BEE	BEGET HOLDINGS LTD	C	20041231	3,578,832	0.0001
ADO	ADONIS KNITWEAR HOLDINGS	C	20041231	3,516,250	0.0001
CCG	CCI HOLDINGS LTD	S	20041231	3,475,576	0.0001
AWT	AWETHU BREWERIES LTD ORD	C	20041231	3,382,276	0.0001
MLL	MILLIONAIR CHARTER LTD	S	20041231	3,019,500	0.0001
ALD	ALUDIE LTD	S	20041231	2,661,275	0.0001
BRY	BRYANT TECHNOLOGY LTD	S	20041231	1,960,000	0.0001
BNT	BONATLA PROPERTY HLDGS	S	20041231	1,853,469	0.0001

ORE	ORION REAL ESTATE LTD	C	20041231	1,823,385	0.0001
CVS	CORVUS CAP (SA) HLDG LTD	C	20041231	1,640,882	0.0001
PAC	PACIFIC HLDGS LTD	S	20041231	1,448,578	0.0001
TRF	TERRAFIN HOLDINGS LTD	S	20041231	954,435	0.0000
PFN	CONSOL PROP AND FIN LTD	S	20041231	900,000	0.0000
AEC	ANBEECO INVESTMENT HLDGS	C	20041231	898,682	0.0000
CYB	CYBERHOST LIMITED	S	20041231	838,158	0.0000
CMG	CENMAG HOLDINGS LTD	C	20041231	768,000	0.0000
RHW	RICHWAY RETAIL PROP LTD	S	20041231	653,021	0.0000
NAI	NEW AFRICA INVEST LD ORD	C	20041231	625,262	0.0000
TRX	TEREXKO LTD	S	20041231	493,525	0.0000
CLO	CALULO PROPERTY FUND LTD	C	20041231	316,542	0.0000

(Source: Johannesburg Securities Exchange)

Appendix I: Dividends & Weightings Used for Beta Calculations

The actual units hold was calculated by dividing the initial investment of each component equally into their respective initial share price. The actual units hold per share in each subportfolios were summed, the weightings (in this case is the percentage of the units hold in portfolio) were then determined. The dividends were determined based on data provided by Standard Bank Group (2006).

Table I1: Dividends & Weightings for Balanced Portfolio

Stock Name	Actual Units Hold	Percentage	Dividends over Test Period [Cents]
AMS	7.81	0.02	2100
CLH	63.13	0.13	238
MTN	52.25	0.10	65
PPC	9.47	0.02	3840
SHP	151.7	0.30	73
WHL	214.59	0.43	63
TOTAL	498.95	1.00	

Table I2: Dividends & Weightings for Conservatives Portfolio

Stock Name	Actual Units Hold	Percentage	Dividends over Test Period [Cents]	Percentage Without VNF
ASA	21	0.13	503	0.20
BVT	22.73	0.14	369	0.21
IPL	16.29	0.10	474	0.15
RLO	46.51	0.28	433	0.44
VNF	60.5	0.35	0	
TOTAL	167.03	1.00		1.00
TOTAL Without VNF	106.53			

From Table I2, there were two sets of weightings used, one set with VNF and the other without VNF. It is because this share was de-listed on 1st March 2006, thus the analyses of the subportfolio have been separated into two parts, one that includes

VNF up to the point before it was de-listed on 1st March 2006, and the other without VNF.

The weightings without VNF have been re-calculated by dividing the actual units hold into the TOTAL Without VNF, this would not affect the market value of this portfolio yet it would consider the exclusion of VNF due to de-listing.

Table I3: Dividends & Weightings for Core Alternative Portfolio

Stock Name	Actual Units Hold	Percentage	Dividends over Test Period [Cents]
AFB	143.37	0.44	59
FSR	123.84	0.38	61
SAB	17.13	0.05	314
SBK	27.78	0.08	289
TBS	15.05	0.05	839
TOTAL	327.17	1.00	

Table I4: Dividends & Weightings for Core Portfolio

Stock Name	Actual Units Hold	Percentage	Dividends over Test Period [Cents]
AGL	18.24	0.08	1260
BAW	29.13	0.14	1314
LBT	26.53	0.13	340
PIK	109.09	0.52	114
REM	27.78	0.13	875
TOTAL	210.77	1.00	

Table I5: Dividends & Weightings for Mid-Term Portfolio

Stock Name	Actual Units Hold	Percentage	Dividends over Test Period [Cents]
BAW	17.65	0.03	1314
FSR	112.58	0.17	60.5
MUR	106.95	0.17	90
MTN	38	0.06	65
PPC	6.89	0.01	3840
RLO	42.28	0.07	433
SAB	15.57	0.02	314
SHP	110.33	0.17	73
SBK	25.25	0.04	289
TBS	13.69	0.02	839
WHL	156.07	0.24	63
TOTAL	645.26	1.00	

Table I6: Dividends & Weightings for Small Caps Portfolio

Stock Name	Actual Units Hold	Percentage	Dividends over Test Period [Cents]
BCX	328.95	0.18	52
BDE	37.29	0.02	0
DST	67.8	0.04	153
ERP	1212.12	0.65	8
FBR	232.56	0.11	30
TOTAL	1878.72	1.00	