The Capital Asset Pricing Model as a tool for investment decisions in South Africa

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ABSTRACT

The Capital Asset Pricing Model (CAPM) is widely used to estimate required equity returns to inform investment decisions. Significant empirical research has shown that the CAPM does not effectively predict the risk-return behaviour of portfolios of assets or individual assets on a number of different stock exchanges. The problem addressed here is the impact of errors in the CAPM on effective investment decisions, especially for single companies unable to diversify risk. Daily share price data for twenty companies on the JSE, as well as data for various JSE indices and government bonds, were sourced from Bloomberg for the period 1 January 2000 through 31 December 2012. The results show that the CAPM does not effectively predict the risk-return behaviour of the twenty companies considered here, and often leads to significant errors in the prediction of Net Present Value of an investment (by as much as 100%). A number of different approaches to application of the CAPM were considered, with the single firm conclusion that the longest possible data period should be used to estimate the parameter β (the factor that represents the responsiveness of the company's return relative to that of the market). The estimation of the equity premium to be used is problematic and makes application of the CAPM difficult. A multiple linear regression using a Fama and French 3-factor model showed that equity returns have a statistical correlation with equity premium, but limited ability to predict future behaviour. Investment decisions underpinned by the CAPM should be taken with consideration of the often large inherent errors.

DECLARATION

I, Bavanethan Pillay, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Business Administration in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Bavanethan Pillay

Signed at Johannesburg

On the 27th day of January 2015

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My wife Ashti and our children Adiya, Vidur, and Pranav (who joined us late in this journey) who made many sacrifices and had to deal with a father who was not always there for the better part of two years. Without your support and understanding nothing gets done

Sasol for financial support and time away from work to write examinations and take electives, and for fascinating and stimulating work opportunities which allowed me to practise the skills I gained during this MBA.

Doug Taylor, the supervisor of this research, for contextualising the work and for his dry sense of humour. A single question he posed on how individual companies make investment decisions transformed this work from a dry, academic exercise into a practical, meaningful piece of work.

Data sourced from Bloomberg, under the able guidance of Mahomed Loonat and Christopher Naidoo of Sasol Corporate Finance. Some data obtained from Standard Bank Online Share Trading.

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CHAPTER 1: INTRODUCTION

1.1 Purpose of the study

The purpose of this research is to evaluate the usefulness of the Capital Asset Pricing Model (CAPM) as a tool for making investment decisions, especially related to projects, in the South African context. Specifically, the research focuses on the efficacy of the CAPM on the Johannesburg Securities Exchange (JSE) which represents a highly volatile environment, with fluctuating inflation, interest rates, and foreign exchange rates, and with a discontinuity created by the financial crisis of 2008. Alternative models, primarily modifications of the CAPM, will be considered.

This study differs from the typical approach in the literature which considers statistical analyses of diversified portfolios of investments. The concern here is with companies who have to use the CAPM to make critical investment decisions without the ability to diversify risk across a broad market.

1.2 Context of the study

The CAPM is described in finance textbooks as one of the pillars of modern finance, with limited discussion on the shortcomings of the model (Ward 1993; Firer, Ross, Westerfield, and Jordan 2012). The CAPM is an intuitively appealing and elegant statement (Ward 1993; Ward and Muller 2012) that the return on an investment is dependent on the systematic (or market) risk inherent in the investment in that all unsystematic risk can be diversified away. Returns above the risk-free rate are linearly proportional to the amount of systematic risk built into the investment, and the factor β is used to indicate risk relative to a capitalisation-weighted market portfolio. Assumptions include those related to investor risk behaviour and time horizons, stickiness of investments, borrowing constraints, and the ability to freely trade in all assets. Goltz and Le Sourd (2010) reviewed the empirical tests of the CAPM and some of the modified forms of the CAPM. They found that empirical testing has usually led to rejection of the single-factor model initially proposed by Sharpe and Lintner in 1964. Brennan and Xia (2006) assert that assets are still most often valued using discount rates derived from the CAPM. They cite a survey of 392 chief financial officers of large corporations in which it was found that 73.5% of respondents use the CAPM for asset valuation and that few firms adjust for other risks.

The CAPM has been empirically tested in a number of different markets. The testing described by Goltz and Le Sourd (2010) was mostly in United States (US) markets, although they do refer to a study by Fama and French (1998) in which the value stock anomalies present in the US are present in 12 major non-US markets (and also emerging markets). Fernandez[1] and Bermejo (2013) showed that annual stock returns on the Dow Jones between 1989 and 2008 correlated better, in general, with β = 1 than with the calculated value of β.

A scan of recent literature reveals a number of studies conducted in emerging markets. Al Abbadi and Louzi (2010) found that there is no correlation between the βs derived from weekly and monthly data on the Amman stock exchange. Febrian and Herwany (2010) studied the impact of the Asian financial crisis of 1997 through 2001 on the performance of asset pricing models using data from the Jakarta Stock Exchange, and found that β did not effectively explain excess market returns. Homsud, Wasunsakul, Phuangnark, and Joongpong (2009) found that a Fama and French 3-factor model (see section 2.5) had better predictive ability for the risk-return correlation using data from the Stock Exchange of Thailand. Beqiri (2010) and Hanif and Bhatti (2010) showed that the CAPM has poor predictive ability in studies on the Macedonian and Karachi Stock Exchanges respectively. A fuller discussion on the application of the CAPM to smaller markets is contained in section 2.3.

The South African market creates a unique opportunity for study of the CAPM given that it is in a developing economy that has a large commodity nature. The

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[1] Pablo Fernandez, Professor of Finance at IESE Business School at the University of Navarra in Spain has written a number of reports on topics related to the CAPM such as β and equity premium. The reports can be accessed at http://papers.ssrn.com/sol3/cf_dev/AbsByAuth.cfm?per_id=12696. We focus in this report on the most relevant.

period from 2000 to 2012 contains a period of sustained growth, but also sustained volatility in market prices, foreign exchange rates, inflation, and interest rates. The financial crisis of 2008 saw the market lose some 45% of its value, and this discontinuity represents a challenge for predictive models such as the CAPM which depend on historic data to predict future behaviour.

In such a context, the application of the CAPM to value investments becomes even more problematic. In applying the CAPM it is critical to understand the level of accuracy of the answer in order to allow businesses to make rational capital allocation decisions. It is also necessary to assess whether applications of the CAPM using different approaches work better. For example, βs derived using different time-period data predict differently. Financial practitioners also need access to tools that have been tested under the conditions of the market being studied. To this end, it is important to evaluate different models to assess whether some are more robust in their ability to predict the risk-return behaviour under volatile conditions.

1.3 Problem statement

1.3.1 *Main problem*

Analyze the ability of the single-factor CAPM to predict the risk-return relationship of a volatile and discontinuous environment such as the Johannesburg Securities Exchange (JSE), and contrast with the predictive ability of different methods of application and different models.

1.3.2 *Sub-problems*

The first sub-problem is to analyse the ability of the single-factor CAPM to predict the risk-return behaviour of investments on the JSE.

The second sub-problem is to assess the variation in the prediction error using different approaches to application of the single-factor CAPM, specifically using βs derived using different frequency data or over different lengths of time and using different proxies for the risk-free rate and market portfolio.

The third sub-problem is to assess the variation in the prediction error using different models for the risk-return relationship.

1.4 Significance of the study

The study fills a gap in that a study of the predictive ability of the CAPM or other models in the South African context given the high weighting to commodities and high volatility in foreign exchange rates, interest rates, and inflation for the period in question has seen limited attention. Reddy and Thomson (2010) studied the applicability of the CAPM to South Africa, focusing on sectoral returns and using yearly interval data, and this study builds on this previous work but is different in its focus. The intent here is not a statistical assessment of whether the CAPM correlates the data, regardless of whether the correlation is marginal. Instead, the intent is to seek a practical answer related to the application of the CAPM for individual companies without the ability to diversify risk. The effect of a discontinuous event such as the financial crisis of 2008 creates challenges for the applicability of the CAPM or other models.

The study will provide guidance to analysts evaluating investment opportunities, with a focus on projects, in South Africa by providing an estimate of the error to be expected in applying the single-factor CAPM in the South African context. This will enable better financial decisions since the error in the predictions will allow financial managers to evaluate the potential downside (or upside) on an investment much more meaningfully than would be possible with current understanding. With better understanding, analysts could choose to apply the CAPM differently, or to use different models with more robust predictive ability.

Academics and theorists in the field of asset pricing could use the outcomes of this study to add to the empirical evidence to be used for the development of improved models for asset pricing.

1.5 Delimitations of the study

- The study is restricted to JSE data between 2000 and 2012.

- The risk-return behaviours of twenty selected companies on the JSE are studied. The conclusions are valid for those companies, and are not generalizable to other companies.

1.6 Definition of terms

No terms need clarification.

1.7 Assumptions

- The JSE ALSH (All Share Index) is a meaningful proxy for the market, and the R157 government bond is a meaningful proxy for the risk-free rate. These assumptions will be tested as part of the study, but most of the results will be based on these assumptions.

- The period 2000 – 2012 is a representative period for the South African economy. With the world economy experiencing significant change during this period, including decreasing tariff barriers and increasing commodity demand as well as unprecedented cross-border liquidity, the quantitative outcomes of this study will be relevant as long as similar conditions prevail in the global and domestic economy. A significant political change could also invalidate the outcomes. The qualitative outcomes will probably remain valid.

- Sufficient data exists to estimate the returns of companies in the forms of dividends and capital returns, and adjustments can be made for share splits.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

The literature related to the formulation and the theoretical basis of the CAPM is reviewed. A number of empirical studies of the CAPM, both on developed markets and small and developing markets, are examined. In doing so, the equity premium puzzle is discussed since it is one of the key inputs into the CAPM. The application of the CAPM in theory and in practise is discussed, with the emphasis on the South African context. In doing so, the choices that are typically made in applying the CAPM are mentioned, together with some alternatives suggested in the literature. Alternative formulations of the CAPM are then examined, including the Black zero-beta model and the Intertemporal CAPM and its special formulation as the Consumption CAPM. The Fama and French 3-factor model developed to explain anomalies in the CAPM is discussed, and this literature review is closed with a discussion of the Arbitrage Pricing Theory for completeness.

Throughout this literature review, literature relevant to the JSE and emerging markets is discussed where this is available, since emerging markets create additional challenges for the models (liquidity, for example).

2.2. Background discussion

The quantitative modelling of the risk-return behaviour of markets is of significant importance to investment decisions, and the subject of this report relates to the levels of error introduced by these models. Specifically, the understanding of how well the models support good investment decisions is sought. The Capital Asset Pricing Model (CAPM) underpins much of the quantitative modelling, and it is appropriate to start with a discussion of the CAPM.

According to Goltz and Le Sourd (2010) and Ward (1993) the Capital Asset Pricing Model (CAPM) was formulated by Treynor, Sharpe, and Lintner in the

1960s. The principle of the CAPM is that a portfolio diversified by selecting investments in ratio to their market capitalisation will only be exposed to the systematic risk of investing in the market. That is, company-specific risk can be diversified away, and investors will not be rewarded for taking on unsystematic risk. The return for a certain degree of risk can be described by a straight line, where (Ward 1993)

$$r_e = r_f + \beta(r_m - r_f)$$

where r_e = expected return on any share

r_f = the expected risk free-return (such as government bonds)

β = the market risk of the particular share

r_m = the expected return on the market as a whole

$r_m - r_f$ = the equity market premium

This is the single-factor CAPM, and can also be seen to be a definition of β, which can be interpreted as a measure of volatility of an individual share relative to the volatility of the market as a whole. Technically, β is defined as (Fama and French 2004)

$$\beta = \frac{\mathrm{cov}\,(r_\mathrm{e}, r_\mathrm{m})}{\sigma^2(r_\mathrm{m})}$$

That is, β is the variance of a given equity relative to the movement of a representative market. Given a specific equity in a specific market, β has different values:

$\beta = 1$	The equity tracks the market exactly
$\beta > 1$	The equity is more volatile than the market, and reacts more strongly to stimuli

$\beta < 1$	The equity is less volatile than the market, and reacts less strongly to stimuli
$\beta < 0$	The equity moves counter to the market. As the market increases, the equity typically decreases

Throughout this work, β is evaluated as the covariance of a specific equity relative to the market proxy following the definition. β could also be calculated by linear regression of the return of the specific equity against the market, and this methodology was suggested in a Strategic Finance course taught as part of the Wits Business School Master of Business Administration (MBA) Program (Spencer-Young 2011). Strugnell, Gilbert and Kruger (2011) refer to the βs estimated in this manner as market model βs, as opposed to the CAPM βs used in this work.

There has been substantial criticism of the CAPM, both empirically and from a theoretical perspective. This body of literature has been reviewed by Goltz and Le Sourd (2010) and Fama and French (2004). Criticisms are either theoretical and address the assumptions in the model, or empirical in that the CAPM is shown to poorly predict the risk-return behaviour of markets. In recent times, there have been a number of tests of application of the CAPM to different markets. The empirical tests are discussed further in section 2.3.

As explained by Fama and French (2004), the model is underpinned by three basic assumptions. Investors choose mean-variance efficient portfolios which maximize return for a certain level of variance (or minimize variance for a certain level of return). There is complete agreement in that all investors will agree at time t – 1 on the portfolio that will be mean-variance efficient at time t. Finally, the model assumes unlimited borrowing and lending at a risk-free rate. These are all fairly restrictive assumptions, and in section 2.5 attempts to relax some of these assumptions are discussed.

As discussed by Fama and French (2004) tests of the CAPM are really tests of the application, rather than of the theory itself. Goltz and Le Sourd (2010) suggest that a true market portfolio would require all assets to be considered and not just equity. A meaningful market is a portfolio consisting not just of stocks and bonds but also of property and human and intellectual capital, with a requirement that all of these assets are liquid and freely tradable. Empirical tests assume proxies for the market portfolio and the risk-free rate. Also, the model uses historical data to predict future behaviours (*ex ante* predictions drawn from *ex post* data), and especially cannot deal with macroeconomic changes that would invalidate future predictions. The CAPM also assumes no transaction costs and taxes or costs of information and analysis. It assumes an efficient market where all information is built into the prices, and there is no asymmetric information. The theory also works better in mature markets, and smaller markets characterised by thin trading and liquidity issues will challenge the model.

Many companies use a required rate of return at some premium to their weighted average cost of capital (WACC) in making investment decisions. The WACC is a weighted average of the rate of return on debt (after tax on the interest) and equity (as modelled by the CAPM), or the weighted average of the returns required on different sources of funding. Textbooks suggest that the Net Present Value (NPV) of an investment, obtained from a discounted cash-flow analysis, is the best way to assess an investment (Ward 1993; Firer *et al.* 2012). This ignores fundamental questions of the equity market premium or debt-to-equity ratios changing over the life of the investment, or the need to re-invest all cash flows in investments having an identical risk and return as the current investment . In this report, the focus is on the potential error introduced by using models such as the CAPM to estimate the required rate of return.

Another major area of application of the CAPM theory is in the development of the principles of portfolio management and balancing of risk and return. Black and Scholes (1974) discuss early attempts by Wells Fargo Bank to develop market funds and the rationale behind these beginning with the CAPM.[2] While not an explicit focus of this study, the conclusions on the ability of the CAPM to

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[2] At the time, the main challenges were about dealing with government restrictions and the costs of selling the product.

predict the risk-return behaviour of the South African market could be used to assess the efficacy of using index funds or passive portfolio management to follow the optimal risk-return profile. However, the more conventional portfolio approaches, such as that of Reddy and Thomson (2010), would be more meaningful for this assessment.

It is beyond the capacity or scope of this report to comprehensively review the vast body of literature on the CAPM that has built up over the almost half century since its formulation. It is clear from the discussion above or from finance textbooks that the CAPM underpins much of the theory and practise of corporate finance. The focus here remains on the application of the CAPM and derivative models to predict the risk-return behaviour of single investments on the JSE, in order to build an understanding of the levels of error that the CAPM can introduce into investment decisions.

2.3. CAPM as a model of the risk-return behaviour of the JSE

As discussed by Black (1972) and French and Fama (2004), Black, Jensen and Scholes studied 100 common stocks on the New York Stock Exchange using data from the period 1926 – 1966 and found that the model overpredicted the returns for portfolios with high levels of β and *vice versa*. The model did suggest higher returns for higher β portfolios, but the dependency was much smaller than predicted by the CAPM.

Fama and Macbeth (1973) empirically tested a two-parameter model using New York Stock Exchange common stock data from January 1926 through June 1968. They found that the hypotheses on the general form of the two-parameter model could not be rejected. That is, they found support that the risk-return behaviour is linear, that there were no systematic effects of risk that were not included in β, and that there was a positive correlation between risk and return. However, when they added the assumption of unlimited borrowing and lending at a risk-free rate, as required by the CAPM, they found that the results were ambiguous.

Goltz and Le Sourd (2010) and Fama and French (2004) give reviews of the empirical testing. In general, the results in the Black, Jensen and Scholes and Fama and Macbeth studies are found to be replicated. The regressions consistently find that the intercept is higher than the risk-free rate and the slope of the line is too low.

Mehra (2006) reviews the literature on the equity premium puzzle, which is in essence an empirical test of part of the CAPM. That is, the equity premium is the required excess return on top of the risk-free rate for taking on the systematic risk of investing in equity, and is a key input into the CAPM. The equity premium for the United States was estimated from historical data as 6.36%, and similar premiums apply in other markets. However, neoclassical economic theory in terms of the utility of buying an asset or receiving returns for consumption predicts an equity premium of just 1%. This is mentioned here to indicate another area where the CAPM is ambiguous in nature and shows limited correlation between prediction and empirical data.

While the equity premium for the chosen market portfolio is an outcome of this study, this will not be further analysed in terms of economic theory. Favish and Affleck-Graves (1987) used various statistical modelling techniques to create models to predict future equity premia on the JSE, using data from the first quarter of 1960 to the third quarter of 1985. They found that the average equity premium over this period was 12.3%, using a South African treasury bill as a proxy for the risk-free rate. These authors found that there were substantial fluctuations of equity premium over this period, with maximum values as high as 28% and an anomalous period of negative returns during 1984 – 1985 reflecting very high interest rates at the time. There have been substantial historic changes between the period studied by Favish and Affleck-Graves and the period proposed for this study, and while their results might not be directly comparable the contrasts will be of interest given that the commodity basis and volatile nature of the South African market has not changed significantly.

While most studies appear to have been done on major stock markets, a number of empirical studies on emerging markets and smaller stock markets have been reported in recent years, as was briefly touched on in Chapter 1.

These might be of more relevance to this work. Of particular relevance to this study is the work by Reddy and Thomson (2010) which looked at the application of the CAPM to South Africa. These authors examined quarterly JSE data from 30 June 1995 through 30 June 2009, and assessed the applicability of the CAPM using sectoral returns or returns on portfolios of sectors given the actuarial focus of the study. They used a money-market index as a proxy for the risk-free rate and the JSE All-Share Index (ALSH)[3] as a proxy for the market. They compared the effect of both prior and in-period βs and also tested a zero-beta form (discussed in section 2.4) and non-linear forms of the CAPM, and for all the forms the results are inconclusive even if the models cannot be rejected statistically. They find that while the CAPM could be rejected for certain periods the model could be used for long-term actuarial modelling. Although the data better support the zero-beta form they feel that the single-factor CAPM carries the advantage of simplicity. Van Rensburg and Robertson (2003b) find a negative correlation of return with β on the JSE, in clear contradiction of the CAPM. This study, and others related to it, is discussed further in section 2.5.

The CAPM has been empirically tested in a number of different markets. Most of the testing discussed so far was on United States (US) markets, and a study by Fama and French (1998) showed that value stock anomalies present in the US are present in twelve major non-US markets (and also emerging markets). Annual stock returns on the Dow Jones between 1989 and 2008 were shown to correlate better, in general, with β = 1 than with the calculated value of β (Fernandez and Bermejo 2013).

Fernandez (2013a) calculated βs for each day of 2001 for 106 companies on the Madrid Stock Exchange (using 5-year monthly data ending on that day) and found significant variation – on average, the maximum β was 2.4 times the minimum β. A similar exercise for 3,813 US companies showed similar variations – the difference between maximum and minimum βs was more than

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[3]The JSE ALSH is a market capitalisation weighted index, comprising shares making up 99% of the total market capitalisation of the JSE on a free-float basis.

1 for 1,500 companies. Fernandez concludes that historical βs cannot be meaningfully used to calculate returns.

A scan of recent literature reveals a number of studies conducted in small or emerging markets.

Using daily prices for 64 stocks on the Amman Stock Exchange between 2003 and 2005, Al Abbadi and Louzi (2010) found that the CAPM could only explain 3.4% of the market return. They also found that there was no correlation between the βs derived from weekly and monthly data.

Febrian and Herwany (2010) studied the impact of the Asian financial crisis of 1997 through 2001 on the performance of asset pricing models using data from 1992 through 2007 from the Jakarta Stock Exchange, and found that β did not effectively explain excess market returns. They split their data up into three periods: pre-crisis, crisis, and post-crisis periods. Interestingly, they found that a consequence of the crisis was that larger companies had higher βs. They found that the Abitrage Pricing Theory (see section 2.5) with the exchange rate and spread between central bank and commercial bank rates as variables better represented the risk-return behaviour of the Jakarta Stock Exchange.

Beqiri (2010) tested the validity of the CAPM on 31 of the 37 stocks listed on the Macedonian Stock Exchange using data between 2006 and 2009, and found limited validity.

Homsud, Wasunsakul, Phuangnark, and Joongpong (2009) found that a Fama and French 3-factor model (with equity premium, size, and book-to-market ratio as variables) had better predictive ability for the risk-return correlation using 2002 – 2007 data from the Stock Exchange of Thailand.

Choudhary and Choudhary (2010) investigated the returns on 278 companies on the Bombay stock exchange using monthly data from January 1996 to December 2009. They found the critical requirement of the CAPM that higher risk correspond to higher return was not met, and concluded that β was not sufficient to explain the excess returns on individual securities or portfolios.

Hanif and Bhatti (2010) regressed the yearly returns for 60 companies listed on the Karachi Stock Exchange between 2003 and 2008 and found that the CAPM could not, in general, predict the risk-return behaviour.

Roodposhti and Amirhosseini (2010) showed that the CAPM was poor in predicting the average return of 70 companies on the Teheran Stock Exchange between 2000 and 2007. They found that a revised CAPM model containing a correction factor for the leverage of a company was more successful in predicting returns than the conventional CAPM.

Wakyiku (submitted) used monthly data for a 33-month period between March 2007 and December 2009 for 10 of the 11 companies listed on the Ugandan Stock Exchange (the 11th was listed too late to have meaningful data for the study) to test the applicability of the CAPM. While the CAPM could not be statistically rejected, it explained only a minor part of the variance in the return.

2.3.1 Research Question 1

The ability of the single-factor CAPM to predict the risk-return behaviour of the JSE will be tested.

2.4. Different approaches to application of the CAPM

Nel (2011) examined the results of a 2008 PriceWaterhouseCoopers (PWC) survey on practical approaches in South Africa to equity valuation. The number of respondents was small (25). The survey found that all of the respondents primarily used the CAPM, with overwhelming preferences for the R157 government bond as the risk-free rate. 96% of the respondents indicated that they used historical βs rather than forecast βs, with most using βs sourced from Bloomberg, UCT/Cadiz, or McGregor BFA. The primary purpose of Nel's study was to assess how closely practioners followed academic teaching, and he formed consensus opinions of academia based on a survey of 35 chartered accountants currently teaching finance. While there is broad agreement that the CAPM should be used for valuation purposes and on the sources of β, there are disagreements between academics and practitioners on the choice of a proxy for the risk-free rate. Academics also suggest the use of a CAPM adjusted for risk factors.

Correia and Cramer (2008) received 28 responses (representing 15% of the top 150 companies on the JSE). 82% of the companies always or almost always use the Net Present Value (NPV) method for project evaluation, compared to 30 – 35% of companies indicating that they used some sort of Discounted Cash Flow (DCF) method in two surveys conducted in the early 1990s. Similar surveys showed equivalent usage of NPV in the USA. The survey found that about 71% of companies estimate their cost of equity and this is exclusively by the use of the CAPM, consistent with the 2005 PWC study.[4] Companies typically use a long-term government bond yield as the risk-free rate (in this survey largely the R153 and R157, given maturity of the R153 in August 2010 and the R157 in September 2015). The mean value for the equity premium was 5.35% with a median value of 5%. Companies largely use published βs (Bloomberg, UCT/Cadiz, McGregor BFA), about 83% use a company β rather than a sectoral or project one, and only about 44% of companies adjust the calculated β. About 77% of companies use the ALSH and about 23% of companies use the FNDI as a proxy for the market.[5] The JSE bias towards resource companies which typically have higher βs means that the βs of companies in other sectors are dampened. The survey also found that 53% of companies add a risk premium to the estimated equity, which the authors postulate to be an imprecise way to adjust for the weaknesses.

These surveys highlight that use of the NPV method for project evaluation and the CAPM for cost of equity capital estimation is deeply entrenched in both theory and practise in South Africa, but that there is not necessarily agreement on how to apply the CAPM.

More recently, Jacobs and Shivdasani (2012) discuss the results of an Association of Financial Professionals (AFP) survey of its 15,000 members. Of

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[4] In an earlier survey, it was found that about 35% of respondents used the cost of the specific source of financing for project evaluation.
[5] The FNDI is a financial index comprising the top 30 financial and industrial shares on the JSE.

the 300 respondents, 79% were in the United States and Canada. More than 80% use discounted-cash flows and more than 90% use the CAPM to estimate their cost of capital. As in the South African results, there are substantially different approaches used in estimating cost of capital. While most use U. S. treasury rates as the risk-free rate, there is a significant spread in the maturity terms chosen as representative (46% use the 10-year rate, 12% use the 5-year rate, 11% use the 30-year rate, and 16% use the 3-month rate). There is a spread of almost 4% in the equity premiums used (about half use 5 – 6%, some use less than 3% and others use numbers as high as 7%). In terms of time periods used to calculate β, there is a spread of five years (41%), three years (15%), two years (13%), and one year (29%). There are other significant variations in estimation of debt costs and debt-to-equity ratios and the investment time period used for evaluation, but these are the ones of most significance to this work.

Fernandez (2013b) received 2,510 responses from professors in 65 countries, of which 1,791 use βs (more than 70%). The comments in the paper are perhaps more revealing than the numbers, in that many of the respondents acknowledge the problems with using β but do not see clear alternatives.

Bradfield (2003) provides guidelines for practitioners calculating βs in a South African context where allowances for thin trading have to be made. He recommends the ALSH as a market proxy, with a Bayesian adjustment for regression bias and suggests that monthly data are used in the regression. Al Abbadi and Louzi (2010) calculated βs using weekly and monthly data from the Amman stock exchange but found that there was no correlation between these. Fernandez (2013a) found significant differences in the βs calculated on 30 September 2003 and 31 December 2000 for four large US companies (Coca Cola, PepsiCo, AT&T and Merck) using data of different periods and frequency and choice of market proxy. The choices of the proxy for risk-free rate and appropriate periodical data to calculate β can clearly lead to different results, and these will be investigated further in this study.

Barr and Bradfield (1988) used an estimator for the βs of thinly-traded shares which defaulted to the ordinary least squares (OLS) estimator for well-traded shares. They found that portfolios on the JSE (using data from January 1974 to January 1985) based on this modified approach to the CAPM performed better in 6 out of 7 periods than those devised using the standard approach. Bowie and Bradfield (1998) extended this work to assess the efficiency of 8 different robust estimators using data from the JSE for 3 different 5-year periods (1980 – 1984, 1985 – 1989, 1990 – 1994). They found that OLS tended to overestimate βs, and they recommend the use of robust estimators for thinly-traded shares.

Another area of application that could lead to significantly different results is in determining a proxy for the market. This is clearly one of the critical gaps in the CAPM, and was discussed in section 2.2. According to Correia and Cramer (2008), about 40% of the market capitalisation on the JSE is resource-based, and resources stocks are typically volatile and tend to dampen the relative response of the non-resource based stocks. Given the difficulty in putting together a meaningful market index (discussed in section 2.2), the opportunity is used to test the opposite concept – that the representative market for a company is one comprising the companies in the same or adjacent sectors with similar profiles. This inherently tests the concept of using sectoral indicators. While the JSE ALSH will be used as the general representation of the market proxy, proxies for each company of which they are a meaningful (but not overly dominating) part of the index are chosen.

2.4.1 Research Question 2

The effects of using weekly returns rather than monthly returns to calculate β, as well as one-year, three-year and five-year βs and different proxies for the risk-free rate and market will be investigated.

2.5. Alternative formulations of the CAPM

Given the limitations of the CAPM, there have been a number of variations proposed. The key thinking behind the most notable variations is discussed. Empirical correlations that have proved successful in predicting risk-return behaviour are also discussed.

Black (1972) proposed a zero-beta version of the CAPM, which relaxed the assumption of limitless borrowing and lending at the risk-free rate by allowing for unlimited short selling of risky assets. As discussed by Fama and French (2004) both assumptions are equally unrealistic, and the assumption of mean-variance efficiency is true for both formulations. What this translates to is that what is termed the risk-free rate in the CAPM is taken to be the excess return on a minimum-variance zero-β portfolio. Then, every efficient portfolio is a weighted combination of the market portfolio and this minimum-variance zero-β portfolio. The early tests of the Black version of the CAPM have shown that this model is a good description of the risk-return behaviour, but this version has also been challenged by later tests (Fama and French 2004). This version has been tested by Reddy and Thomson (2010) in a South African context, and has been found to be a marginally better predictor than the one-factor CAPM. For the purposes of this study, the restrictive assumptions, the portfolio nature of the theory, the similar formulation to the CAPM, and the lack of significant positive empirical results make this formulation of limited interest and it will not be further considered in this work.

Merton (1973) relaxes the static nature of the CAPM in developing the Intertemporal CAPM (ICAPM). In this model, he takes the utility function of an investor to respond to changing investment conditions (determined by state variables such as labour rates, prices of consumption goods, investment opportunities and expectations on these state variables after time *t*) across periods, in contrast to the CAPM which assumes a constant utility function (Fama and French 2004). In his model, trading takes place continually rather than at discrete times at the end of periods, and an investor's decisions at $t - 1$ are based on a view of the state variables at *t*. Raputsoane (2009) found that for 45 of the 50 JSE indices he considered using data between 1995 and 2009 (but with different periods for different indices), the hypothesis of a positive relationship between return and equity premium as stated in the ICAPM is satisfied.

Breeden (1979) shows that Merton's multi-β formulation of the ICAPM can be simplified to a single β formulation, where β is the covariance of the return with aggregate consumption. Grossman and Shiller (1981) come to a similar result in suggesting that returns that come in periods of high consumption are less valued, and suggested that it would be sufficient to use per capita consumption figures to predict the return. This thinking has led to the Consumption CAPM (CCAPM), which has not performed particularly well in empirical testing. Empirical testing of the CCAPM in industrialized and developing markets (Jordan, Turkey, and Pakistan) has not proved successful (Cashin and McDermott 1998). The ICAPM and CCAPM are not considered further in this work, since in both these models the ambiguity is transferred to another parameter and there is no empirical testing that shows that these models perform better than the CAPM.

A number of empirical regressions have shown that return correlates better with factors such as price-to-earnings ratio, firm size, book-to-market ratio, and leverage than with β (Fama and French 1993). Banz (1981) suggests that the CAPM is mis-specified in that the size effect is better able to explain the return behaviour than β. Fama and French (1993) show that a 3-factor model using firm size (size premium), book-to-market ratio (value premium) and the excess market premium (equity premium) was sufficient to explain the returns on stocks. The Fama and French 3-factor model is not derived from a theoretical foundation, but rather can be argued as being based on investor perception of risk – smaller companies and value companies might be seen as lower profitability and more likely to require higher returns because of the possibility of distress (Estrada 2011).

Shum and Tang (2005) apply Fama and French's 3-factor model to 3 Asian emerging markets (Hong Kong, Singapore, and Taiwan) and show that the model explained most of the variance in the returns, with the market return having the most significant effect (the effects of book-to-market ratio and size being small and sometimes negligible). Michailidis, Tsopoglou, and Papanastasiou (2007), using weekly data between 1997 and 2003, showed that there was a contradictory relationship between β and return on the Athens Stock Exchange but that size and book-to-market ratio explained the variance in returns.

Van Rensburg and Robertson (2003a) used the Fama and French approach to investigate the effects of 24 factors that might potentially lead to anomalies in the risk-return behaviour on the JSE. They found that a two-factor model using size and price-to-earnings ratio as explanatory variables explain the anomalies, based on data between July 1990 and June 2000. In a subsequent paper (Van Rensburg and Robertson 2003b), they found that smaller firms and those with lower price-to-earnings ratio stocks have low values of β but earn higher returns. Their study empirically contradicts the CAPM in suggesting that β is negatively correlated with return. The negative correlation of return with β is supported by Strugnell, Gilbert and Kruger (2011) who used JSE data between 1994 and 2007 to build on the Van Rensburg and Robertson work. As with Van Rensburg and Robertson, these later authors separated the JSE into portfolios of market capitalisation quintiles. They affirmed the broad findings on size and value anomalies, and found that the size effect is significant for the smallest firms on the JSE.

Ward and Muller (2012) replicated the work of Van Rensburg and Robertson (2003b) and Strugnell, Gilbert and Kruger (2011) using a much longer data set (1985 to 2011), which they ensured was more consistent and accurate than the data set of Strugnell *et al*, and a methodology they feel is simpler and better than those used by the earlier authors. They restricted their study to the 160 companies on the ALSH, which represents 99% of the total JSE capital, thereby eliminating the large number of illiquid and overly small companies. Similarly to Strugnell, Gilbert and Kruger, Ward and Muller used both ordinary-least squares and Dimson aggregated coefficients to estimate β. They separated the ALSH into five equally-weighted portfolios on the basis of β ranking. They found a negative relationship between β and returns for the period 1986 and 2004, and no relationship between β and returns for the seven-year period up to end 2011.

Hearn, Piesse, and Strange (2010) replaced the book-to-market ratio term with a liquidity term (based on trading volumes and price movements) in their comparison of the London Stock Market to those in South Africa, Egypt, Morocco, and Kenya. Using data from January 1996 to December 2007, they found that only the equity premium was statistically significant, and that the returns showed no statistically significant dependence on size and liquidity.

While it is clear that the Fama and French approach might be better viewed as an empirical correlation rather than an alternative formulation of the CAPM, its ability to better predict the risk-return behaviour makes it of interest to the underlying intent of this study to understand how to make better investment decisions. It is also simple in formulation and easy in application, suggesting that it would be usable in practise.

A model touched on here is Arbitrage Pricing Theory (APT) as discussed by Ward (1993) and van Rensburg (1997), because of its academic attractiveness. APT suggests that there is a limited, common group of systematic economic (primarily macro-economic) factors that act independently to determine the long-term return on each security or portfolio, but that the weighting of the impact of each factor is different for each security or portfolio. Roll and Ross (1980) found that the data supported the APT, but used a model containing multiple (3 or 4) unspecified factors to do this. It is clear that this is not a unique set of factors, unlike the Fama and French formulation which casts the empirical factors as measurable attributes related to each security. In this light, the APT is primarily an empirical model (van Rensburg 1997). Roll and Ross (1995) suggest a set of economic factors that could be used as factors in the APT, and mention the link between these factors and the discounted cash flow methodology.

McNulty, Yeh, Schulze, and Lubatkin (2002) identify the key issues with the CAPM as the definition of β encompassing both volatility and correlation, the reliance on historical data, and the cost of capital remaining the same regardless of holding period. They argue that the cost of capital should compensate for three types of risk. The first two, which they call the national confiscation risk (the risk that national policy will cause the loss of an investment) and the corporate default risk (losses due to mismanagement), are relatively easily quantified as the bond rate and the premium above the bond rate that companies use to secure funds. The third type of risk, the equity premiums risk, reflects the position of an equity holder as last in line for claims behind debt holders. They introduce the Market-Derived Capital Pricing Model (MCPM), which relies on market estimates of future-price volatility (through options pricing) rather than on historical data. Their results show more realistic returns than the CAPM for the relatively small set of companies they discussed.

Literature references to the MCPM are limited and there is no indication of widespread acceptance, but this does not definitively prove that the MCPM is not widespread in practice. Fink (2003), in a practice note, summarises the method and suggests that there had been some uptake through the consulting work of the original authors. The criticism mentioned is that this model, like the CAPM, makes important assumptions about the equity premium.

Correia and Cramer (2008) found that the CAPM (or some sort of modified CAPM) was overwhelmingly used for cost of capital estimation. They found no evidence for the use of the dividend-discount model, the APT, or the risk-free rate plus a premium. The Fama and French 3-factor model was not mentioned, and this is taken to mean that it is not widely used by the respondents. Fama and French-type models are widely mentioned in the literature, and examples of their use have been cited in this literature survey. Estrada (2011) suggests that it is only this three-factor model that has emerged strongly as an alternative to the CAPM.

It is not intended that this work be a comprehensive tests of models of equity returns. It is also felt that adding complexity to the models will not add significant value, in that people are less likely to use complex models. Accordingly, this work focuses on the Fama and French 3-factor model, which is structurally different but practically useable in terms of computation and data requirements. Most of the models discussed here are variations of the CAPM, and typically shift the estimation challenge to the prediction of different parameters.

2.5.1 Research Question 3

An alternative cost of capital model will be investigated. A Fama and French 3-factor model approach will be developed.

2.6. Conclusion of Literature Review

There is substantial theoretical reasoning and empirical evidence to identify the limitations of the CAPM in predicting the risk-return behaviour of various markets, including the JSE. In this context, the current empirical study might be seen as gratuitous, but the focus here is on understanding the use of the CAPM to make investment decisions, especially those related to projects. The reliability of the method is investigated, and the impacts of different means of application or alternative forms of the CAPM on decision making are evaluated. Since much of the testing has been on portfolios, the other value in this work is the focus on individual securities, since this is how the CAPM is often used in practise when making investment decisions.

The reality for any individual company is that it has to deal with non-diversified risk, and is exposed to the risks related to the company itself and the sector it is in. That is, a company does not get to invest in a diversified portfolio, yet it is this principle of diversification of risk through a properly diversified portfolio that underpins the CAPM. This seems to be a fundamental mismatch, and even if the CAPM was successful in predicting the behaviour of markets, and the literature survey shows it is clearly not, the prediction of individual company behaviour does not fit with the premises of the CAPM. The wide subscription to the CAPM for investment decisions is most probably due to its simplicity and ease of use and intellectual underpinnings, but it is critical that decisions are made with a full understanding of the limitations.

The CAPM might be limited, but it continues to be used and taught without significant consideration for its limitations. In this context, it is important to understand the level of error and uncertainty one accepts in using a simple model to predict a complex and volatile environment.

2.6.1 Research Question 1:

The ability of the single-factor CAPM to predict the risk-return behaviour of the JSE will be tested.

2.6.2 Research Question 2:

The effects of using weekly returns rather than monthly returns to calculate β, as well as one-year, three-year and five-year βs and different proxies for the risk-free rate and market will be investigated.

2.6.3 Research Question 3:

An alternative cost of capital model will be investigated. A Fama and French 3-factor model approach will be developed.

CHAPTER 3: RESEARCH METHODOLOGY

In this section, the methodology used in this work is discussed. Theory to show the sensitivity of the NPV to β is developed, since the intent is to examine the errors introduced by individual companies using the CAPM.

3.1 Research methodology/paradigm

This study will use a quantitative methodology, since it involves primarily analyses of empirical data. Most of the previous empirical studies discussed in Chapter 2 were primarily focused on statistical testing of hypotheses related to the CAPM and variants, although there were a few tests on individual equities. The focus of this study will not be on statistical testing of hypotheses, but rather on the assessment of the error introduced by using the CAPM to make investment decisions. That is, the interest here is in understanding how well the CAPM and variants predict the risk-return behaviour, rather than understanding whether there is statistical significance in the correlations.

In Chapter 2, the work of various authors was drawn on to show that the CAPM is widely used globally and in South Africa to generate an estimate of the WACC and, accordingly, the discount rate used to calculate the net present value (NPV) of an investment. This study is intended to evaluate the potential implications of the inability of the CAPM to represent the market, represented mainly through the variability in β. Accordingly, the effect of the variability of β on NPV is studied using sensitivity analysis. These analyses lie at the heart of this study, and while the focus here is on investment analyses these conclusions are readily translatable to other areas where the CAPM is used – such as valuation or portfolio management.

The NPV is defined as (Firer *et al* 2012):

$$\mathrm{NPV} = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t} - C_0$$

Where r = an appropriate discount rate

t = the time period, with T as the final time period

C_t = the cash flow from the investment for time period t (C_0 is the cash flow out in time period 0 – normally capital expenditure)

Most companies set r to be their estimated WACC to calculate the NPV of an investment. It is the sensitivity of NPV to β through the WACC that is of interest in this work.[6] This sensitivity can be expressed as the first derivative of NPV with β. Given that WACC is defined (Firer *et al* 2012):

$$\text{WACC} = \frac{E}{V}r_e + \frac{D}{V}r_d(1 - T_c)$$

where E = the equity in the business

D = the debt in the business

$V = D + E$

r_d = the required return on (cost of) debt

T_c = the applicable corporate tax rate

and with

$$r_e = r_f + \beta(r_m - r_f)$$

as shown in section 2.2, then it can be shown that

$$\frac{d\text{NPV}}{d\beta} = \sum_{t=1}^{T} \frac{C_t}{(1 + \text{WACC})^{t-1}} \frac{E}{V}(r_m - r_f)$$

where the discount rate has been set to WACC. The first derivative then gives the rate of change of NPV with β, and the higher the value the more sensitive the NPV to β.

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[6] There are a number of flaws in the discounted cash flow methodology. Some issues are the requirements to invest the cash flows in an investment having equivalent risks and returns and the assumption of a static debt/equity ratio and a simple corporate tax structure in calculating WACC. This research focuses on the errors in calculating the cost of equity capital using the CAPM these other issues are not dwelt on.

The evaluation of these numbers clearly depends on the specific investment and the specific company, and some assumptions have been made to allow quantification of the sensitivities. The approach taken to illustrate the impact of the variability in β on the NPV is discussed in section 3.4.1.

3.2 Research Design

The methodological approach was to develop mathematical models using Microsoft Excel. βs were generated by calculating the covariance of the equity relative to the chosen market, and this largely covers research questions 1 and 2.

Multiple linear regression was used to investigate Research Question 3.

3.3 Population and sample

3.3.1 Population

The population is all the companies on the JSE since its inception.

3.3.2 Sample and sampling method

A broad sample of twenty companies from different sectors and varying in size has been chosen. The choice of a broad sample allows for the identification of effects that are active across the JSE, and allows for the isolation of those effects that might be representative of just a specific sector or size sample. Given the large influence of resource stocks on the JSE, for example, it is important to consider the CAPM-behaviour of both resource and non-resource based stocks. Similarly, the firm size anomaly (Strugnell, Gilbert and Kruger 2011) suggests that the CAPM shows different predictive behaviour for the returns of small firms. Clearly, there are other characteristics that might be used to select a sample (book-to-market or price-to-earnings ratios, for example) but the current sample is thought to be broadly representative. The other important selection criteria for this sample are that companies had to be listed in the same form at the beginning and end of the sample period (1 January 2000 through 31 December 2012).

Table 1. List of companies in sample.

COMPANY	JSE SHARE CODE	SECTOR
AECI Limited	AFE	Speciality Chemicals
Anglo American plc	AGL	General Mining
Aspen Pharmacare Hldgs Ltd	APN	Pharmaceuticals
Astrapak Limited	APK	Containers & Packaging
Barloworld Limited	BAW	Diversified Industrials
BHP Billiton plc	BIL	General Mining
Bidvest Limited	BVT	Diversified Industrials
Discovery Holdings Limited	DSY	Life Insurance
Gold Fields Limited	GFI	Gold Mining
Group Five Limited	GRF	Heavy Construction
Growthpoint Prop Limited	GRT	Real Estate Holding & Development
Mr Price Group Limited	MPC	Apparel Retailers

MTN Group Limited	MTN	Mobile Telecommunications
Pick n Pay Stores Limited	PIK	Food Retailers & Wholesalers
RMB Holdings Limited	RMH	Banks
SABMiller plc	SAB	Brewers
Sanlam Limited	SLM	Life Insurance
Sasol Limited	SOL	Integrated Oil & Gas
Standard Bank Group Limited	SBK	Banks
Tiger Brands Limited	TBS	Food Products

3.4 The research instrument

3.4.1 Research Question 1

For each of the companies in the sample, βs were generated using monthly data for a rolling 3-year period finishing on the last trading day in December for each year, across the 13-year period that is under evaluation. The standard deviations of these data give a meaningful indication of the variation in β, which can then be related to the impact on NPV.

Illustrative numbers for sensitivity were generated. A hypothetical investment with a positive cash flow of a fifth of the capital for 10 years is contemplated for each of the companies in this study. Since the sensitivity of NPV to β is the parameter of interest, the actual value of the NPV and the size of the capital is not of relevance. The assumption of constant cash flows is thought acceptable for conceptual purposes.

As part of the calculation of NPV, it is necessary to choose values for the market return r_m, the risk-free rate r_f, and the equity premium $r_m - r_f$. The market return is taken as the compound-annual growth rate in the ALSH (as market proxy) for the three-year period preceding the date of the investment decision. To test changes over time, the sensitivity was calculated at the end of 2002, 2004, 2006, 2008, 2010 and 2012. As will be shown in the results section, the equity premium calculated over 3-year intervals is very volatile and is negative for extended periods. Accordingly, the equity premium is taken as the value over the 13-year period of the data. In Section 2.3, it was pointed out that the equity premium puzzle was an important concern in application of the CAPM, and the results of the calculations of the equity premium are presented in section 4.3.

Values are available for the debt:equity ratios (D/E) for these companies but these are mostly very volatile. Since the appropriate D/E to be used in a discounted-cash flow analysis is the targeted ratio, the D/E has been set at 40%. Few companies in South Africa have traded debt which makes the cost of debt difficult to meaningfully quantify, the return on debt is set to the risk-free rate plus 3%. The corporate tax rate is taken at the currently prevailing value of 28%. None of these assumptions have a significant impact on the results, and do not justify the substantial work required to refine these values. However, the fact that these assumptions need to be made also emphasizes the weaknesses in the discounted-cash flow approach to investment analysis based on the CAPM. The data show that assumptions such as a constant D/E over the investment period are very weak, since the D/E changes significantly over time periods as short as 6 months.

To contextualise the effect of the error in the CAPM on the NPV estimation, the NPV variation relating to a single standard deviation of β for each company at the end of each reporting period is reported.

3.4.2 Research Question 2

For each of the twenty companies in the sample, βs were generated using daily, weekly, and monthly data for three-year periods, compared to the default of three-year βs based on monthly data. βs were also generated using monthly data over one, three, and five year periods. The effect of using different sampling days was evaluated by calculated βs using data from the first trading day of the month rather than the last trading day that is used in the rest of this work.

As discussed in section 2.4, for all companies in this study the FNDI was tested as a market proxy alternative to the default ALSH. The use of the FNDI by 23% of the respondents to the Correia and Cramer (2008) study is believed to reflect the discomfort with use of the ALSH given the bias of the JSE to resource shares and the subsequent damping effect on non-resource shares.

This thought is extended by using indices for the companies in this study where the companies in the index are of similar profile to the company being studied or in similar or adjacent sectors, or both. Indices are selected such that there are a moderate to large number of companies represented and the company being studied does not dominate the index. For each of the different companies, alternate indices that reflect the concept of a more representative market have been chosen. This is similar to the valuation practise of using sectoral Price-to-Earnings ratio (P/E) as a means to estimate the value of the company.

The equity premium is by definition the rate of return on the market above the risk-free rate of return:

$$\text{Equity Premium} = r_m - r_f$$

The equity premiums for combinations of different market proxies and risk-free rates were estimated, allowing the testing of the validity of use of rules of thumb values for the equity premium. As discussed in section 2.4, Correia and Cramer (2008) found that the mean equity premium used was 5% with a median of 5.35%. Students are sometimes given representative values during classes on finance. As a specific example, 6% was suggested as a representative equity premium worldwide as part of a Finance course taught as part of the Wits Business School MBA Program (Taylor 2010). From a survey of the equity premiums used in 82 countries in 2012, Fernandez, Aguirreamalloa and Corres (2013) found from 73 respondents for South Africa that the average equity premium used was 6.5% with a standard deviation of 1.5% and a median of 6.0%. In a repeat of the same study in 2014, Fernandez, Linares and Fernandez Acin (2014) found similar numbers (6.3%, 1.4%, 6.0%). It is clear that numbers around 5% - 7% are commonly used as representative for South Africa.

In addition to testing the use of different frequency data over different time periods, different proxies for the risk-free rate were also evaluated. The R157 government bond was taken as the default (Correia and Cramer 2008; Nel 2011), and the impact on NPV estimation using the R153 and R186 government bonds as well as a money-market interest rate were tested (the STeFI Index - Alexander Forbes Short-Term Fixed Interest Composite Index - an index weighted on 3, 6, and 12 months and overnight calls – reported from 6 June 2003). The maturation of the R153 in August 2010 does challenge its use as a meaningful risk-free rate for this period, and the estimations using the R153 are only done until the maturity date. However, it is included here largely because of its usage in practise (Correia and Cramer 2008). The NPV is estimated using the approach and assumptions discussed in section 3.4.1, with the risk-free rate now taken as the value at the date of estimation of the NPV.

It is to be noted that according to the definition of β as the variance of a given equity relative to the movement of a representative market, β does not depend on the choice of the risk-free rate. It is the prediction of an expected rate of return that depends on the risk-free rate.[7]

For the purpose of reporting, the twenty companies being studied have been clustered into 4 groups – CAPS (consisting of companies in the Fledgling

[7] It is noted that, if the CAPM were an accurate and representative model, β for an equity or portfolio would be the slope of the straight line that would result from plotting the return on that equity or portfolio against the equity premium for a given market return and risk-free rate. While the results show that the CAPM is clearly not reliable for the time periods and data considered here, β is sometimes approximated using this method (Spencer-Young 2011).

(FLED), Small Cap (SMLC), or Mid Cap (MIDC) indices), and companies that appear in the Resource 20 (RESI), Industrial 25 (INDI), and Financial 15 (FINI) indices. The clustering is somewhat arbitrary since many companies appear in many different indices, and is largely for brevity in reporting. Tiger Brands (TBS) has been included in the CAPS grouping even though its market cap at end-2012 at R61-billion was substantially higher than the next company in our study appearing in the MIDC index (Discovery Holdings at R33-billion).

Table 2. List of JSE indices considered.

INDEX NAME	JSE CODE	NO OF COMPANIES IN INDEX
All Share	ALSH	159
Financial & Industrial 30	FNDI	30
Financial 15	FINI	15
Fledgling	FLED	100
Food	FOOD	10
Gold Mining	GLDX	5
Industrial 15	INDI	15
Midcap	MIDC	60
Resource 20	RESI	20

Small Cap	SMLC	56

Table 3. Market caps and reporting group for companies in sample.

COMPANY	INDEX	MARKET CAP AT 21 DEC 2012 (R millions)	REPORTING GROUP
AECI Limited	MIDC	9 072	CAPS
Anglo American plc	RESI	362 190	RESI
Aspen Pharmacare Hldgs Ltd	INDI	75 643	INDI
Astrapak Limited	FLED	970	CAPS
Barloworld Limited	INDI	19 567	CAPS
BHP Billiton plc	RESI	1 677 675	RESI
Bidvest Limited	INDI	69 971	INDI
Discovery Holdings Limited	FINI	33 486	FINI
Gold Fields Limited	GLDX	72 971	RESI
Group Five Limited	SMLC	3 122	CAPS
Growthpoint Prop Limited	FINI	44 135	FINI
Mr Price Group Limited	INDI	37 026	INDI
MTN Group Limited	INDI	331 324	INDI

Pick n Pay Stores Limited	INDI	21 512	INDI
RMB Holdings Limited	FINI	57 386	FINI
SABMiller plc	INDI	625 106	INDI
Sanlam Limited	FINI	94 710	FINI
Sasol Limited	RESI	232 581	RESI
Standard Bank Group Limited	FINI	191 757	FINI
Tiger Brands Limited	FOOD	61 183	CAPS

3.4.3 Research Question 3

The other major part of this work will be to test the Fama and French 3-factor model as an alternative means of estimating the cost of capital. While a number of variables that potentially explain the return on stocks can be identified (equity premium, size, book-to-market ratio, price-to-earnings ratio, leverage and liquidity), as discussed in section 2.4, Fama and French (1993) found that the size and book-to-market ratio seem to absorb the effects of price-to-earnings ratio and leverage. These authors also found that a market factor with their chosen proxies for size and book-to-market ratio were effective variables to predict the return on stock portfolios. The same approach is followed in this work, with the market capitalisation chosen as a proxy for size and the equity premium chosen as an indicator for the overall market factor. The book-to-market ratio (B/M) is added as an indicator of market perception, to stay consistent with the 3-factor model. While it might be meaningful to consider liquidity in a South African context (Hearn, Piesse and Strange 2010), this adds a layer of complexity and is beyond the scope of this work. The significant difference in this work, as is true for all of this work, is that whereas

Fama and French studied the return on portfolios, the return on individual stocks is discussed here.

The 3-factor model as written by Fama and French (2004):

$$E(r_{it}) - r_{ft} = \beta_{im}\left[E(r_{mt}) - r_{ft}\right] + \beta_{is}E(SMB_t) + \beta_{ih}E(HML_t)$$

Where the subscript *t* highlights the time-series regression nature of this correlation rather than a cross-sectional regression, and $E(r_{it})$ is the expected return on portfolio *i.* SMB_t represents the difference in returns on diversified portfolios of small stocks versus those consisting of large stocks, and HML_t is the difference in returns on portfolios with high book-to-market values and those with low values. Following a similar approach, the 3-factor model adopted in this work for individual equities is written:

$$r_e = r_f + a\left(r_m - r_f\right) + b(B/M) + c(Mkt\ cap)$$

Since the coefficients are no longer analogous to βs the symbols *a, b* and *c* are used to represent the coefficients.

In this analysis, the monthly returns on stocks are time regressed against the market capitalisation, the book-to-market ratio and the equity premium. The equity premiums used here are calculated for each monthly data point.

3.5 Procedure for data collection

The data has been sourced from Bloomberg, with some of the preliminary data sourced from Standard Bank Online Share Trading.

3.6 Data analysis and interpretation

Price and dividend data for each share on the JSE and the ALSH and long-term government bonds were gathered for the period of interest, as well as ratios of interest for each company. Weekly and monthly returns were generated using the capital gains and dividends, there being no share splits in our sample during the period of interest. The effects of share buybacks as a means of delivering returns to shareholders should appear in improvements in the share price.

3.7 Limitations of the study

The key limitation of the study is that it will not test the veracity of the CAPM, given that one is actually testing the application of the CAPM. Another major limitation is that the time period is too short to test the CAPM appropriately (Fama and French 1993). However, the conditions used do reflect the conditions under which the CAPM is used in practise.

3.8 Validity and reliability

3.8.1 External validity

The results generated here will not be readily extendable to all markets. The JSE exists in a highly volatile, commodity-based environment with fluctuating interest rates. The results might be relevant to other emerging markets, but the JSE does not necessarily share the same characteristics as other markets. However, the qualitative results should be relevant.

3.8.2 Internal validity

The biggest concern is that the results of this study are not extensible to future time periods. That is, while the error in using the CAPM to make investment decisions is better understood, the results will change as macro-economic factors change. However, the general principles that are uncovered will remain relevant even if the quantitative answers do not.

3.8.3 Reliability

As amply demonstrated in the literature review, the CAPM and its derivatives depend on the time period chosen and the application methodology, for example the time-period used to calculate β. Choices have to be made for proxies for the market and the risk-free rate and different choices will result in different outcomes. While part of this study is to test the impact of these choices, it does mean that results might be inconsistent.

CHAPTER 4: PRESENTATION OF RESULTS

4.1 Introduction

The results for the 3 research questions are presented per research question. A number of different models have been developed and results generated, and for the sake of brevity, tables or graphs are shown according to which best illustrates the result. In general, the graphs show the time-variation in the parameter under consideration whilst the tables illustrate time-averaged properties (such as averages or standard deviations of the parameters of interest). While all the results are available, in certain cases the results for all the companies are not presented to keep the length of this research report tractable.

4.2 Demographic profile of respondents

The sample was twenty companies selected across different sectors and with different sizes.

4.3 Results pertaining to Research Question 1

Figure 1 through Figure 4 show the βs for the twenty companies clustered as discussed in section 3.4.2. The βs were calculated using monthly data over a 3-year period, with the ALSH as a market proxy – this has been adopted as the base case.

In the presentation of the results, the company names are generally not written out in full in order to save space. The names are truncated to the core part of the name that should identify the company.

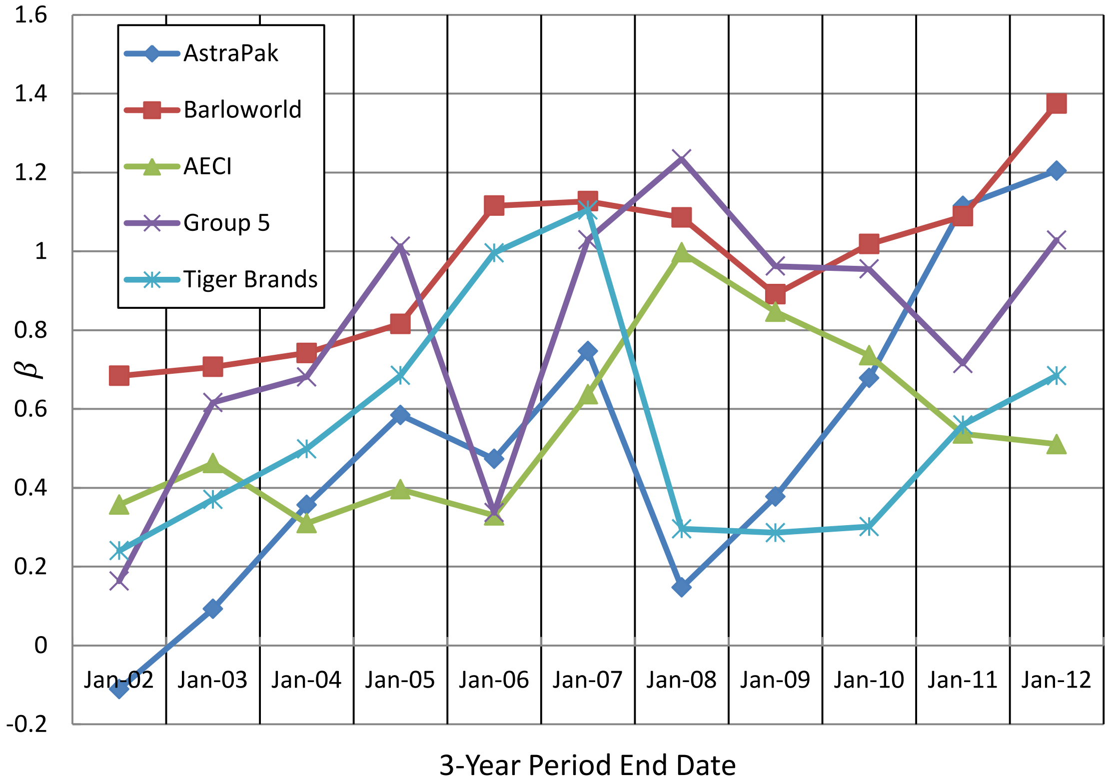

Figure 1. Base case βs for companies clustered in the CAPS Grouping

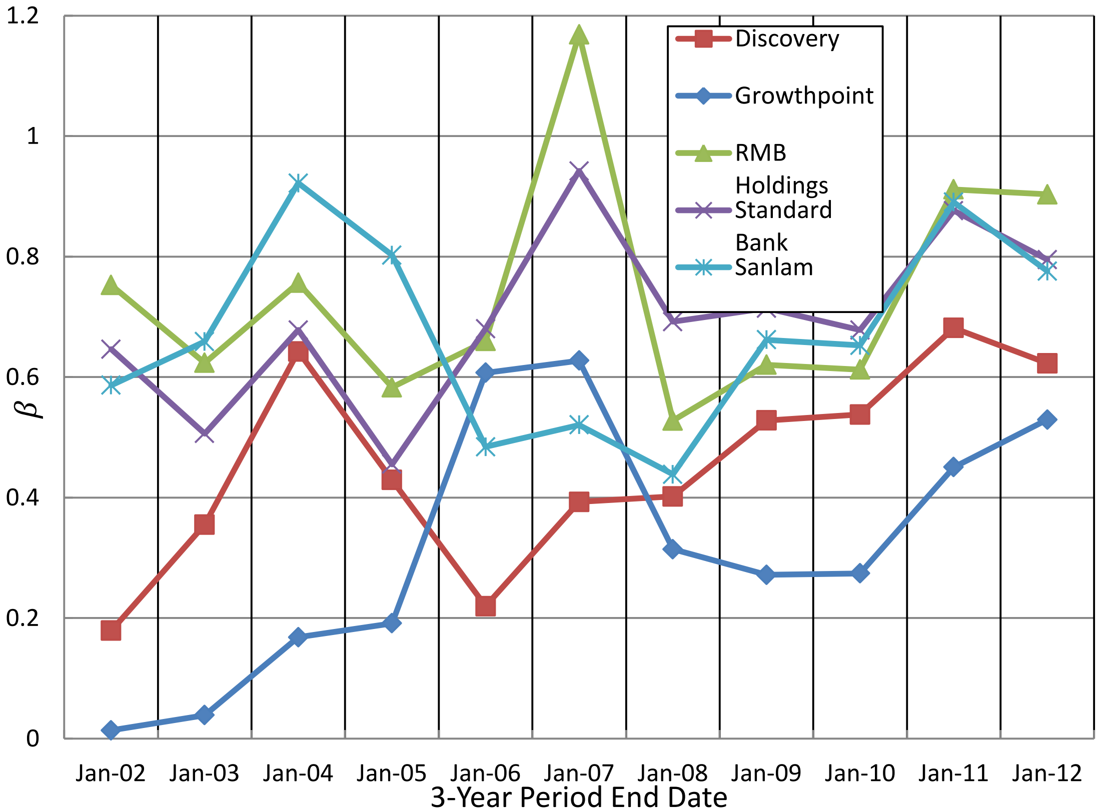

Figure 2. Base case βs for companies clustered in the FINI Grouping

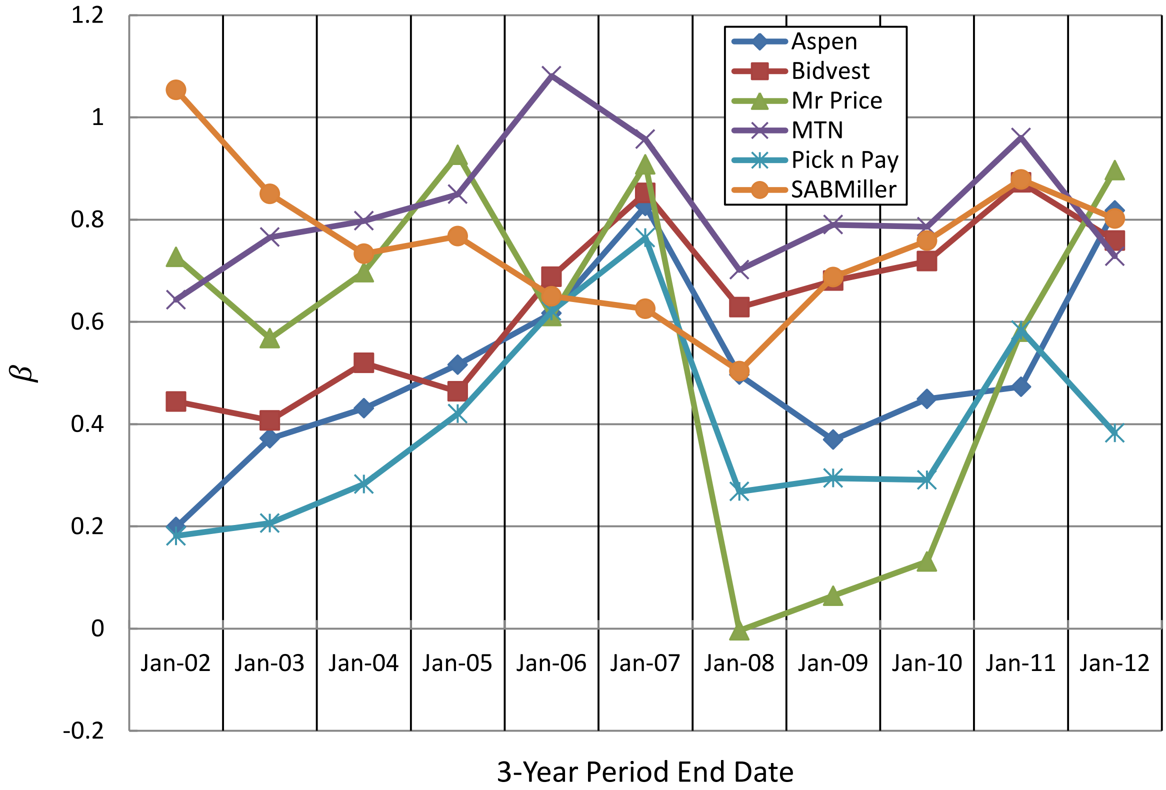

Figure 3. Base case βs for companies clustered in the INDI Grouping

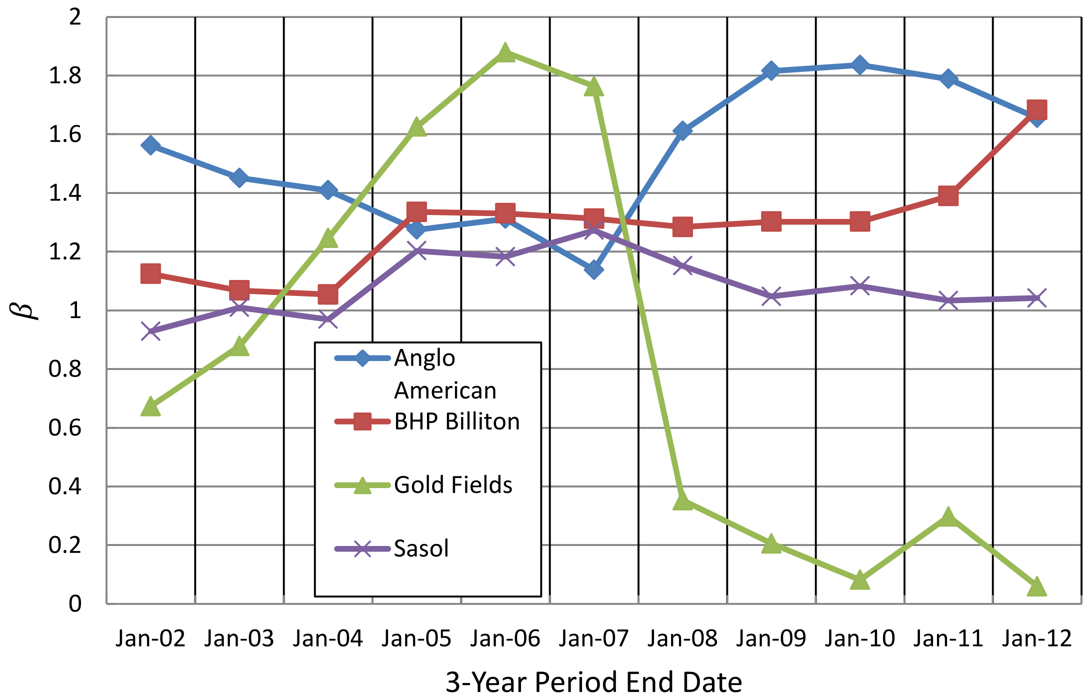

Figure 4. Base case βs for companies clustered in the RESI Grouping.

Table 4 shows the average values of β for the twenty companies in our sample, together with the standard deviation.

Table 4. Average and standard deviations of β calculated with base case assumptions (3 year monthly data with ALSH as market proxy). Also shown are the βs calculated across the full-13 year data set (again, monthly against the ALSH), and the percentage difference from the average β.

COMPANY	**Average** β	**St Dev** β (abs)	**St Dev** β (%)	**13-year** β	**% Diff**
AECI	0.56	0.21	38.6%	0.56	-1.5%
Anglo American	1.53	0.22	14.6%	1.55	-1.4%
Aspen	0.51	0.18	35.4%	0.44	14.3%
Astrapak	0.51	0.39	75.7%	0.37	40.3%
Barloworld	0.97	0.21	21.4%	0.91	5.9%
BHP Billiton	1.29	0.17	12.8%	1.27	1.3%
Bidvest	0.64	0.15	24.1%	0.60	6.2%
Discovery	0.45	0.16	34.9%	0.43	5.5%
Gold Fields	0.82	0.66	80.7%	0.66	23.9%
Group Five	0.79	0.31	39.2%	0.76	5.1%

Growthpoint	0.32	0.20	64.1%	0.23	39.3%
Mr Price	0.56	0.33	58.6%	0.59	-5.3%
MTN	0.82	0.12	14.9%	0.79	4.4%
Pick n Pay	0.39	0.18	46.0%	0.33	17.1%
RMB Holdings	0.74	0.18	24.5%	0.71	3.5%
SABMiller	0.76	0.14	18.4%	0.82	-7.6%
Sanlam	0.67	0.15	22.8%	0.67	1.0%
Sasol	1.08	0.10	9.3%	1.05	3.0%
Standard Bank	0.70	0.14	19.4%	0.67	3.7%
Tiger Brands	0.55	0.28	51.4%	0.46	19.6%

Figure 5 through Figure 8 show the impact on NPVs that variability in β could create. Here, the percentage change in NPV that corresponds to a single standard deviation change in β at the end of each 3-year period is shown. The methodology and assumptions of this estimation was discussed in section 3.4.1.

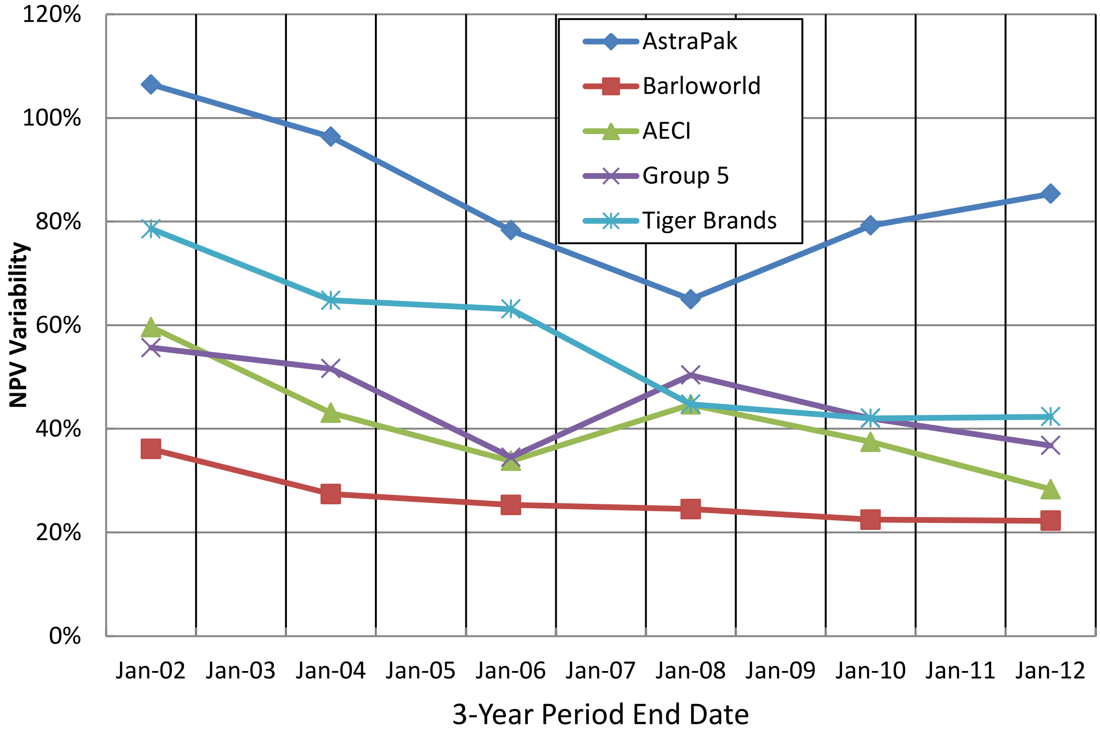

Figure 5. Impact of a single standard deviation variation in β on prediction of NPV, for companies clustered in the CAPS grouping.

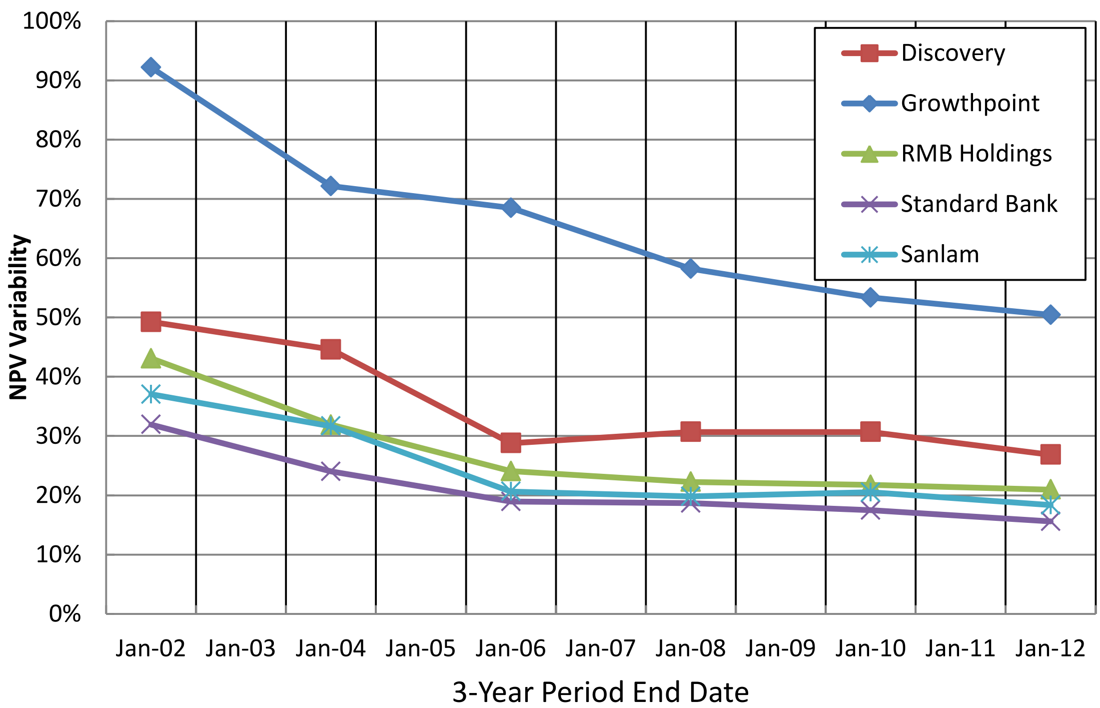

Figure 6. Impact of a single standard deviation variation in β on prediction of NPV, for companies clustered in the CAPS grouping.

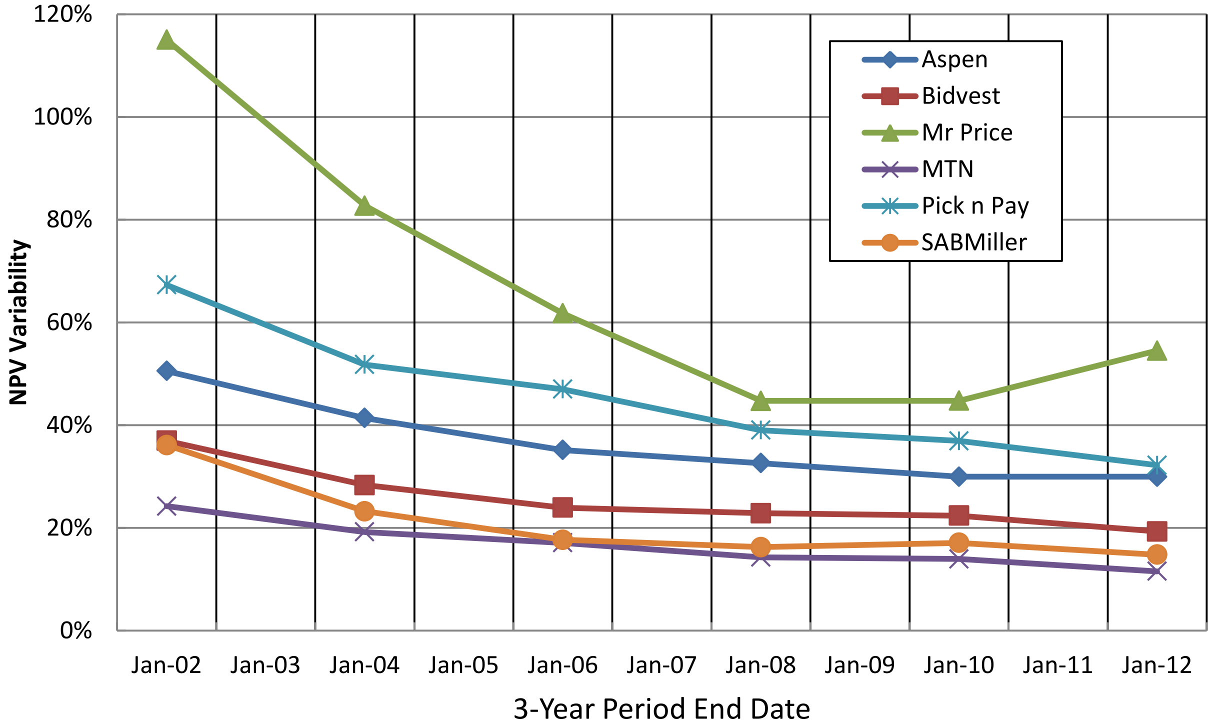

Figure 7. Impact of a single standard deviation variation in β on prediction of NPV, for companies clustered in the INDI grouping.

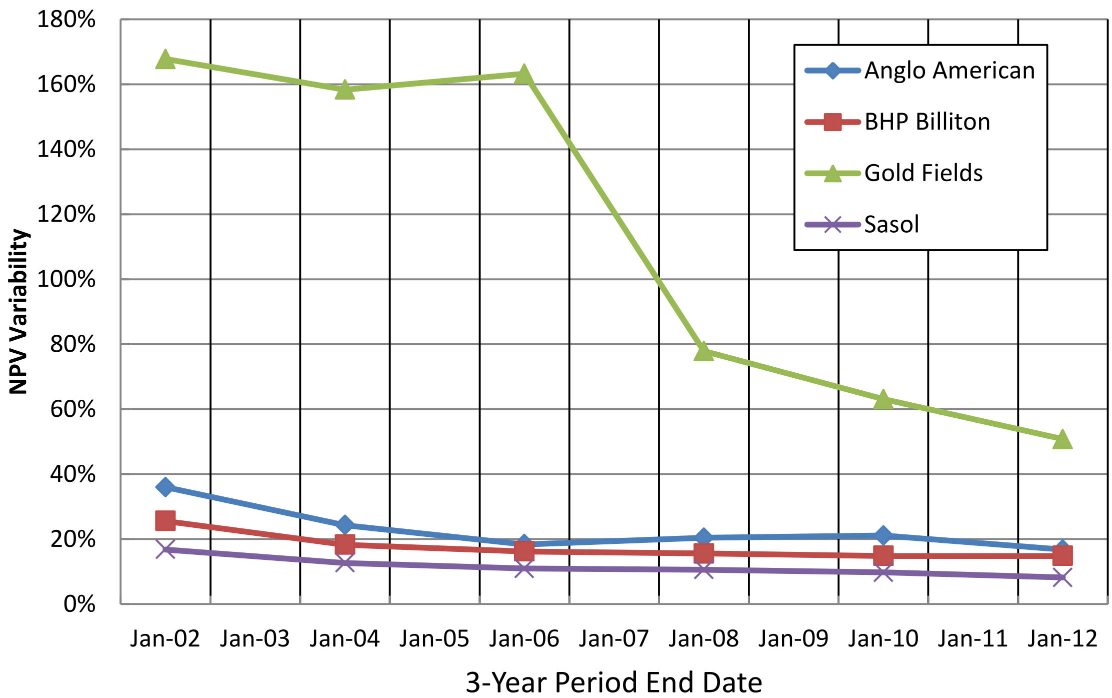

Figure 8. Impact of a single standard deviation variation in β on prediction of NPV, for companies clustered in the RESI grouping.

4.4 Results pertaining to Research Question 2

4.4.1 Effect of Data Frequency, Data Period, and Sampling Day

Table 5 and Table 6 show data illustrating the impact of using different data frequencies (Table 5) and different data periods (Table 6) on the estimation of β. Table 7 illustrates the impact of using data from the first trading day of the month rather than the last trading day of the month, as in the base case assumptions. These tables reflect the impact on the averages and standard deviations, and since the variances from the base case can be both positive and negative the figures in these tables show only a part of the picture. Figure 9 to Figure 12 show graphically the impact of using different frequencies, periods, and sampling days to calculate β for one company from each of the groupings. The company in each grouping having the smallest standard deviation of β for the base case is chosen, since this would suggest a measure of stability. The data for the other companies are not presented, in order to keep this report to a tractable length, but the results can be inferred.

Table 5. Effect of data frequency on β. Average and standard deviations of the βs calculated with base case assumptions (3-year monthly data with ALSH as market proxy), compared to the βs generated from 3-year daily and weekly data.

COMPANY	Monthly		Weekly				Daily			
	Average β	**St Dev β (abs)**	**Average β**	**St Dev β (abs)**	**Diff in Average**	**Relative St Dev**	**Average β**	**St Dev β (abs)**	**Diff in Average**	**Relative St Dev**
AECI	0.56	0.21	0.45	0.09	-19.3%	43.4%	0.31	0.07	-43.8%	33.2%
Anglo American	1.53	0.22	1.61	0.06	5.2%	28.7%	1.64	0.13	6.9%	58.8%
Aspen	0.51	0.18	0.47	0.17	-8.0%	94.7%	0.46	0.18	-8.7%	98.7%
Astrapak	0.51	0.39	0.33	0.15	-34.9%	38.1%	0.19	0.08	-63.5%	20.5%
Barloworld	0.97	0.21	0.85	0.09	-12.0%	45.4%	0.73	0.11	-24.4%	52.7%
BHP Billiton	1.29	0.17	1.48	0.12	14.4%	71.6%	1.50	0.08	16.2%	49.9%

Bidvest	0.64	0.15	0.61	0.19	-5.1%	120.2%	0.70	0.13	9.2%	84.4%
Discovery	0.45	0.16	0.44	0.07	-2.4%	43.3%	0.39	0.09	-14.8%	54.5%
Gold Fields	0.82	0.66	0.95	0.29	15.7%	43.5%	0.86	0.30	4.9%	45.5%
Group Five	0.79	0.31	0.45	0.31	-43.2%	98.5%	0.43	0.17	-45.2%	53.9%
Growthpoint	0.32	0.20	0.29	0.12	-8.8%	56.9%	0.22	0.15	-31.7%	75.9%
Mr Price	0.56	0.33	0.57	0.15	3.1%	47.5%	0.49	0.14	-12.5%	43.2%
MTN	0.82	0.12	0.97	0.16	17.3%	128.5%	0.93	0.15	13.4%	124.8%
Pick n Pay	0.39	0.18	0.43	0.09	11.1%	52.0%	0.53	0.06	36.0%	33.1%
RMB Holdings	0.74	0.18	0.78	0.13	5.6%	69.8%	0.86	0.18	17.1%	101.5%

SABMiller	0.76	0.14	0.75	0.06	-0.9%	40.5%	0.72	0.08	-4.2%	54.7%
Sanlam	0.67	0.15	0.66	0.11	-2.5%	68.8%	0.75	0.10	11.7%	67.9%
Sasol	1.08	0.10	1.15	0.22	6.3%	213.4%	1.13	0.10	3.9%	97.2%
Standard Bank	0.70	0.14	0.73	0.13	4.6%	96.0%	0.83	0.16	19.6%	117.2%
Tiger Brands	0.55	0.28	0.48	0.10	-12.9%	35.9%	0.52	0.10	-5.8%	34.8%

Table 6. Effect of data period on β. Average and standard deviations of the βs calculated with base case assumptions (3-year monthly data with ALSH as market proxy), compared to the βs generated over one and five year periods.

COMPANY	Three Years		One Year				Five Years			
	Average β	St Dev β (abs)	Average β	St Dev β (abs)	Diff in Average	Relative St Dev	Average β	St Dev β (abs)	Diff in Average	Relative St Dev
AECI	0.56	0.21	0.57	0.45	1.8%	210.3%	0.61	0.19	9.2%	86.7%
Anglo American	1.53	0.22	1.54	0.44	0.5%	194.3%	1.55	0.18	1.0%	82.4%
Aspen	0.51	0.18	0.50	0.42	-1.5%	232.4%	0.47	0.08	-6.4%	46.1%
Astrapak	0.51	0.39	0.39	0.67	-24.5%	171.5%	0.43	0.18	-17.2%	46.7%
Barloworld	0.97	0.21	1.00	0.40	3.3%	192.1%	0.94	0.13	-2.9%	62.6%
BHP Billiton	1.29	0.17	1.39	0.41	7.9%	249.6%	1.26	0.09	-2.6%	54.0%

Bidvest	0.64	0.15	0.65	0.21	2.3%	136.9%	0.62	0.11	-2.8%	68.5%
Discovery	0.45	0.16	0.49	0.23	7.0%	147.7%	0.46	0.08	0.5%	51.0%
Gold Fields	0.82	0.66	0.85	0.81	2.7%	122.1%	0.77	0.49	-6.4%	73.9%
Group Five	0.79	0.31	0.72	0.89	-9.4%	285.8%	0.84	0.22	5.8%	70.4%
Growthpoint	0.32	0.20	0.38	0.38	20.5%	185.0%	0.28	0.11	-10.9%	53.5%
Mr Price	0.56	0.33	0.73	0.61	31.8%	186.8%	0.47	0.26	-15.6%	79.4%
MTN	0.82	0.12	0.76	0.43	-7.3%	348.7%	0.82	0.04	-1.0%	31.4%
Pick n Pay	0.39	0.18	0.41	0.39	3.9%	219.7%	0.36	0.08	-9.0%	44.4%
RMB Holdings	0.74	0.18	0.86	0.48	16.5%	266.7%	0.69	0.05	-6.9%	28.7%

SABMiller	0.76	0.14	0.75	0.41	-0.5%	295.0%	0.73	0.10	-3.1%	70.4%
Sanlam	0.67	0.15	0.67	0.36	-0.2%	236.2%	0.66	0.07	-1.6%	44.7%
Sasol	1.08	0.10	1.04	0.35	-3.8%	350.1%	1.09	0.07	0.4%	65.1%
Standard Bank	0.70	0.14	0.81	0.37	15.8%	276.6%	0.67	0.07	-4.2%	52.4%
Tiger Brands	0.55	0.28	0.67	0.50	22.1%	177.4%	0.49	0.14	-9.9%	49.6%

Table 7. Effect of sampling day on β. Average and standard deviations of β calculated with base case assumptions (3-year monthly data with ALSH as market proxy with data sampled on last trading day of the month), compared to β generated using data sampled on first trading day of the month.

COMPANY	Last Trading Day		First Trading Day			
	Average β	St Dev β (abs)	Average β	St Dev β (abs)	Diff in Average	Relative St Dev
AECI	0.56	0.21	0.58	0.13	3.4%	59.6%
Anglo American	1.53	0.22	1.56	0.27	2.0%	118.3%
Aspen	0.51	0.18	0.53	0.26	4.7%	145.5%
Astrapak	0.51	0.39	0.49	0.35	-4.4%	90.3%
Barloworld	0.97	0.21	0.98	0.31	1.6%	150.8%

BHP Billiton	1.29	0.17	1.34	0.15	3.6%	91.1%
Bidvest	0.64	0.15	0.62	0.18	-3.1%	118.8%
Discovery	0.45	0.16	-0.03	0.23	-106.8%	146.7%
Gold Fields	0.82	0.66	0.90	0.51	8.6%	77.2%
Group Five	0.79	0.31	0.77	0.27	-2.8%	86.3%
Growthpoint	0.32	0.20	0.25	0.21	-20.1%	102.6%
Mr Price	0.56	0.33	0.48	0.34	-13.3%	103.0%
MTN	0.82	0.12	0.77	0.11	-6.4%	92.0%
Pick n Pay	0.39	0.18	0.42	0.17	8.2%	93.3%

RMB Holdings	0.74	0.18	0.69	0.19	-7.1%	107.3%
SABMiller	0.76	0.14	0.73	0.14	-3.8%	101.1%
Sanlam	0.67	0.15	0.55	0.13	-18.7%	87.0%
Sasol	1.08	0.10	1.11	0.14	2.3%	141.3%
Standard Bank	0.70	0.14	0.66	0.16	-5.2%	117.2%
Tiger Brands	0.55	0.28	0.59	0.25	7.5%	90.0%

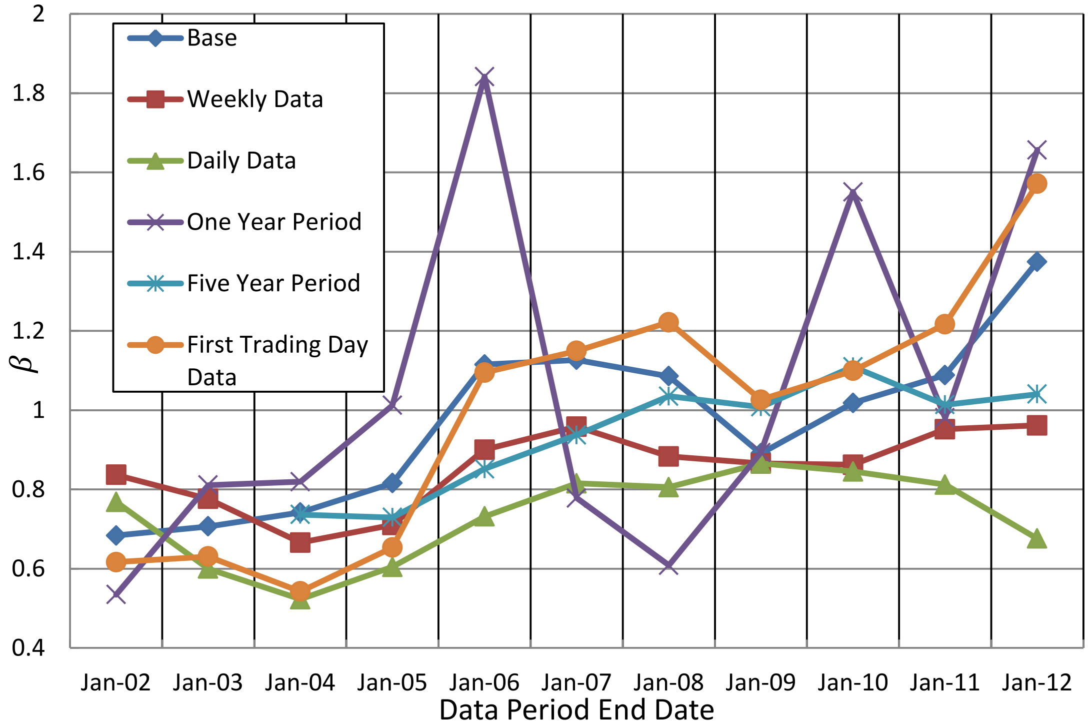

Figure 9. Impact of different data frequencies and periods and sampling day on estimation of β for Barloworld.

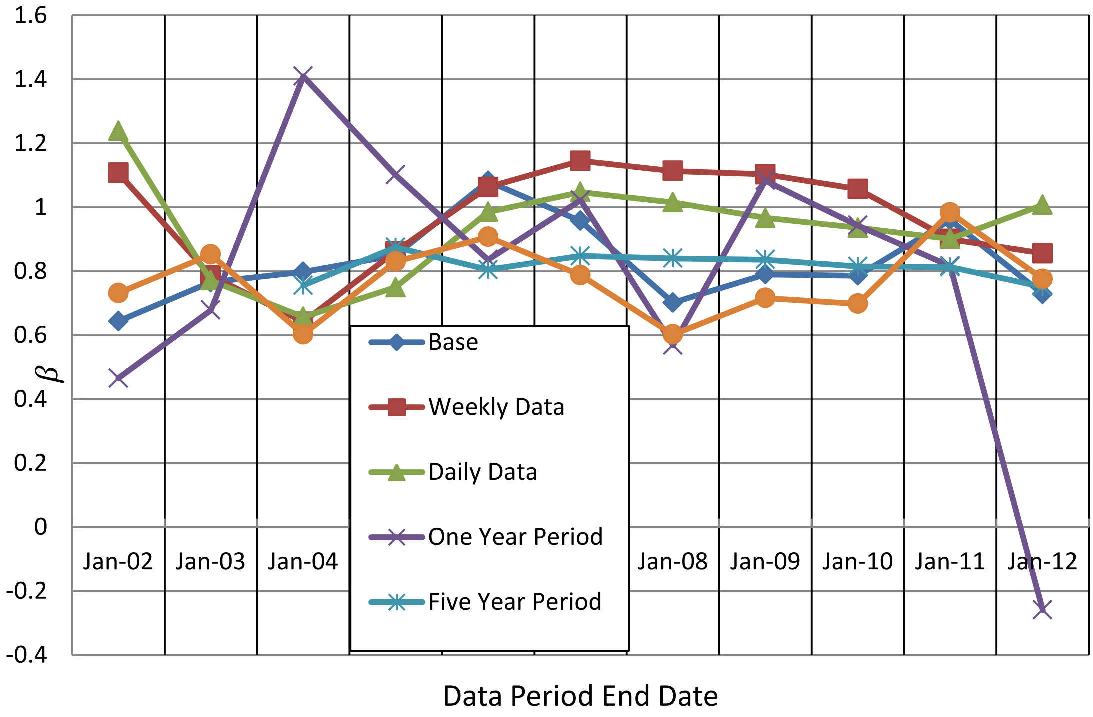

Figure 10. Impact of different data frequencies and periods and sampling day on estimation of β for MTN.

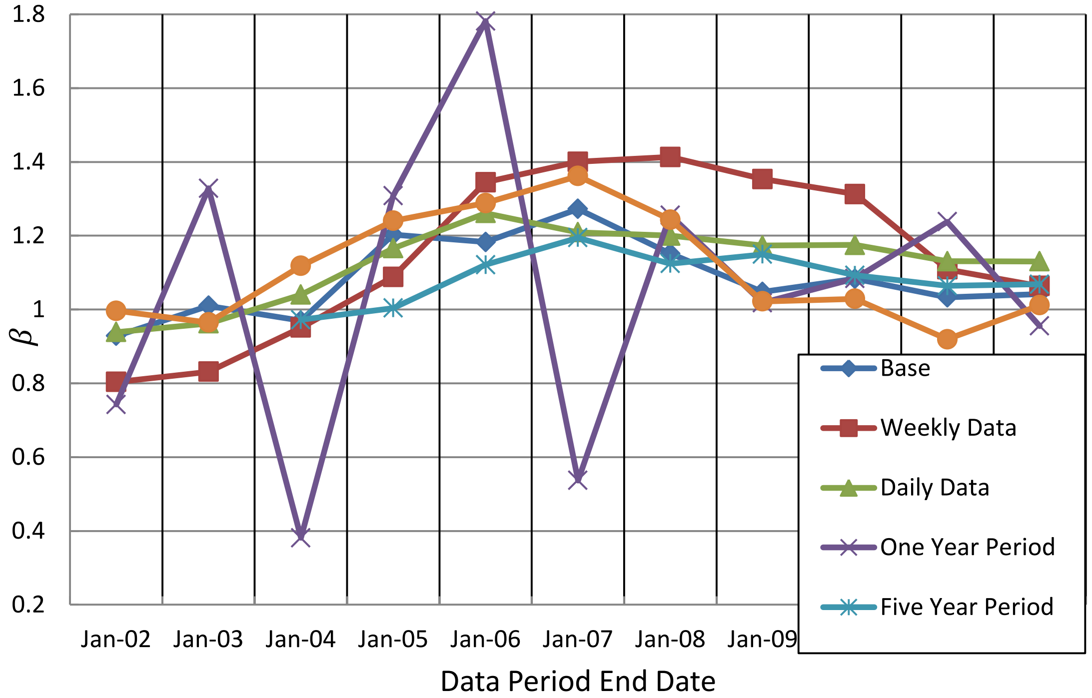

Figure 11. Impact of different data frequencies and periods and sampling day on estimation of β for Sasol.

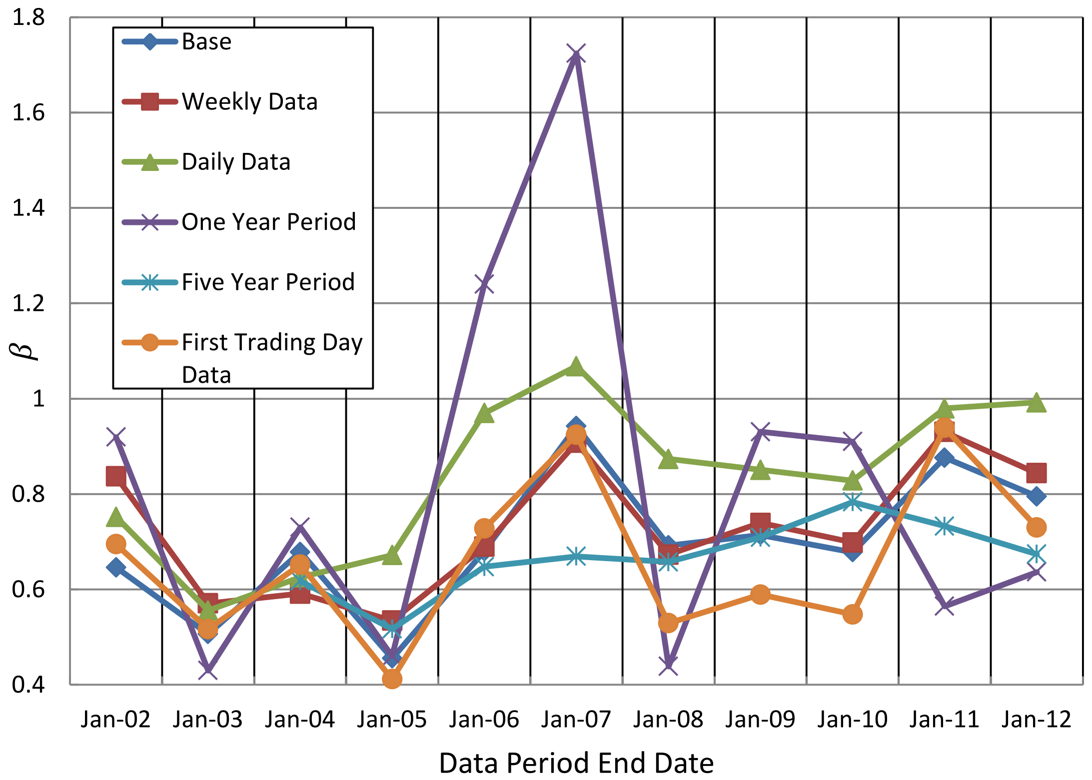

Figure 12. Impact of different data frequencies and periods and sampling day on estimation of β for Standard Bank.

4.4.2 Effect of Choice of Market Proxy

The impact of choice of market proxy is shown in Table 8. Averages and standard deviations of β generated using ALSH as a market proxy are compared for each company in this study to β generated using the FNDI and a narrower market proxy chosen according to sector or size. Again, it is informative to look at time variations in β rather than time-averaged data. The βs calculated using different market proxies are shown in Figure 13 through Figure 16 for the same companies that were focused on in section 4.4.1.

Table 8. Effect of choice of market proxy on β. Average and standard deviations of β calculated with base case assumptions (3-year monthly data with ALSH as market proxy), compared to β generated using FNDI as market proxy and a narrow market proxy selected by sector or size.

COMPANY	**ALSH**		**FNDI**				**NARROW MARKET PROXY**				
	Average β	**St Dev** β (abs)	**Average** β	**St Dev** β (abs)	**Diff in Average**	**Relative St Dev**	**INDEX**	**Average** β	**St Dev** β (abs)	**Diff in Average**	**Relative St Dev**
AECI	0.56	0.21	0.62	0.28	11.1%	132.3%	MIDC	0.89	0.24	60.9%	111.7%
Anglo American	1.53	0.22	1.02	0.32	-33.3%	141.6%	RESI	1.13	0.14	-26.3%	64.3%

Aspen	0.51	0.18	0.68	0.17	35.3%	92.2%	ALEX	0.80	0.17	59.0%	97.4%
Astrapak	0.51	0.39	0.64	0.39	25.1%	100.6%	FLED	0.73	0.35	41.2%	89.3%
Barloworld	0.97	0.21	1.09	0.21	12.4%	101.2%	MIDC	1.20	0.26	24.0%	126.3%
BHP Billiton	1.29	0.17	0.82	0.28	-36.0%	167.6%	RESI	0.96	0.13	-25.6%	75.7%
Bidvest	0.64	0.15	0.86	0.18	34.8%	119.1%	ALEX	0.99	0.16	54.2%	103.2%
Discovery	0.45	0.16	0.62	0.15	37.1%	94.7%	FINI	0.49	0.11	7.7%	69.7%
Gold Fields	0.82	0.66	0.26	0.56	-68.7%	84.2%	GOLD	0.98	0.05	19.4%	6.9%
Group Five	0.79	0.31	0.98	0.36	23.1%	117.0%	SMLC	1.63	0.39	104.9%	126.5%
Growthpoint	0.32	0.20	0.47	0.26	48.4%	127.2%	TOPI	0.26	0.17	-19.3%	83.1%

Mr Price	0.56	0.33	0.91	0.27	63.9%	84.3%	INDI	0.86	0.26	55.0%	78.9%
MTN	0.82	0.12	1.19	0.15	44.5%	124.5%	INDI	1.13	0.13	37.7%	107.3%
Pick n Pay	0.39	0.18	0.54	0.12	37.4%	69.0%	INDI	0.51	0.15	30.8%	83.1%
RMB Holdings	0.74	0.18	1.12	0.16	51.4%	86.9%	FINI	1.20	0.12	62.4%	65.8%
SABMiller	0.76	0.14	0.80	0.08	6.4%	59.4%	TOPI	0.70	0.12	-7.0%	89.7%
Sanlam	0.67	0.15	0.95	0.13	41.1%	85.5%	ALEX	1.00	0.16	48.1%	106.5%
Sasol	1.08	0.10	0.75	0.15	-30.6%	150.8%	RESI	0.79	0.05	-27.3%	45.2%
Standard Bank	0.70	0.14	1.04	0.14	49.2%	103.9%	FINI	1.16	0.07	66.2%	55.1%
Tiger Brands	0.55	0.28	0.77	0.25	40.7%	89.7%	FOOD	1.16	0.18	112.2%	64.5%

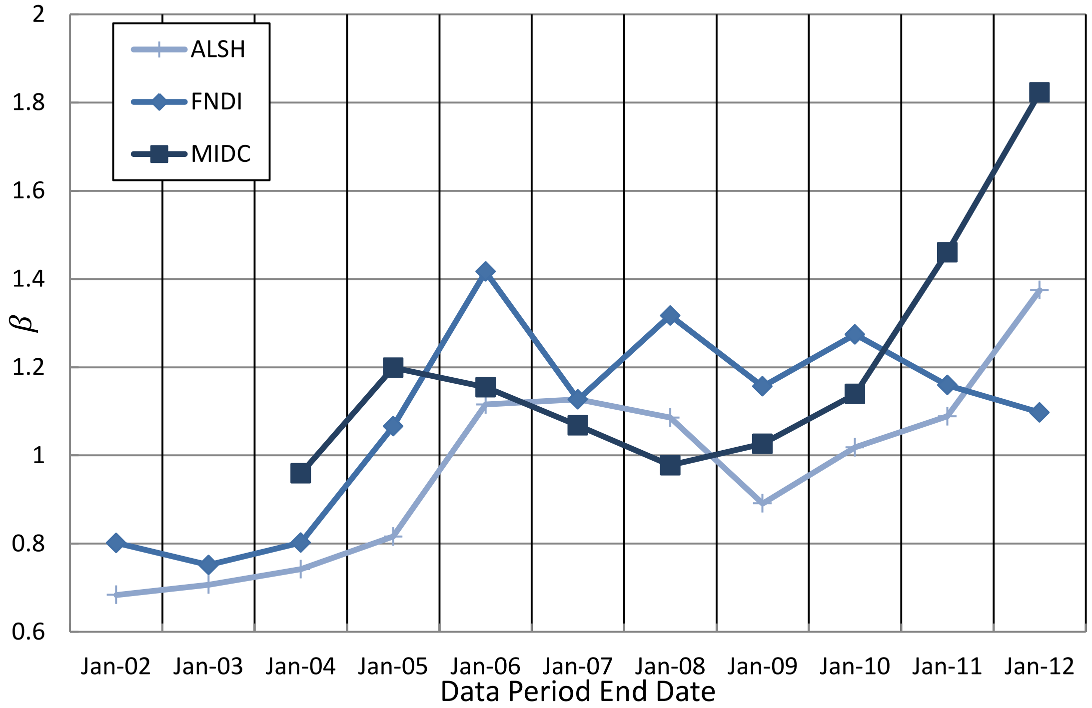

Figure 13. Impact of using different market proxies for the calculation of β for Barloworld.

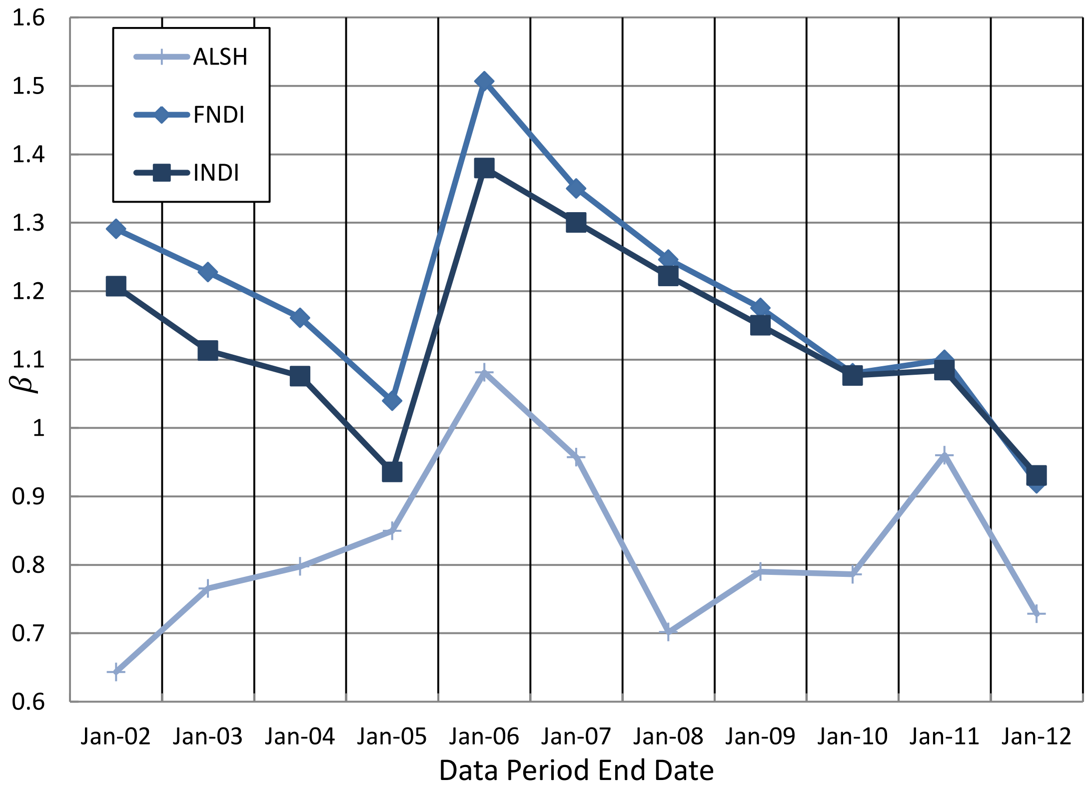

Figure 14. Impact of using different market proxies for the calculation of β for MTN.

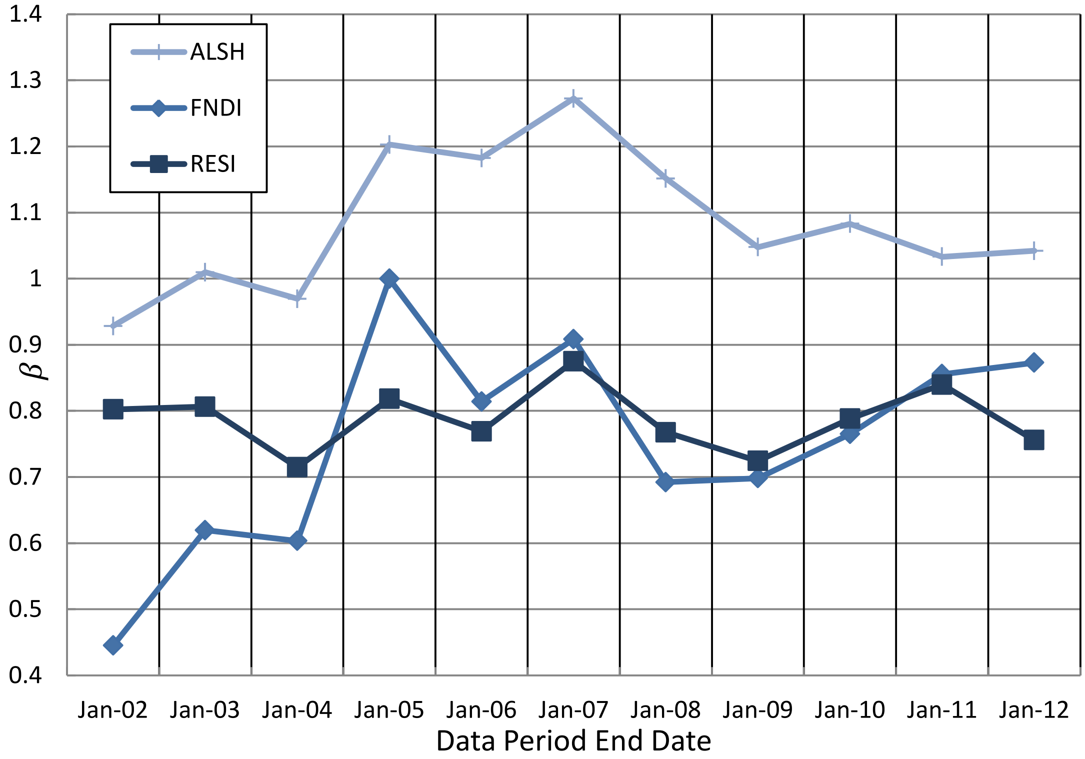

Figure 15. Impact of using different market proxies for the calculation of β for Sasol.

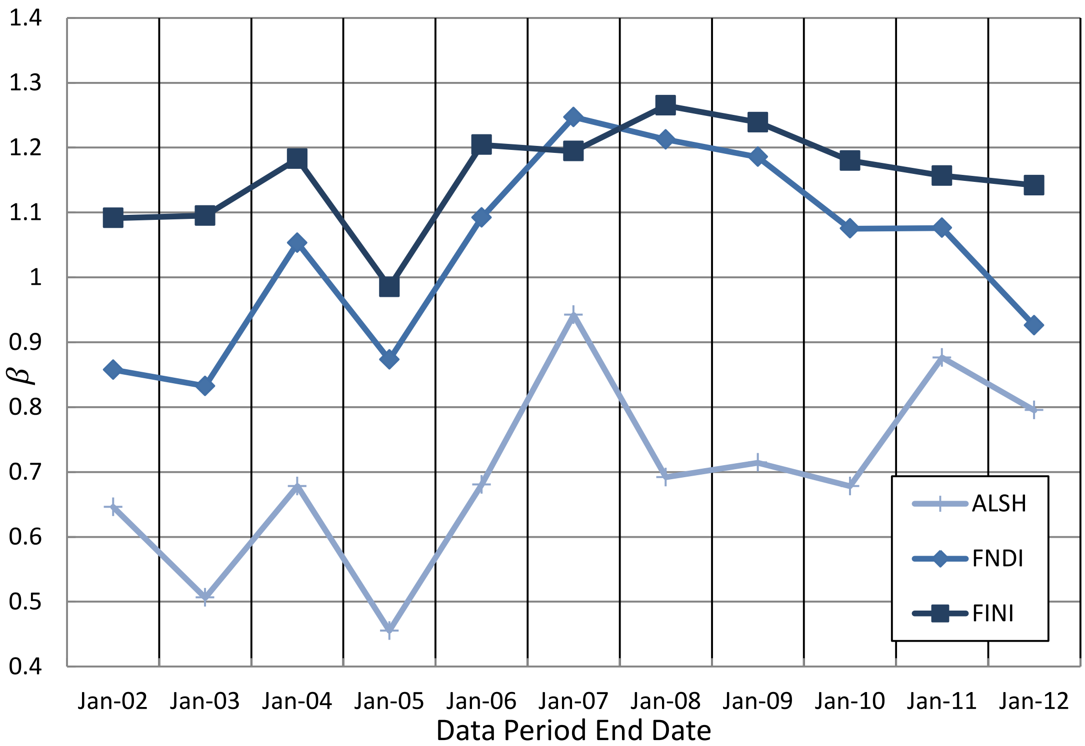

Figure 16. Impact of using different market proxies for the calculation of β for Standard Bank.

4.4.3 Equity Premium

Table 9 shows the equity premiums calculated based on the ALSH as the market proxy and the R157, R153, and R186 Government Bonds and the STeFI as the risk-free instruments. Since the R153 matured in August 2010 and the STeFI is only reported from Jun 2003, the equity premiums estimated for these two instruments in the first line of the table are for periods of 10 and 9 years, respectively. The ALSH (market) return and the equity premiums based on the R157 and R186 government bonds in the first line are for the full 13 years of the data.

Table 10 shows the analogous results when the FNDI is taken as the market proxy.

Table 9. Equity premiums estimated using the ALSH as a market proxy, and the R157, R153, R186 governments bonds and the STeFI as proxies for risk-free instruments.

			Equity Premiums (based on different risk-free rates)			
Period Start	**Period End**	**ALSH Return**	**R157**	**R153**	**R186**	**STeFI**
3-Jan-00	31-Dec-12	12.6%	3.1%	2.4%	2.3%	4.7%
3-Jan-00	31-Dec-02	-0.5%	-12.6%	-12.7%	-11.9%	
1-Jan-01	31-Dec-03	8.4%	-2.5%	-2.5%	-2.0%	
1-Jan-02	31-Dec-04	6.6%	-3.5%	-3.1%	-2.9%	
1-Jan-03	30-Dec-05	24.9%	16.0%	15.9%	16.7%	

1-Jan-04	29-Dec-06	33.9%	25.4%	25.3%	26.0%	26.4%
3-Jan-05	31-Dec-07	31.3%	23.0%	22.7%	23.5%	23.4%
2-Jan-06	31-Dec-08	5.9%	-1.4%	-1.4%	-1.2%	-3.6%
1-Jan-07	31-Dec-09	3.6%	-4.6%	-4.3%	-4.7%	-6.5%
1-Jan-08	31-Dec-10	3.5%	-4.4%		-4.7%	-5.7%
1-Jan-09	30-Dec-11	14.1%	7.2%		6.3%	6.9%
1-Jan-10	31-Dec-12	12.4%	5.5%		4.2%	6.3%

Table 10. Equity premiums estimated using the FNDI as a market proxy, and the R157, R153, R186 Government Bonds and the STeFI as proxies for risk-free instruments.

			Equity Premiums			
Period Start	**Period End**	**FNDI Return**	**R157**	**R153**	**R186**	**STeFI**
3-Jan-00	31-Dec-12	11.2%	1.7%	1.0%	0.9%	3.3%
3-Jan-00	31-Dec-02	-9.5%	-21.5%	-21.7%	-20.8%	
1-Jan-01	31-Dec-03	-4.9%	-15.8%	-15.8%	-15.2%	

1-Jan-02	31-Dec-04	11.4%	1.3%	1.7%	1.9%	
1-Jan-03	30-Dec-05	28.5%	19.5%	19.5%	20.2%	
1-Jan-04	29-Dec-06	36.5%	28.0%	27.9%	28.6%	29.0%
3-Jan-05	31-Dec-07	23.6%	15.3%	15.0%	15.8%	15.7%
2-Jan-06	31-Dec-08	4.7%	-2.6%	-2.6%	-2.4%	-4.8%
1-Jan-07	31-Dec-09	2.0%	-6.1%	-5.8%	-6.2%	-8.1%
1-Jan-08	31-Dec-10	5.1%	-2.8%		-3.1%	-4.1%
1-Jan-09	30-Dec-11	16.6%	9.7%		8.8%	9.4%
1-Jan-10	31-Dec-12	20.3%	13.5%		12.2%	14.3%

4.4.4 Effect of Choice of Risk-free Rate

As discussed in section 3.4.2, the choice of risk-free rate does not impact the estimation of β unless one linearly regresses the return on equity versus the equity premium to find an approximate value of β. Table 11 shows how the NPV of the same investment varies depending on the proxy that is used for the risk-free rate. Because of the high volatility in the equity premiums – see Table 9 and Table 10 – the values in Table 11 were generated using the equity premiums determined using the longest applicable period (the total data set or 13 years for the R157 and R186, 10 years for the R153 and 9 years for the STeFI). As seen in the first row of Table 9, the 13-year equity premiums are small but consistently positive.

The time variations in the NPV estimation based on different choices of risk-free rate are shown in Figure 17 through Figure 20 for the four companies that have been considered in more detail in this report (Barloworld, MTN, Sasol and Standard Bank).

Table 11. NPV as a percentage of Capital Expenditure for hypothetical investments, estimated using the R157, R153, R186 Governments Bonds and the STeFI as proxies for risk-free instruments. The difference from the R157 estimate is shown for the R153, R186, and STeFI instruments.

COMPANY	R157	R153		R186		STeFI	
	$\frac{NPV}{CAPEX}$	$\frac{NPV}{CAPEX}$	%Diff	$\frac{NPV}{CAPEX}$	%Diff	$\frac{NPV}{CAPEX}$	%Diff
AECI	24.7%	22.5%	-9.2%	22.2%	-10.4%	30.2%	21.9%
Anglo American	11.7%	12.4%	6.3%	12.5%	7.1%	10.0%	-14.2%
Aspen	26.5%	23.8%	-10.3%	23.4%	-11.5%	33.0%	24.5%
Astrapak	27.6%	24.6%	-10.8%	24.2%	-12.2%	34.8%	26.0%
Barloworld	19.9%	18.8%	-5.7%	18.7%	-6.4%	22.6%	13.2%
BHP Billiton	15.2%	15.2%	-0.3%	15.2%	-0.3%	15.3%	0.7%
Bidvest	24.2%	22.1%	-8.9%	21.8%	-10.0%	29.3%	21.1%
Discovery	26.7%	23.9%	-10.4%	23.6%	-11.6%	33.3%	24.8%
Gold Fields	23.3%	21.4%	-8.3%	21.2%	-9.4%	27.9%	19.7%

Group Five	22.1%	20.4%	-7.4%	20.2%	-8.4%	25.9%	17.5%
Growthpoint	29.7%	26.1%	-11.8%	25.7%	-13.3%	38.1%	28.6%
Mr Price	24.4%	22.2%	-9.1%	22.0%	-10.2%	29.7%	21.5%
MTN	21.6%	20.1%	-7.1%	19.9%	-8.0%	25.2%	16.6%
Pick n Pay	28.1%	25.0%	-11.1%	24.6%	-12.4%	35.6%	26.7%
RMB Holdings	22.7%	20.9%	-7.9%	20.7%	-8.8%	26.9%	18.5%
SABMiller	21.2%	19.8%	-6.8%	19.6%	-7.6%	24.6%	15.9%
Sanlam	23.3%	21.4%	-8.3%	21.2%	-9.4%	27.9%	19.7%
Sasol	18.1%	17.4%	-3.9%	17.3%	-4.4%	19.7%	9.0%
Standard Bank	23.2%	21.3%	-8.3%	21.1%	-9.3%	27.8%	19.5%
Tiger Brands	26.3%	23.6%	-10.1%	23.3%	-11.4%	32.6%	24.2%

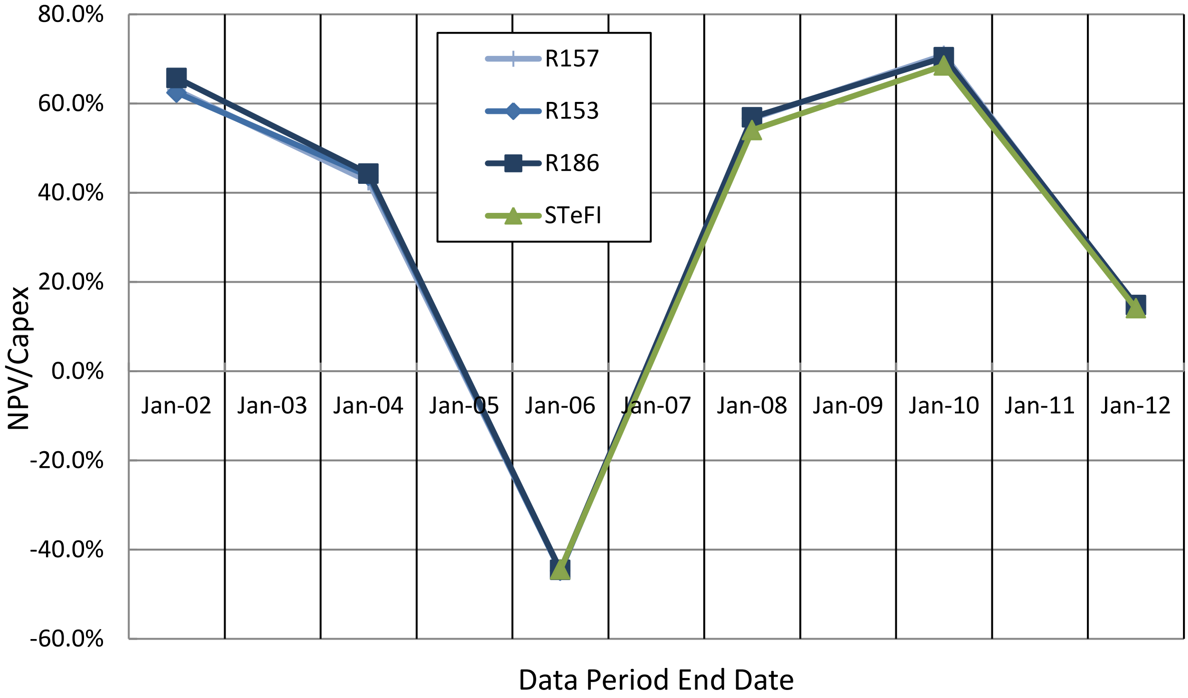

Figure 17. Impact of using different proxies for risk-free rate on the estimation of NPV for a hypothetical investment for Barloworld.

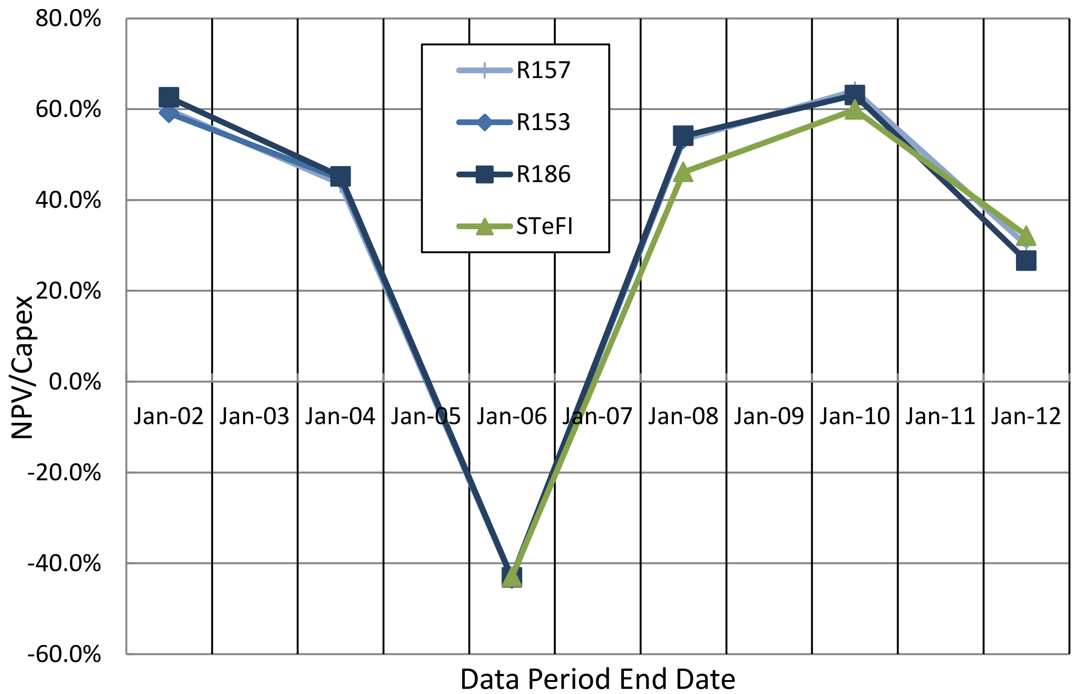

Figure 18. Impact of using different proxies for risk-free rate on the estimation of NPV for a hypothetical investment for MTN.

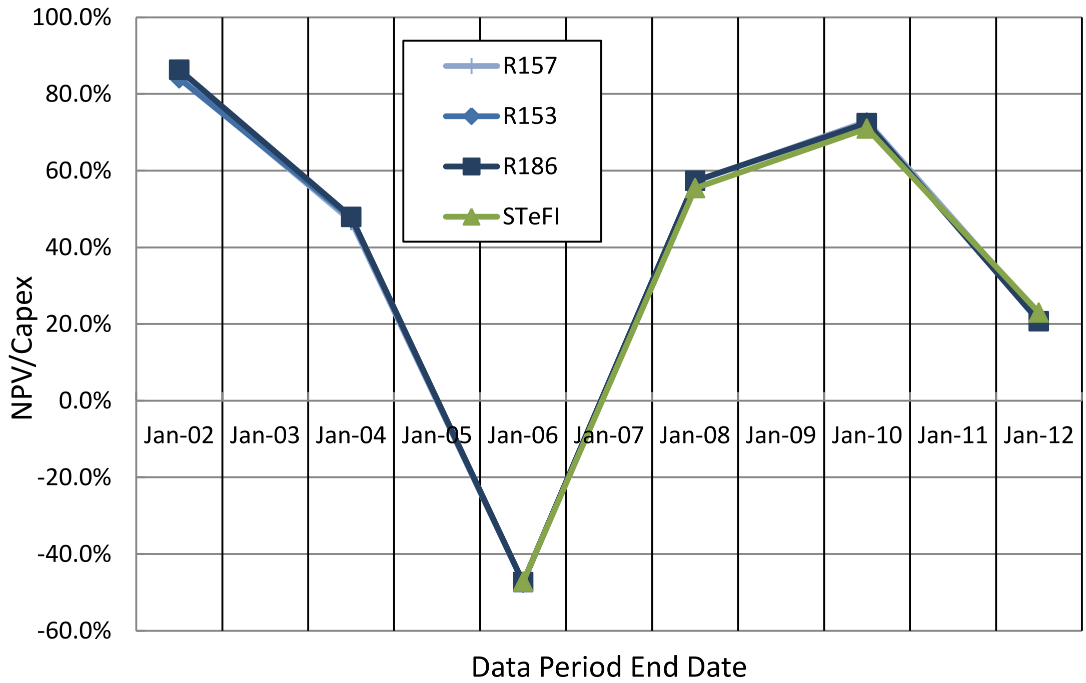

Figure 19. Impact of using different proxies for risk-free rate on the estimation of NPV for a hypothetical investment for Sasol.

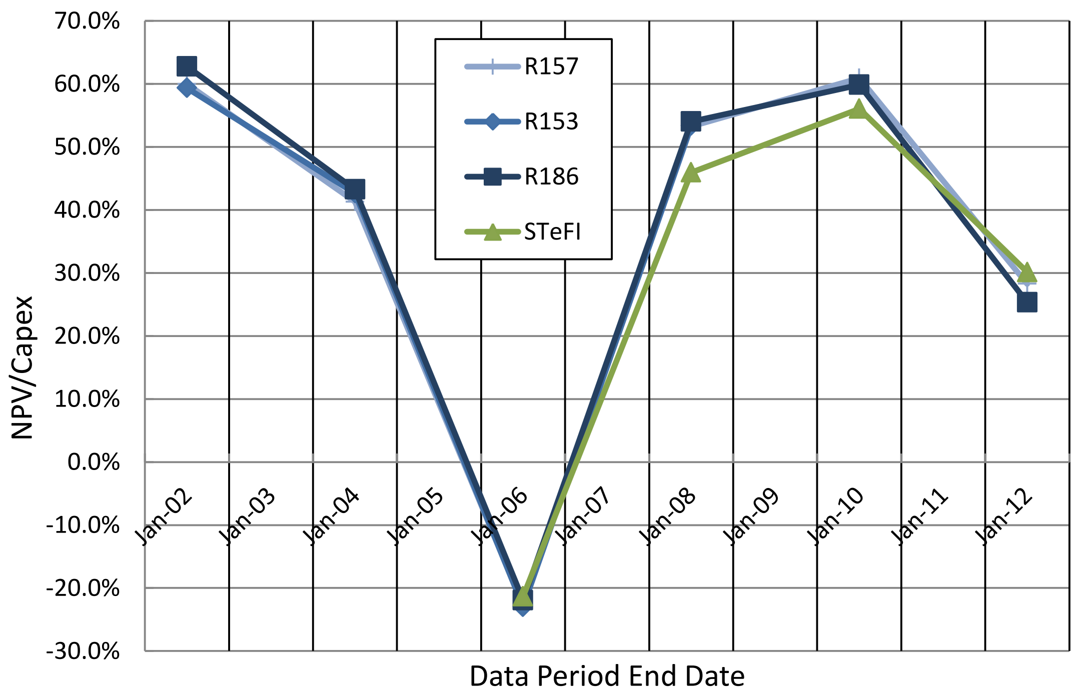

Figure 20. Impact of using different proxies for risk-free rate on the estimation of NPV for a hypothetical investment for Standard Bank.

4.5 Results pertaining to Research Question 3

The results of the multiple linear regression following the Fama and French 3-factor approach discussed in section 3.4.3 are presented in Table 12. Here, the monthly returns for each of the companies in the sample set have been regressed against market capitalisation (as a proxy for size), equity premium (as a market factor) and the book-to-market ratio (which reflects the market perception of the equity). The adjusted R^2 are shown together with the coefficients and the *p*-values for each of these, reflecting the goodness of fit and statistical significance of each of the coefficients as well as the overall regression.

Table 12. Results from multiple linear regression analysis on the sample company returns following the Fama and French 3-factor model. The independent variables are the market capitalisation (Mkt Cap), equity premium (Eq Prem) and book-to-market ratio (B/M)

Company	Coefficients								Adj $R2$	Significa nce F
	Intercept	*p*-value	Mkt Cap	*p*-value	Eq Prem	*p*-value	B/M	*p*-value		
AECI	5.55E-02	7.54E-02	-4.26E-06	1.40E-01	4.84E-02	5.78E-09	-1.53E-02	3.29E-01	0.20	7.09E-08
Anglo American	-2.11E-02	6.50E-01	3.59E-08	5.88E-01	1.29E-01	1.82E-37	2.21E-02	5.34E-01	0.67	7.25E-36
Aspen	4.14E-02	4.19E-02	5.42E-07	1.83E-01	3.43E-02	7.50E-04	-1.27E-01	1.93E-01	0.08	1.15E-03
Astrapak	1.54E-01	1.10E-03	-6.48E-05	2.99E-03	2.98E-02	1.28E-02	-1.08E-01	5.57E-03	0.08	1.83E-03
Barloworld	-3.33E-02	2.32E-01	1.78E-06	7.29E-02	7.41E-02	5.72E-13	1.13E-02	2.03E-01	0.30	1.52E-12
BHP Billiton	1.96E-02	2.69E-01	-4.74E-09	5.99E-01	1.03E-01	2.00E-29	1.22E-03	9.70E-01	0.58	4.85E-28
Bidvest	1.61E-02	2.54E-01	1.78E-07	4.88E-01	4.93E-02	8.72E-12	-2.17E-02	4.73E-01	0.27	7.35E-11

Discovery	-3.64E-02	5.83E-02	1.19E-08	9.86E-01	3.71E-02	1.12E-05	1.32E-01	1.99E-02	0.13	1.61E-05
Gold Fields	6.98E-02	4.29E-02	-3.35E-07	3.52E-01	5.19E-02	1.17E-04	-6.43E-02	7.73E-02	0.11	1.84E-04
Group Five	2.68E-02	4.15E-01	-4.24E-06	4.74E-01	6.31E-02	7.16E-06	7.22E-03	7.33E-01	0.13	4.77E-05
Growthpoint	1.07E-01	3.36E-02	-1.32E-06	1.12E-01	2.30E-02	1.21E-02	-4.63E-02	9.65E-02	0.08	5.62E-03
Mr Price	6.26E-02	2.87E-02	-8.84E-07	5.30E-01	4.38E-02	1.01E-03	-6.17E-02	8.90E-02	0.08	1.34E-03
MTN	1.42E-02	5.25E-01	4.45E-08	5.93E-01	6.48E-02	3.40E-08	-1.80E-02	5.48E-01	0.18	2.42E-07
Pick n Pay	3.82E-02	3.00E-01	-1.01E-06	5.15E-01	2.93E-02	6.32E-04	-6.79E-02	5.66E-01	0.06	5.37E-03
RMB Holdings	6.32E-02	4.19E-01	-5.79E-07	6.69E-01	7.66E-02	7.09E-05	-1.72E-02	6.47E-01	0.34	7.05E-04
SABMiller	4.55E-02	1.78E-02	-1.86E-08	5.51E-01	6.38E-02	9.05E-18	-4.70E-02	6.28E-02	0.42	4.93E-18
Sanlam	1.86E-02	6.91E-01	1.14E-07	8.39E-01	5.92E-02	1.93E-12	-6.89E-03	7.94E-01	0.34	1.45E-11
Sasol	1.26E-01	1.79E-03	-3.02E-07	6.66E-03	8.33E-02	1.60E-20	-1.11E-01	1.02E-02	0.47	2.75E-21

Standard Bank	4.26E-02	2.58E-01	-1.06E-07	4.48E-01	5.46E-02	1.89E-10	-2.24E-02	5.15E-01	0.24	9.56E-10
Tiger Brands	1.19E-02	6.15E-01	2.73E-07	5.55E-01	3.78E-02	1.27E-06	9.78E-04	9.81E-01	0.13	1.65E-05

Figure 21 through Figure 24 show the predictions of the Fama and French 3-factor model against the actual values for 4 companies in the sample. Here, companies have been chosen with both high and low adjusted R^2 as well as having different sizes and being from different sectors – Anglo American (adjusted R^2 = 0.67), AstraPak (0.08), Pick 'n Pay (0.06) and Sasol (0.47). The adjusted R^2 reflects how well the independent variables predict the variation in the dependent variable, and in these regressions it is the monthly fluctuations of return that are predicted. Of most interest is how well the models predict the long-term value of the equity and this is what is shown here.

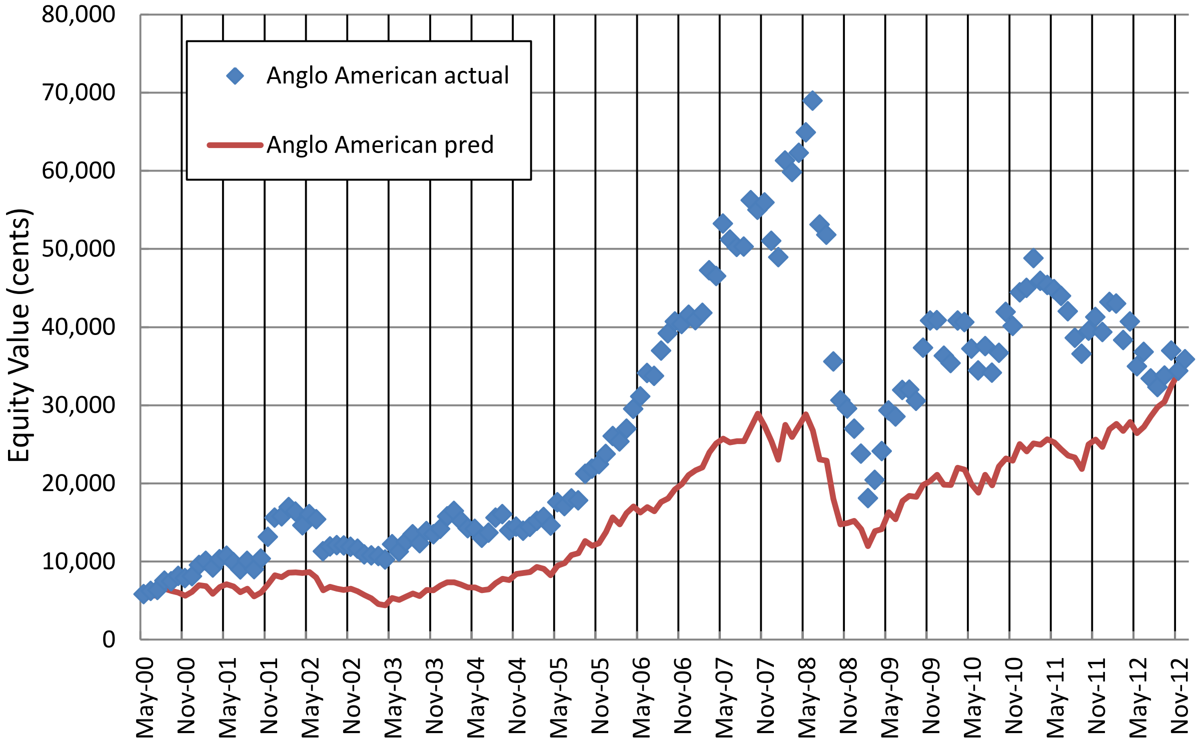

Figure 21. Predictions of equity value for Anglo American using the Fama and French 3-factor approach.

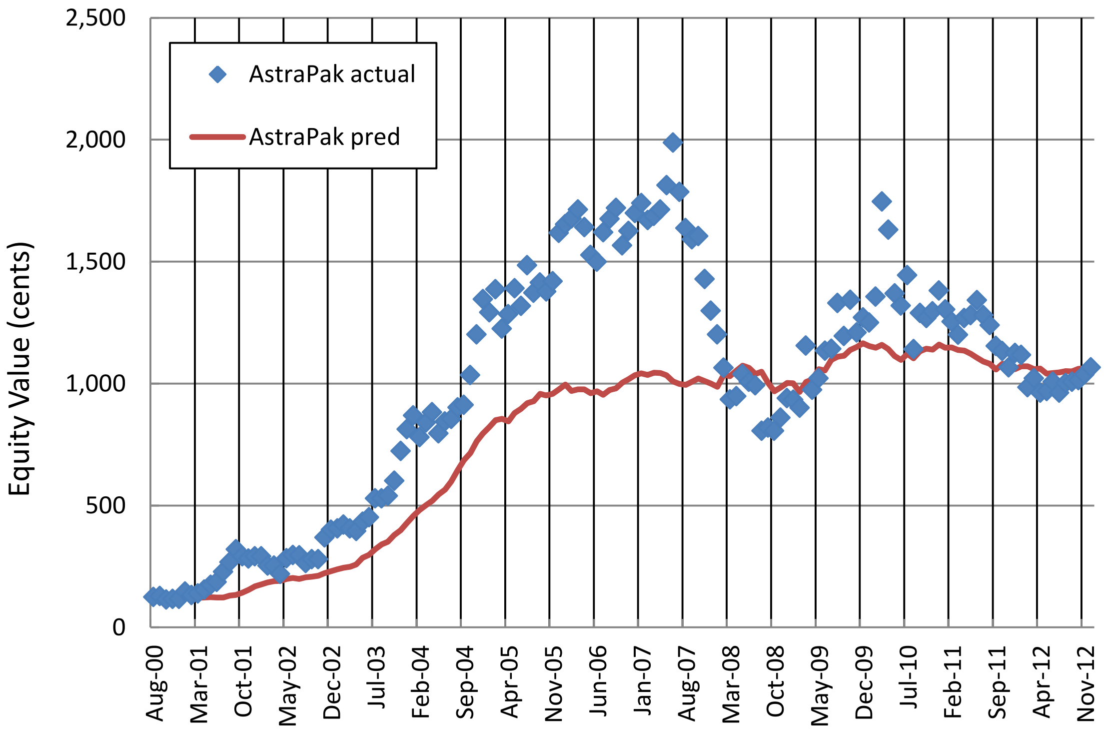

Figure 22. Predictions of equity value for AstraPak using the Fama and French 3-factor approach.

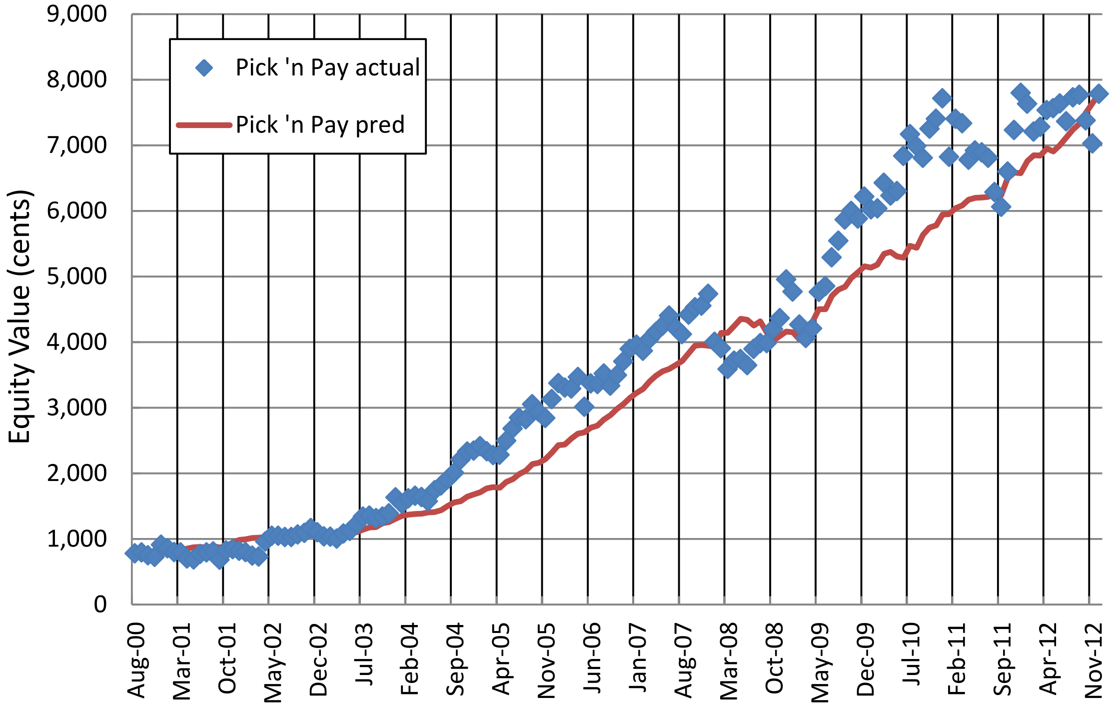

Figure 23. Predictions of equity value for Pick 'n Pay using the Fama and French 3-factor approach.

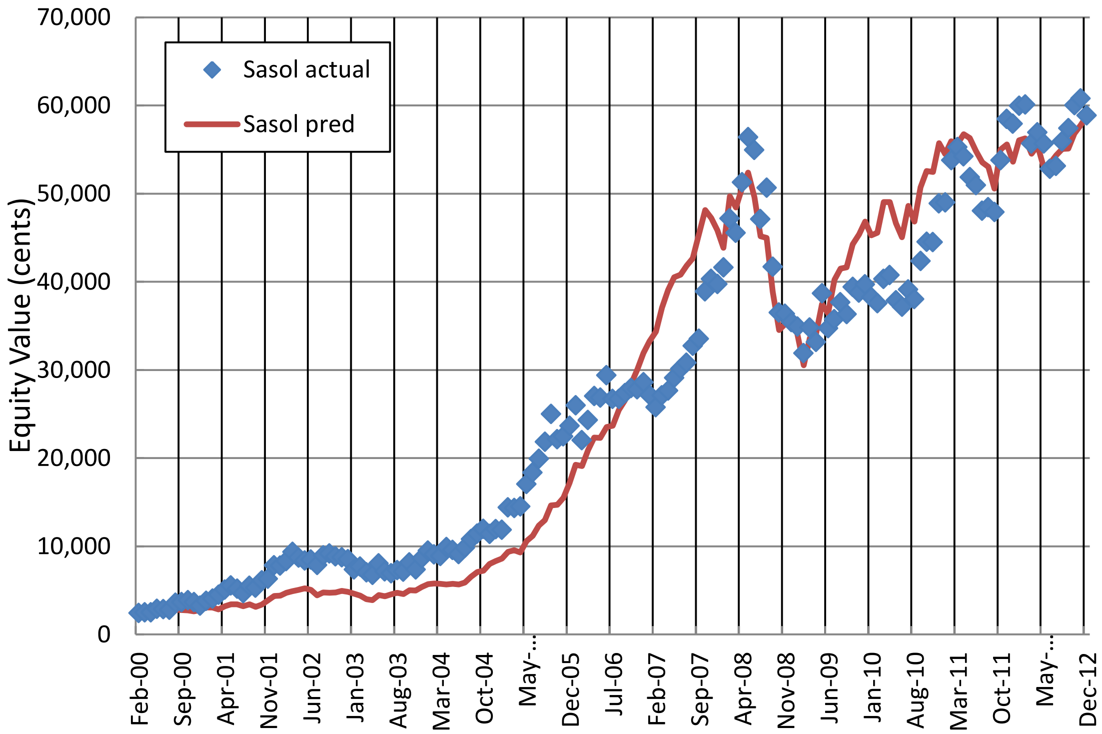

Figure 24. Predictions of equity value for Sasol using the Fama and French 3-factor approach.

4.6 Summary of the results

The results of the analyses related to the three research questions have been presented in this chapter for the twenty companies that comprise the sample of companies on the JSE.

To test the ability of the CAPM to predict the behaviour of individual equities on the JSE (Research Question 1), the variances of 3-year βs over the 13-year study period were determined and the averages and standard deviations were calculated. To illustrate the significance of the variability, the effect of a single standard deviation variation in β on the NPV was estimated.

Research Question 2 challenges the variability of β introduced by using different approaches to estimate β. Daily, weekly and monthly data were used to determine β and the averages and standard deviations were determined and tabulated. The same was done for βs determined using 1-year, 3-year and 5-year data periods. The βs generated using data from the last trading day of the month (base case) were compared to those generated using data from the first trading day of the month. The effect of different choices for market proxies – ALSH, FNDI and a specific narrow market proxy chosen for each particular company – on βs was determined and the differences in averages and standard deviations compared. The data for 4 companies were plotted to illustrate the time variation. Since the equity premium is a key parameter in the CAPM, the equity premiums using different risk-free rates (R157, R153, R186 and the STeFI Index) and the ALSH as market proxy were estimated. The same exercise was carried out using the FNDI as market proxy. By definition, β is not related to the choice of risk-free rate but the latter still has a significant effect on the estimation of NPV, and this has been estimated and shown for a hypothetical investment for all the companies in our sample (and the time variation for 4 companies).

Research Question 3 tests whether a Fama and French 3-factor model might be a better way to correlate and predict the data. The results of multiple linear regression of returns against size (market capitalisation), equity premium and the book-to-market ratio are shown for all 20 companies in this sample. The regressions are shown graphically for 4 companies varying in size and degree of correlation.

CHAPTER 5: DISCUSSION OF THE RESULTS

5.1 Introduction

The results pertaining to the three research questions were presented in Chapter 4 and are discussed in Chapter 5. Conclusions around these research questions are drawn.

5.2 Demographic profile of respondents

The sample was twenty companies selected from across sectors and sizes of those listed on the Johannesburg Securities Exchange. While the original intent was to study all of the shares constituting the ALSH, this would have made this work overly large and cumbersome without really adding value to the outcomes. The companies selected are from those which retained their current form at the start and end of the period of study (1 January 2000 through 31 December 2012).

5.3 Discussion pertaining to Research Question 1

Research Question 1

The ability of the single-factor CAPM to predict the risk-return behaviour of the JSE will be tested.

The CAPM, by definition, predicts a straight line regression between the return on equity and the equity premium. The theory requires that all market structural risk is contained in the equity premium, and β contains all the risk related to a specific equity. For any given company, one would expect a reasonably constant β with significant shifts explainable by changes in the fundamentals underpinning the risks (environmental factors or significant shifts in strategy). Large fluctuations in βs clearly challenge the ability of the CAPM to predict risk-return behaviour.

Figure 1 through Figure 4 show the results for βs calculated using the base case set of assumptions; that is, monthly data over a three-year period with the ALSH as the market proxy. Each point represents the β given by the covariance of the equity return relative to the market return over the preceding three years.

The results show significant variations in β. Figure 1 shows variability by a factor of 5 – 6 for companies like AstraPak, Group Five and Tiger Brands, with AstraPak even showing a negative first value – implying a counter-cyclicality to the market. It could be reasoned that the packaging industry could have an inherent counter-cyclicality due to the demand for smaller packaging sizes in times of economic downturn, but the β shows a minimum in January 2008 and then rises rapidly during the worst part of the economic downturn in mid-2008 through 2010. As shown in Figure 1 through Figure 3, most companies have βs that vary by factors of at least 2 – 3 (in other words, by 200% through 300%) during the period of interest. The one exception in these first three groupings is MTN, which shows a relatively consistently high β (as Table 4 shows, the average is 0.82). A possible explanation could be the nature of the telecommunications industry relative to the rest of the JSE, which is dominated by possibly even more volatile resources stocks. On a more conventional bourse with a wider spread of companies, one would expect the telecommunications stocks to be more volatile than the market.

The dominance of the JSE by resource stocks is graphically illustrated in Figure 4, which shows three of the very large resource-based companies (Sasol, Anglo American, and BHP Billiton) having βs on the order of or larger than 1. Anglo American and BHP Billiton consistently show βs much larger than 1, meaning that these companies respond much more strongly to stimuli than the market – which demonstrates that resource stocks tend to be more volatile than the market. Of interest is Sasol's relatively stable β around one. This suggests that the two major drivers (oil price and rand/dollar exchange rate) of Sasol's returns could also be the major drivers of the overall market. The performance of Gold Fields, though, demonstrates that there a number of factors at stake beyond just the sector in which the company operates.

The time-averaged results are show in Table 4. The averages of the 3-year βs are reported together with the standard deviation in the β values both as absolute values and as a percentage of the average β. The standard deviation data show that two-thirds of the calculated βs fall within 9.3% of the average value of β for Sasol. Gold Fields, on the other extreme, shows a spread as wide as 80.7%, with the results for the rest of the companies falling in between. The standard deviations remove the outliers that are shown in Figure 1 through Figure 4, but it is clear that βs vary by significant percentages in general depending on when these are calculated.

Also shown in Table 4 is the β calculated by considering all the data over the 13-year period. The conceptual formulation suggests that the representativeness of the CAPM improves as a longer time period is considered, and that the 13-year β should be the most representative. For 14 out of 20 companies, the averages of the 3-year βs compare to within 10% of the 13-year β, but there are significant differences for the balance.

The question at hand is how well the CAPM predicts the risk-return behaviour of equities on the JSE. Specifically, the use of the CAPM in investment decisions requires a smooth and predictable value for β. To understand the significance of the variability in β, the impact on the net present value (NPV) of a hypothetical significant investment is investigated for each company. The impact of a single standard deviation percentage variation on the NPV at the end of each 3-year period is determined and plotted in Figure 5 through Figure 8. The NPV Variability that is reported is the percentage change in NPV if the β calculated at that time is increased by a single standard deviation percentage increase (as shown in Table 4). In order to meaningfully quantify the effect, assumptions were made to set the target[8] debt-to-equity ratio (D/E) to 40%, the equity premium to 3.1%[9] and the return on debt as 3% over the risk-free rate (here, taken as the R157 government bond).

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[8] Target D/E should be used in discounted cash-flow analyses (see Firer *et al* 2012).
[9] In section 4.4 it will be shown that the equity premium is very volatile and can even become negative at times.

As can be seen in Figure 5 through Figure 8 the NPV predictions using the CAPM can vary by more than 100%. The most stable NPV prediction is for Sasol which varies between 16% and 8%. Clearly, the variability in the β values has a significant impact on decision making. The discounted-cash flow (DCF) methodology is often portrayed as the most meaningful way to make investment decisions (Firer *et al* 2012, Ward 1993) and many companies use it in practise (82% of the companies surveyed by Correia and Cramer 2008), but the significant uncertainty introduced by the CAPM as a model for the equity return, and consequently the WACC, makes the DCF methodology questionable for decision making. A fairly conservative target of 40% for D/E has been used for quantification, and companies using higher equity financing should also see higher uncertainty in the DCF decision making.

These results are not surprising given all the previous empirical work done on the CAPM. As discussed in Chapter 2, the previous work has largely focused on portfolios rather than individual equities. In principle, portfolios should broadly demonstrate better diversification and inherently better CAPM behaviour than individual equities (unless specifically chosen to maximise volatility). Focusing on individual equities, as in this work, should inherently represent the worst case for the CAPM.

The conclusion here is that the single-factor CAPM is a very poor predictor of the risk-return behaviour of the JSE. This conclusion is consistent with all of the findings in the literature in Chapter 2, where the CAPM is found to be a poor predictor of the behaviour largely of portfolios of equities but also of individual equities. In terms of the broader question of the value of using the CAPM as the basis of investment decisions, it can be clearly seen that it is not very reliable in general primarily due to the volatility in the β values leading to large variations in the NPVs calculated using the DCF methodology. Practically, an over reliance on the CAPM to predict required equity returns is likely to lead to poor investment decisions.

5.4 Discussion pertaining to Research Question 2

Research Question 2

The effects of using weekly returns rather than monthly returns to calculate β, as well as one-year, three-year and five-year βs and different proxies for the risk-free rate and market will be investigated.

5.4.1 Effect of Data Frequency, Data Period, and Sampling Day

As discussed in section 2.4, there are a number of different approaches to application of the CAPM in practise. These approaches vary from the data frequency used to calculate the βs through the length of the data set to the choices of proxies for the market and the risk-free rate. While section 2.4 refers to more sophisticated methods for calculating β, there is little indication that these are used in practise. Accordingly, the focus here is on the impact of the different approaches on the value of β calculated using the covariance approach that is used throughout this work.

The impact of using daily, weekly and monthly data frequencies on the calculation of β are shown in Table 5. It is expected that sampling the data more frequently would introduce more volatility. However, if the CAPM theory is robust, the statistical treatment through the covariance should inherently smooth out these fluctuations and the data frequency should not have a major impact on the βs. In Table 5, the average and standard deviations of the βs calculated using the base case assumptions (3-year monthly data with ALSH as market proxy) is compared to the averages and standard deviations of the βs generated from 3-year daily and weekly data for each of the companies in this study. The differences in averages vary between 0% and 20%, with some outliers at 40% - 60%. The standard deviations represent the spread of the data, and here the standard deviations of the daily and weekly data vary from around 50% to 120% of the standard deviations of the monthly data, with the standard deviation of the βs calculated using weekly data for Sasol more than twice that for the monthly data. In general, the βs calculated using weekly and daily data typically have a much smaller spread than the βs calculated using monthly data, which is somewhat counterintuitive. The one positive effect of using weekly or daily data might be that the number of data points used to calculate a statistical parameter increases significantly. Clearly, the effects of using daily, weekly and monthly data are significant on the calculation of β, but since there is really no true value of β it is not possible to evaluate which approach best approximates the true values. Decreasing variability is directionally good for application of the CAPM, and the results suggest that there might be some value in using weekly data to evaluate β. In terms of the research question, the effects of different frequency data have a significant impact on β and, by extension, on investment decisions made using the calculated β.

The effect of the period of data used to calculate β should be more straightforward, since in terms of the CAPM theory the longer the data period used the more likely β is to approach a true value. Short-term under or over-performance should be smoothed out over time. That is, βs calculated using three-year data should show less volatility than βs calculated using one-year data, and similarly five-year data should produce better and more stable results than three-year data. This is supported by the results shown in Table 6. For all the companies studied, the differences in averages are not significant, but the 5-year standard deviations are significantly less than the 3-year standard deviations, and the 1-year standard deviations are significantly larger than the 3-year standard deviations. In fact, the 1-year data show spreads about twice as large, in general, as the spreads of the 3-year data, and as much as 3.5 times in the case of Sasol and MTN. Clearly, the results show that one should use the longest-term data that are available to predict β.

The volatility of the calculated βs suggest that even the choice of the day of the week or the month might have a significant impact on the determination of β. The effect of calculating β using data from the first trading day of the month was compared to the base case which used data from the last trading day of the month. These data are shown in Table 7. The differences are not as large as using different data periods, but there are significant differences which calls into question the theoretical basis of the CAPM. For a methodology to be meaningful and robust, there should not be significant differences between results calculated using data effectively one trading day apart given the number of observations.[10]

Table 5 through Table 7 have focused on the statistical variations of the βs generated using different approaches. Figure 9 through Figure 12 show graphically the time-variance of the effect of using different approaches on 4 different companies (Barloworld, MTN, Sasol and Standard Bank). As explained in section 4.4, the company having the smallest standard deviation of β for the base case in each grouping is chosen. This test infers some measure of stability. The data for the other sixteen companies are not presented to keep this report short. As is to be expected from the discussion of the statistical values earlier in this section, the volatility associated with 1-year data is pronounced. In contrast, the other data show much smaller variations, but the only approach that has a significant impact on smoothing out the β data is using the data set across a 5-year period to calculate β.

It is clear that using different approaches for estimating β involving different data frequencies or data periods or sampling days do not significantly address the concerns raised in section 5.3 around the ability of the single-factor CAPM to predict the risk-return behaviour of the JSE. Even using a 5-year data period rather than a 3-year period shows the reduction of the standard deviation of the βs to an average of 58% and a median of 53% for the twenty companies in this study. This standard deviation is still significantly large enough that it does not resolve the concerns raised in section 5.3. Other authors have found similar results as discussed in section 2.3, mostly for portfolios but also for individual stocks on, for example, the Amman Stock Exchange (Al Abbadi and Louzi 2010), the Bombay Stock Exchange (Choudhary and Choudhary 2010) and the Karachi Stock Exchange (Hanif and Bhatti 2010). All of these authors found that the CAPM poorly represented the risk-return behaviour of individual stocks. Al Abbadi and Louzi also found a lack of correlation between βs derived from

[10] The 106.8% difference in the averages for Discovery is significantly larger than any of the other differences, and difficult to explain. The calculations have been checked but no errors are evident.

weekly and monthly data, as was found here. The results for the JSE as discussed here are consistent with the results of other stock exchanges that were discussed in section 2.3.

5.4.2 Effect of Choice of Market Proxy

The market to be considered should not just be the equities market, but the market for all investments including property, stocks and bonds, and human and intellectual capital (Goltz and Le Sourd 2010). The ALSH is the base choice for a market proxy, but as discussed in section 3.4.2, the use of the FNDI by 23% of respondents reflects a discomfort with the skew of the JSE towards resources stocks. For these respondents, analysis is done with the FNDI index, which strips out the resources stocks. The theory requires the market be as broad as possible, but in this work the market is more narrowly defined for each equity by considering a representative sector of the JSE. The definitions of the indices and the assignment of each company to a representative index are given in section 3.4.2.

The results of the analysis are shown in Table 8, and the time-variance data for the four companies chosen in section 5.4.1 are shown in Figure 13 through Figure 16. As expected, when the FNDI is used as the market proxy, the resource shares show a significantly larger standard deviation. These shares retain their inherent volatility while the volatility of the different market is now damped. The standard deviations for Sasol, AngloAmerican and BHPBilliton are about 50% higher than before. However, the average βs for all three of these companies decrease with the FNDI as market proxy, which is surprising since this means the responsiveness of these companies to the market is now much lower. This suggests that the responses of different types of equities to the same perturbations are quite different, and trying to lump all these effects into a single β does not make sense. The R/$ exchange rate, for example, clearly has a large, short-term impact on resource stocks, while the effect on a manufacturing company might be in the opposite direction (short-term impact on markets with a long-term opposite impact on capital goods).

This reasoning clearly supports the drive to look at narrower proxies of markets, where the responses to the same perturbations (whether positive or negative) are relatively similar. The average values of the βs of the non-resource stocks all increase when the FNDI is used as market proxy, which is expected since these now represent a significantly larger fraction of the market. In general, the standard deviations decrease or remain similar, although there are significant exceptions.

Narrowing the market further has mixed results. The average values of β show very mixed results and the responses appear quite random. The standard deviations tend to remain similar or decrease, which is clearly to be expected with the narrower proxies for the market. It is the value of β that is important for investment decisions, and it is clear that one cannot draw significant or meaningful conclusions on the usage of the FNDI or narrower market proxies to improve the ability of the CAPM to predict risk-return behaviour of the JSE.

This conclusion is supported by the time-variation data shown in Figure 13 through Figure 16. The problem seen in this work is that the values of β fluctuate significantly and randomly, making the consistent prediction of value challenging. There might be some value to narrow the market, as seen for Sasol in Figure 15 and Standard Bank in Figure 16, but the companies must still be part of an index large enough that individual companies do not dominate.[11]

5.4.3 Equity Premium

The equity premium puzzle was introduced in section 2.3 where the observation of Mehra (2006) that economic theory did not explain the equity premium was mentioned. The work of Favish and Affleck-Graves (1987), using data from the first quarter of 1960 to the third quarter of 1985 to show an average equity premium of 12.3% relative to a South African treasury bill, was also discussed in that section. As discussed in section 3.4.2, Correia and Cramer (2008) showed that the mean equity premium used in practise by their sample was 5%,

[11] The obvious extreme case of narrowing the index all the way down to a single company gives a β of 1 with a zero standard deviation, but with no predictive ability.

and 6% has been suggested as a representative worldwide value. Taken with the work of Fernandez *et al* (2013) and Fernandez *et al* (2014), a view of 5% - 7% for the equity premium in South Africa is suggested.

The results of calculations of equity premium using the data in this study are shown in Table 9 and Table 10 using the ALSH and FNDI, respectively, as market proxies. The equity premiums are calculated for different choices of risk-free rate (R157 – base, R153, R186, STeFI). The first line in both tables shows the equity premium values calculated across the longest period available - all 13 years of data in this study for the R157 and the R186, but 10 years for the R153 which matured in August 2010 and 9 years for the STeFI which is only reported from Jun 2013.

The theory and practise of the CAPM would suggest that equity premiums for a single stock exchange remain relatively consistent across many years. The results in Table 9 and Table 10 highlight one of the biggest issues with the CAPM, which is the value of the equity premium to use in practise. Even if βs are relatively constant, the choice of equity premium is a challenge. As discussed, rules of thumb suggest values of 5% to 7%, and historical data showing values as high as 12%, have been discussed. However, the data in this study show values in the region of 3% across the 13 years of data in this study. If the FNDI (rather than the ALSH) is used as market proxy, then the equity premium drops by about a percentage point.

The challenge with the equity premium is that periods of very strong over performance (January 2004 – December 2006) are offset by years of strong under performance (January 2000 – December 2002, January 2007 – December 2009), with many years of marginal performance. The very large variation in performance suggests that the average values over two lengthy periods could be quite different, with significant potential consequences on investment decisions. If an equity premium of 5% – 6% over the risk-free rate is considered acceptable but 3% (to use the current value) is realisable, then good investments will be rejected in pursuit of unachievably-high returns since a high discount rate will push the predicted NPV of many investments into the negati7e.

The other challenge is that the different values during different periods (as long as a typical investment period) might actually be meaningful. In the current case, the JSE showed a sustained equity premium value of 12.3% over 26 years from 1960 to 1985 while it showed a marginal 3.1% over 13 years from 2000 to 2012. Whether this is simply random due to two recessions between 2000 and 2012 and a bad choice of dates, or whether there is a structural shift in the economy underpinning the JSE returns would be the subject of a much deeper economics study.

5.4.4 Effect of Choice of Risk-free Rate

Table 11 shows the impact of the choice of the risk-free rate on the NPV of a hypothetical investment. As discussed in section 4.4.4, the choice of risk-free rate does not directly impact the estimated value of β, since this is defined as the covariance of an equity return with the market return. Compared to the effects on NPV due to the variability of β, the effects of the choice of risk-free rate are relatively small. Choosing between the three government bonds considered here changes the NPV/CAPEX about 10%. If the STeFI is chosen as risk-free rate, the NPV/CAPEX moves out as much as 20%.

Given the level of uncertainty in all the numbers, this type of variability should not have a major effect on investment decisions, unless the numbers are given an unreasonable weight in decision making. It is variability on the level that is brought on by the variability of the βs that is of concern here.

The relatively small impact of the choice of risk-free rate on the NPV/CAPEX ratio is emphasised graphically in Figure 17 through Figure 20 for the 4 companies whose results have been highlighted throughout this study.

5.5 Discussion pertaining to Research Question 3

Research Question 3

An alternative cost of capital model will be investigated. A Fama and French 3-factor model approach will be developed.

The statistical results of Excel multiple linear regression following a Fama and French 3-factor model approach are shown in Table 12. Here, the monthly equity returns for the twenty individual companies in this study are regressed against market capitalisation (as a proxy for size), equity premium (as a market factor) and the book-to-market ratio (which reflects the market perception of the value of the equity). This follows the Fama and French (1993) construct, as discussed in section 3.4.3.

The Significance F values are all smaller than 0.05, establishing that the null hypothesis (no statistical relationship) can be rejected with a 95% certainty level. That is, a statistical relationship between the returns and one or more of the three dependent variables considered here is established. However, the adjusted R^2 values are generally small, with only those for the large resource-focused companies - BHPBilliton (0.58), AngloAmerican (0.67) and Sasol (0.47) - being around half or greater. Interestingly, SABMiller has a value of 0.42, with the rest of the companies being around a third to much smaller. Clearly, while the return on equity has a statistical correlation with size, equity premium and market perception these three variables only explain part of the variability in the return. For about half of the companies considered, these three variables only account for a fifth or less of the variability in the return.

The equity premium was allowed to fluctuate as the monthly difference between the return on the ALSH and the interest rate on the R157 government bond. Not surprisingly, all the *p*-values for the coefficient of the equity premium are less than 0.05, and most of these are significantly less. There is a direct statistical relationship between the market returns and the equity premium. For only two companies (AstraPak and Sasol) are the *p*-values for the coefficient of the market capitalisation less than 0.05. Since these two companies are on the opposite ends of the size spectrum, it is difficult to draw a meaningful conclusion on the effect of size. Only AstraPak, Sasol and Discovery have *p*-values for the coefficient of the book-to-market ratio (market perception) of less than 0.05, and the equity returns for the rest of the companies do not have a statistical relationship with book-to-market ratio. Interestingly, AstraPak and Sasol are the only companies showing statistical significance for all three dependent variables, but the adjusted R^2 for AstraPak is 0.08 while that for Sasol is 0.47.

Clearly, the Fama and French model using these three variables has limited success in predicting the equity returns of companies on the JSE, with the size and book-to-market ratios having minor effects. As was discussed in section 2.5, Shum and Tang (2005) found that the 3-factor model explained most of the variance in the returns for Hong Kong, Singapore and Taiwan, with the market return having the most significant effect (the effects of book-to-market ratio and size being small and sometimes negligible). On the other hand, Michailidis, Tsopoglou, and Papanastasiou (2007) found that size and book-to-market ratio explained the variance in returns. Van Rensburg and Robertson (2003a) investigated the effects of 24 factors for equities on the JSE, and found that size and price-to-earnings ratio explains the returns behaviour. All of these previous studies contradict the results of this study, but the statistical correlation with only equity premium is in agreement with the observations of Hearn, Piesse, and Strange (2010) who studied the stock exchanges of London, Johannesburg, Egypt, Morocco and Kenya. Strugnell, Gilbert and Kruger (2011) showed that the size effect is only significant for a portfolio comprising the smallest firms on the JSE. Ward and Muller (2012) also found positive correlations of β (inverse to return) and size, but identified important deviations from the pattern.

Figure 21 through Figure 24 show the actual equity returns predicted by the regression, based on the historical values of equity premium, market capitalisation and book-to-market ratio for companies with high and low adjusted $R^{2,}$ different sizes and in different sectors – Anglo American (adjusted R^2 = 0.67), AstraPak (0.08), Pick ‘n Pay (0.06) and Sasol (0.47). In general, the regressions tend to dampen the sharp variations in return.

The usefulness of the Fama and French 3-factor model is limited from a predictive perspective, since the problem of predicting the equity return on a single equity turns into the problem of predicting the equity premium for the market as a whole and, in some cases, the book-to-market ratio and the market capitalisation. There are perhaps more sophisticated means of applying the

Fama and French method, but this would be the subject of deeper study and beyond the scope of this work.

5.6 Conclusion

The results of the analyses related to the three research questions have been discussed in this chapter. In general, it has been shown that the CAPM poorly predicts the risk-return behaviour of the JSE, and investment decisions underpinned by analyses related to the CAPM could be poor. Different approaches to application of the CAPM have been considered, and it is clear that data sets for the largest possible period should be used. No other conclusions on better approaches to application of the CAPM could be drawn – there might be some benefit in investigating narrower market proxies although this is contradictory to the theory of the CAPM, and the effect of the proxy for the risk-free rate is small. The evaluation of the equity premium, and the variance even across two long periods, is a challenge to the application of the CAPM. A Fama and French 3-factor model shows statistical significance for the correlation with equity premium, but limited correlation with book-to-market ratio and size and has limited predictive ability.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

The main conclusions of this work are summarised, and recommendations are made as to the use of the CAPM. A number of suggestions for future research, which arose during the course of this work, are made.

6.2 Conclusions of the study

Accurate and meaningful estimation of a company's cost of capital is of critical importance for good investment decisions. If the cost of capital is set too high, then the company stands to lose opportunities. If set too low, value is likely to be destroyed. A key input into the cost of capital is the required equity return, which is often estimated using the CAPM. At the heart of the CAPM is the parameter β which reflects the responsiveness of the return of an individual equity relative to the return of the market as a whole.

The calculated βs vary by significant factors across the period under consideration (1 January 2000 through 31 December 2012), and it is concluded that the CAPM cannot predict the risk-reward behaviour of equities on the JSE. The significant variation in the NPVs of investments during this period leads to poor investment decision making for most companies in this study.

A number of practical alternative approaches to calculation of β have been considered to address research question 2.

The effect of data frequency is counterintuitive, in that monthly data should have less vulnerability to short-term fluctuations and thus less volatile results than those calculated using daily and weekly data. The results show that the use of daily and weekly data to calculate β actually results in smaller standard deviations of β. The use of longer data periods to calculate the data leads to less spread in β. The choice of the sampling day was shown to have surprisingly large consequences when considering data sampled on the first trading day of the month relative to the last trading day. Over a 3-year period, the effect should be that of a single trading-day shift and the resulting variances raise concerns about the robustness of the CAPM.

Changing the market proxy to the FNDI surprisingly increases the βs for the resource-based companies, which suggests that the response of the FNDI and the resource-based companies to the same perturbations is directionally different. This underpins an argument to choose a market proxy that more narrowly represents the market of a particular equity. Choosing the FNDI as a proxy lessens the variability of non-resource based equities, in general. Choosing an even narrower market proxy (such as the sector in which the company operates) has mixed results, but the improvement for companies like Sasol and Standard Bank suggests some potential in this approach (counter to the theory of the CAPM, which calls for the largest possible market).

The choice of a meaningful equity premium for use in the CAPM is challenging. For the JSE, historical data from 1960 – 1985 suggest numbers as high as 12%, rules of thumb suggest 5% – 7%, and the analyses in this work suggest equity premiums as low as 2% – 3%. The application of the CAPM calls for a consistent equity premium, but the data shows large variances across any 3-year period, and even across longer periods when considered across different historical times.

The choice of risk-free rate does not affect β, but it does have a significant impact on the equity premium required. However, the variations in NPV are not significant enough that the choice of risk-free rate should lead to different decisions on investments.

A Fama and French 3-factor model shows statistical significance for the correlation with equity premium, but limited correlation with book-to-market ratio and size. Apart from a few companies, for which the correlation explains about 50% or more of the variance, the correlation shows limited ability to explain more than a third or less of the variances. The need to predict the equity premium limits the predictive ability of this method.

The findings of this work, done specifically for a volatile period on the JSE, are largely consistent with what other authors have seen on different stock exchanges across the world during different time periods. As discussed in Chapter 2, the empirical evidence does not support the CAPM as a tool for decision-making. In this work, it has been demonstrated that the use of the CAPM can lead to significant errors.

6.3 Recommendations

The discounted-cash flow (DCF) methodology using the CAPM to predict the equity return (and thus the discount rate) is widely used to make investment decisions. The analyses done here show that the numbers generated have substantial variability. While it is accepted that the DCF can help with decision making, it is recommended that it is used in conjunction with other methods, given that all these methods (such as payback period) have structural problems (Firer, Ross, Westerfield and Jordan 2012), but an over-reliance on the DCF can lead to flawed decision making. This recommendation clearly extends across all investment decisions where DCF is used, such as capital project decisions or valuations.

The large variances of the CAPM results make the quantification of error resulting from the use of the CAPM difficult. This was one of the original objectives of this work, but the randomness of the variances does not allow for a prediction of the error. The effects of a single standard deviation variation in β on the NPV (subject to certain assumptions) for the twenty companies in this study are indicated in Figure 5 through Figure 8. There are a few companies for which the errors are small, but the fluctuations can be as high as 100%. That is, the NPV can be twice as large as calculated for certain investments. These Figures can give some quick indications of the potential scale of the error.

It is recommended that when the CAPM is used, data for the longest possible period is sourced and used to evaluate β, but that for each company analyses of the potential NPV error (following the methodology here) are done to contextualise the numbers.

The results of this work are recommended to academics and theorists to add to the empirical evidence to underpin the need for development of improved models for asset pricing. The work has raised many questions, and many of these are discussed in the next section.

6.4 Suggestions for further research

It is suggested to survey the financial management of companies to understand how many companies have recognised the shortcomings in the CAPM methodology and the methods they use to compensate for this. The concerns around WACC (and DCF analysis in general) should be relatively well understood, and it would be insightful to understand how these are being managed in practise.

An exhaustive and detailed analysis of the alternative methods for cost of equity capital evaluations should be carried out for companies on the JSE. This was one of the original intents of this research, but only a high-level analysis was conducted, and there is a depth of potential in the literature.

With access to company-confidential data, it would be useful to use the concepts in this work to test the correlation of the CAPM or other methods with project financial outcomes, with an accepted need to correct for other issues (such as project cost and schedule overruns) leading to loss in value. The conceptual approach used here to test the impact of errors in the CAPM on the NPV is useful for illustrative purposes, but actual investment data would add significant robustness to the study. However, there is no reason to believe that this would change the qualitative outcomes of this study.

Using different frequency data to estimate βs showed counterintuitive results, with βs estimated using daily and weekly data showing less spread than those estimated using monthly data. It is suggested that a data set much longer than that used here is used to investigate this issue. A similar approach would help resolve the issues around the equity premium.

The use of indices representing companies of similar profile or in the same or similar sectors, or both, to represent the market proxy for a given company showed some interesting results. It would be of interest to investigate whether other indices (such as sectoral ones) are more meaningful for the market proxy in the CAPM.

Since many of the companies surveyed by PriceWaterhouseCoopers (Nel 2011) and Correia and Cramer (2008) used proprietary data from sources such as Bloomberg, UCT/Cadiz, or McGregor BFA it would be enlightening to study these data sources to find out the variation between them. It would be of significant value to also understand the methods used by these companies to generate βs.

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