

**UNIVERSITY OF KWAZULU NATAL**

**THE INTERNATIONAL CAPITAL ASSET PRICING  
MODEL: EMPIRICAL EVIDENCE FOR SOUTH AFRICA**

Faezah Peerbhai

206514321

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School of Accounting, Economics and Finance

College of Law and Management Studies

Pietermaritzburg

Supervisor: Barry Strydom

Co-Supervisor: Andrew Christison

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*The teacher who is indeed wise does not bid you to enter the house of his wisdom but rather leads you to the threshold of your mind.*

*~Khalil Gibran*

The journey thus far has been a memorable one, and I have many teachers to thank, each of whom has contributed to my education and journey in different ways.

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And finally, all praise is due to my Creator, who has blessed me with able body, mind and resources; and Who has led me down a better path than I ever could have imagined for myself.

## **GLOSSARY OF ACRONYMS**

ACWI – All Country World Index

ADR – American Depository Receipts

AIC – Akaike Information Criterion

ALSI – All Share Index

ANC – African National Congress

APT – Arbitrage Pricing Theory

BA - Bankers Acceptances

BESA – Bond Exchange of South Africa

BHHH - Berndt, Hall, Hall and Hausman (1974) algorithm

BRICS – Brazil, Russia, India, China and South Africa

CAPM – Capital Asset Pricing Model

CML – Capital Market Line

DCAPM – Domestic Capital Asset Pricing Model

DCF - Discounted Cash Flow model

DTI – Department of Trade and Industry

EIV – Errors-in-variables

FDI – Foreign Direct Investment

FM – Fama-Macbeth

GARCH - Generalised AutoRegressive Conditional Heteroskedasticity model

GARCH-M – Garch-in-mean model

GLS – Generalised Least Squares

GMM – Generalised Method of Moments

HQIC – Hannan Quinn Information Criterion

ICAPM – International Capital Asset Pricing Model

ICAPM<sup>EX</sup> – International Capital Asset Pricing Model with exchange rate risk

IID - independent and identically distributed

IRP – Interest Rate Parity

JSE – Johannesburg Stock Exchange

LSE – London Stock Exchange

MAE -Mean Absolute Error

ML – Maximum Likelihood

MS - Markov Switching model (MS)

MSCI – Morgan Stanley Capital International

MSCI EAFE - Morgan Stanley Capital International East Asia and Far East index

MSE - Mean Squared Error

NCD - Negotiable Certificates of Deposit

OLS – Ordinary Least Squares

PPP – Purchasing Price Parity

QML - Quasi-Maximum Likelihood method

RMSE - Root Mean Squared Error

RSS - Residual Sum of Squares

SA – South Africa

SAFEX – South African futures exchange

SARB – South African Reserve Bank

SBIC – Shwartz Bayesian Information Criterion

TSS – Total Sum of Squares

UK – United Kingdom

US – United States

WEF – World Economic Forum

WLS - Weighted Least Squares

WTO – World Trade Organisation

## ABSTRACT

An integral component of all corporations' financial operations is the determination of the cost of equity of the firm. This input is required in many financial decision making processes, and the correct estimation of this value is therefore a very important issue. The Capital Asset Pricing Model (CAPM) of Sharpe (1964) and Lintner (1965) has filled this gap since its inception, and has been extensively used by both corporations and individuals in their estimation of expected return. Whilst the standard form of this model is intuitive and simple in its implementation, an additional issue faced when utilising it in the current day is that of global financial integration. Whilst the CAPM is suitable for use in a market which is completely segmented from the rest of the world, this is often not the case as the barriers across countries have gradually declined, with the result that much of the world is now internationally integrated.

This therefore led to two extensions of the CAPM to the international environment by both Solnik (1974) and Grauer, Litzenberger and Stehle (1976). Whilst both are referred to as International CAPM (ICAPM) models, the difference lies in that Solnik's (1974) model incorporates the presence of exchange rate risk, whilst the Grauer, Litzenberger and Stehle (1976) one does not. This study therefore provides an analysis of the suitability of these two models to the South African environment, along with a comparison of the relative performances of each model against that of the standard CAPM model. The three different methods of analysis used are: the unconditional approach, a conditional GARCH approach, as well as the cost of equity approach. The analyses are applied to the data which consists of all listed firms on the JSE from 1990 up to 2010, with multiple methods of evaluation employed, such as information criteria and forecasting, in order to provide a robust analysis of all three models.

The results of the analysis vary across the different methods used, however since a significant amount of evidence was found of the International CAPM models, it can be concluded that an international asset pricing model should be used instead of a domestic one. In the choice between the single-factor ICAPM model and the multifactor ICAPM<sup>EX</sup>, even though use of the Grauer et al (1976) model would not be inappropriate, it was concluded that use of Solnik's (1974) ICAPM<sup>EX</sup> model would be the best suited to the South African financial environment, as the presence of exchange rate risk factors in an asset pricing model is found to be an important inclusion which may lead to better cost of equity estimates.

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## CHAPTER 1 : INTRODUCTION

### **1.1. Background and Problem definition**

#### **1.1.1. Calculation of the Cost of Equity**

There are a wide variety of issues which are faced by organizations, as well as individual investors on a daily basis. One such issue is the cost of equity, which is required by both financial managers of corporations, as well as investment analysts who wish to calculate the rate of return on specific securities, based on the risk inherent in each. The development of the Capital Asset Pricing Model (CAPM) by Sharpe (1964) and Lintner (1965) marked the introduction of asset pricing theory, and was the first model which provided a direct link between risk and return (Fama and French, 2004: 1). This significant advancement in financial theory later led to the development of many other asset pricing models, with some, like the Intertemporal CAPM by Merton (1973) and the Consumption CAPM of Breeden (1979) being extensions of the basic model, whilst others like the Arbitrage Pricing Theory (APT) of Ross (1976) was developed independently as an alternative to the CAPM.

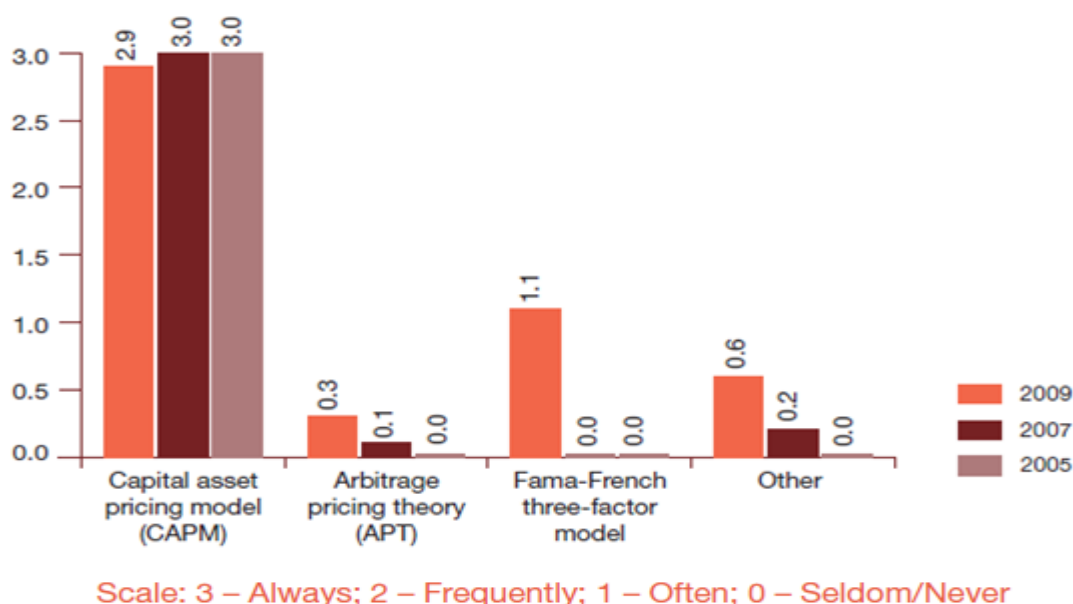
The popularity of the basic CAPM model, has however, outweighed that of the other asset pricing models developed, with this model being the dominant one mentioned in financial textbooks, as well as being widely used by practitioners in industry. In their early study of US companies, Gitman and Mercurio (1980: 27) found that the CAPM model was the most frequently used for the estimation of expected returns, with 36% of the companies surveyed using this model. This study was thereafter replicated by Gitman and Vandenburg (2000: 58) using statistics obtained in 1997, after which it was found that the CAPM was still the most popular asset pricing model, with an increased 65% of companies surveyed advocating its use. The study by Bruner, Eades, Harris and Higgins (1998: 17) echoed this result, as they found that 81% of the companies surveyed employ the CAPM model when estimating the cost of capital, with a further 4% using a modified version of the CAPM. They also found that 80% of all financial advisors surveyed also use the CAPM model in the estimation of returns. Graham and Harvey's (2001: 201) results produced also confirmed the popularity of the CAPM model in the US environment, as out of the 392 firms surveyed, 73.5% confirmed use of the CAPM as their method of analysis.

The preceding Graham and Harvey (2001) approach was replicated by Brounen, Jong and Koedijk (2004:84) on a sample of companies from the UK, France, Germany and the Netherlands. Whilst their

overall evidence found that the CAPM is also the most frequently used in the countries surveyed, it was also found that only 43% of the European respondents utilised the model, as opposed to the 74% which was found in Graham and Harvey's (2001) study of their US counterparts. The results of Brounen, Jong and Koedijk (2004) study was confirmed by those of McLaney, Pointon and Tucker's (2004) study of the UK environment and Peterson, Plenborg and Scholer's (2006) study of the European region.

When tested in a South African context, the evidence produced is largely the same, with studies finding that not only is the CAPM the most regularly used model, but its use has also increased over time. In 1991, Pocock, Correia and Wormald, found that 35% of the respondents in their survey utilised the CAPM to estimate a firm's cost of capital, whilst when the Graham and Harvey (2001) study was replicated in the South African context by Correia and Cramer (2008: 41), it was again found that a majority of 71.4% of corporations surveyed use the CAPM. A recent survey conducted by PriceWaterhouseCoopers (2010: 2) of 27 corporate financial analysts in South African companies also found that the CAPM is the primary method chosen by companies. The results of their survey is summarised in figure 1-1 below:

**Figure 1-1. Methods used to estimate the cost of equity**



(Source: PWC, 2010: 26)

The preceding evidence provided shows that the CAPM model is an extremely popular one, and its popularity extends across many countries of the world. The standard form of the CAPM model which is generally used can be expressed as follows:

$$E(R_i) = R_f + \beta_i(R_D - R_f) \quad (1.1)$$

where:  $E(R_i)$  = the expected return of asset  $i$ ;

$R_f$  = the risk-free rate;

$R_D$  = the return on the domestic market portfolio,  $D$ ; and

$\beta_i = \frac{cov(R_D, R_i)}{var(R_D)}$ , which is referred to as the beta of asset  $i$ .

The above model assumes that the only risk factor which is applicable in the determination of returns is that of beta, which is a measure of systematic risk<sup>1</sup>. The popularity of the CAPM model in estimating returns therefore lies in its simplicity and intuitive appeal (Fama and French, 2004:4). The standard form of the CAPM model however, should only hold for a capital market in which there is only one currency, and which is totally segmented from other capital markets which have different currencies (Stehle, 1977: 495). In a world where the process of globalisation has caused an increasing trend of integration amongst different countries, it can therefore be inferred that the standard CAPM model would not be appropriate for use.

### **1.1.2. Globalisation**

According to Bekaert and Harvey (2002: 431), the phenomenon of globalisation can be subdivided into two categories: Economic globalisation, and financial globalisation. Spoor Fisher (2010: 12) defines economic globalisation as “the increasing connectivity and interdependence of the world’s markets and businesses as a result of the growing scale of cross-border trade of services, flow of international capital and wide spread of technologies.” Financial globalisation on the other hand, is present if there are no barriers to investing between capital markets, which means that a foreigner will

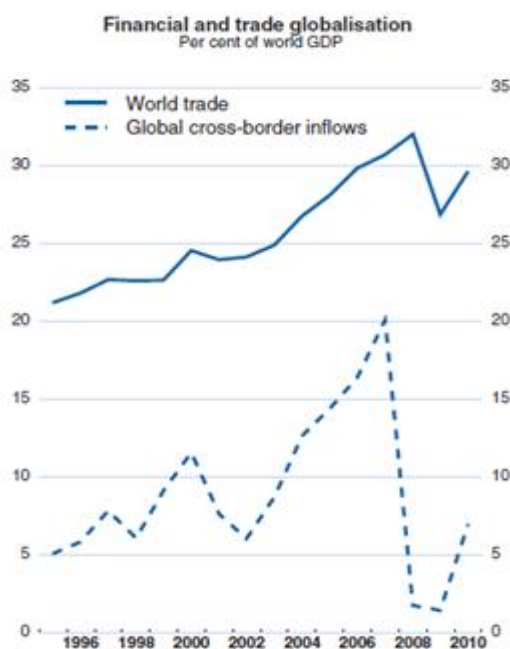
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<sup>1</sup> Systematic risk is the risk inherent in an asset due to variations in market factors which affect all firms in the economy, and therefore cannot be diversified away (Gitman, 2009: 145). Beta is therefore a measure of the responsiveness of asset  $i$  to changes in the domestic market portfolio  $D$ . This model will be derived and discussed further in chapter 2.

be able to freely access the South African market, and a South African investor will be able to freely access foreign market (Bekaert and Harvey, 2002: 431).

The process of globalisation therefore leads to a world in which there are no barriers between countries, and instead the world functions as a single community, which shares a common pool of resources (Mapuva, 2010:391). In recent years, there has been a drastically increasing trend of integration between countries across economic, financial, social, as well as political borders. According to Outtara (1997: 4), this trend can be clearly seen when observing the increasing importance of both world trade, as well as capital flows in the global economy, which is shown in figure 1-2 below:

**Figure 1-2. Global Financial Integration for the period of 1995-2010**



(Source: OECD, 2010: 291)

It can be seen from the preceding figure that the amount of world trade and cross-border capital flows has drastically increased from 1995 up to 2010, which provides substantial evidence that the world has become increasingly integrated. According to Stultz (1999: 13), the reason for this integration is due to the immense benefits associated with investing across borders. When a country opens up its market to foreign investors, the risk of the economic activities of the country is now shared between local and foreign investors. This will thus cause a decrease in the risk of an investor's portfolio without the usual corresponding decrease in return. Therefore, by investing in many countries with offsetting economic cycles, the investor's portfolio can be diversified greatly. This concept of



diversification is also applicable when international trade is considered. This is because firms are likely to have significant sales and/or operations outside their home country, which would serve to diversify the firm's profit potential, thereby creating a competitive advantage.

This increase in integration has consequently led to the need for a model which is more suited to the environment. If markets and conditions were perfect, there would be no difference in extending the domestic CAPM to the international one. However, theoretically, using a domestic market index is appropriate only for "an asset traded in a closed, rational market" (Harris, Marston, Mishra and O'Brein, 2003: 55). Solnik and McLeavy (2004: 147) outline the two assumptions requested for the domestic CAPM to hold in an international context:

- All investors worldwide have identical consumption baskets.
- The theory of Purchasing Power Parity (PPP) holds exactly at all times i.e. the real prices of commodities is identical in every country.

The above-mentioned assumptions are clearly unreasonable. Furthermore, the domestic CAPM does not take into consideration currency, changing interest rates or differing consumption preferences in different countries. Therefore, it can be seen that, whilst the domestic CAPM would be ideal to estimate expected returns in a market which was segmented from the rest of the world, the reality is that current markets are becoming increasingly integrated with global markets, which leads to the conclusion that the standard CAPM model will no longer be sufficient for use in the estimation of the cost of capital.

This necessity has led to the development of the International CAPM (ICAPM) model which was first developed by Solnik (1974), whose multifactor model included the use of a global market index as a proxy for the market portfolio, as well as the presence of exchange rate risks brought about by his assumption that PPP does not hold. His model was later followed by that of Grauer, Litzenberger and Stehle (1976), who, under different assumptions, developed an ICAPM model which excluded exchange rate factors and only incorporated a world market index. Due to the differences between these two ICAPM models, Solnik's (1974) model will henceforth be referred to as the ICAPM<sup>EX</sup>, whilst the Grauer *et al* (1976) model will be referred to as the ICAPM.

### **1.1.3. The necessity of a study of the South African environment**

Whilst there is a wide array of evidence that corresponds to the hypothesis that the world is becoming increasingly integrated, the level and extent of integration across countries vary. In emerging markets such as South Africa, there are different barriers applicable which inhibit investment and capital flows, and therefore have an effect on the level of globalisation inherent in that country. According to Bekaert (1995: 95), there are three barriers to investment which apply to emerging markets<sup>2</sup>:

- Direct barriers, such as legal restrictions imposed by government on foreign ownership of assets. These are also referred to as capital/exchange controls.
- Indirect barriers such as lack of availability of financial information on certain foreign markets, inadequate investor protection and poor accounting standards.
- Risk factors which are not restricted to emerging markets, but which have a more significant effect on the activities in these countries, such as political risk and exchange rate risk.

The removal of direct barriers may be partially accomplished through the method of financial liberalisation, in which case foreign investors are allowed to freely trade on the domestic capital market, and domestic investors are freely able to invest on foreign markets. Studies such as Bekaert and Harvey (2003), and Taskin and Murdoglu (2003) have shown that financial liberalisation leads to larger flows of both foreign direct investment as well as portfolio flows into the country concerned<sup>3</sup>, and thus increases the level of financial integration. Whilst in the case of South Africa, there are still capital and exchange controls present, research has shown that the removal of these barriers do not necessarily result in increased foreign participation, as the other two indirect barriers which were outlined above may be considered to be more important (Bekaert and Urias, 1999; Bekaert and Harvey, 2003; Hunter, 2006; Errunza, 2001).

These barriers to investment may therefore serve as a deterrent to globalisation, in which case emerging markets such as South Africa can be considered to be segmented from the rest of the world. In a case like this, global market factors will be unable to explain returns, and the only relevant factors in the estimation of expected returns would be local factors (Garcia and Ghysels, 1998: 457). However, there have been many empirical studies on the subject of integration in emerging markets, the results of which have been varying. Whilst Harvey (1995a), Garcia and Ghysels (1998) and Carrieri, Errunza and Hogan (2003) all find that emerging markets are largely segmented, other

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<sup>2</sup> These barriers will be addressed further in both Chapters 2 and 3.

<sup>3</sup> The Johannesburg Stock Exchange (JSE) was liberalised in 1995.

studies such as Bekaert (1995), Bekaert and Harvey (1995) and Taskin and Muradoglu (2003) all find support for the hypothesis of integration in emerging markets.

Whilst many studies of integration in emerging markets excluded South Africa from their analyses due to the country only being included in emerging market database in later years, South African studies by Lambda and Otchere (2001), and Marais (2008) have shown that, whilst South Africa may not be fully globally integrated, the level of integration is steadily increasing over time. The possibility therefore exists that global factors may exhibit a significant influence on asset returns experienced, in which case the ICAPM models should hold. If, on the other hand, the South African market is found to be segmented, the DCAPM model should be found to be sufficient in the explanation of expected returns. Since to date, there have been very few studies surrounding the ICAPM models in a South African context, this study therefore fills a gap which currently exists in South African literature.

#### **1.1.4. Research problem**

The primary focus of this study is therefore summarised in the following question:

*Are the International CAPM models appropriate for use in the South African environment?*

#### **1.2. Research objectives**

The primary objective of this study is:

- To assess the accuracy of each of the three models being studied here: the Domestic CAPM (DCAPM), Grauer *et al* (1976) International CAPM (ICAPM), and the Solnik (1974) multifactor ICAPM model with exchange rate risk (ICAPM<sup>EX</sup>), and to determine which of these models are superior in the estimation of expected returns.

In the pursuit of this objective, answers to the following questions will therefore be sought after:

- a) Is the world market index a priced risk factor for companies listed on the Johannesburg Stock Exchange (JSE)?
- b) Is exchange rate risk priced for JSE-listed companies or not?
- c) Which model has greater explanatory power for JSE-listed firms: the domestic CAPM model, the single-factor ICAPM model, or the multifactor ICAPM with exchange rates model?

The secondary objectives of this analysis are as follows:

- To determine which global market proxy – the Morgan Stanley Capital International (MSCI) world index or the MCSI All Country World Index (ACWI) is superior in capturing the risks inherent in South African assets.
- To determine which specific exchange rate factors exert a significant influence on the returns of JSE-listed assets.
- To investigate the industry-specific characteristics and the responsiveness of different industries to different risk factors, in order to determine if their performances are consistent with theory.

The aim of this study is therefore to provide sufficient evidence on the appropriate risk factors applicable to the South African economy, and ultimately, if a domestic or international model is more appropriate for use. This information could therefore prove valuable to practitioners in industry in the estimation of the cost of equity, as well as domestic investors who wish to analyse their investment opportunities.

### **1.3. The Scope and Method of this Study**

#### **1.3.1. Scope of the study**

The time period of this study extends from February 1990 and ends in February 2010, to allow for twenty one full years of data. The start date of February 1990 was based on the studies of Brooks, Davidson and Faff (1997) and Makina and Negash (2004) who found that the unbanning of the African National Congress (ANC) in February 1990 marked the beginning of South Africa's process of global integration. The use of this period also allows for a more robust analysis as more data points will be available for testing.

The asset returns required for this study made use of the entire population of the JSE over the entire period. Since beta estimates are estimated over 60 months in this study, in conjunction with Fama and Macbeth (1973), Wu (2002 and 2008), and Bartram and Bodnar (2006), any companies which had less than five consecutive years of data available were excluded from the study. The returns of delisted companies which conformed to the requirements were also included, in order to eliminate any

effects that survivorship bias<sup>4</sup> may have on the study. Monthly return and dividend data were therefore obtained for all listed and delisted companies which met the data requirements during the period of 1990 – 2010. This data was then sorted into twenty industry portfolios in order to provide for an additional dimension of analysis.

In order to estimate the different CAPM models, appropriate proxies are required for the different variables. The proxies used for each of the three models are therefore shown in table 1-1 below:

**Table 1-1. Summary of proxies utilised for each CAPM model estimated**

<b>Model</b>	<b>Risk-free rate</b>	<b>Market portfolio</b>	<b>Exchange rates</b>
<b>DCAPM</b>	SA 90-day treasury bill	JSE All Share Index (ALSI)	N/A
<b>ICAPM</b>	SA 90-day treasury bill	MSCI World index, MSCI ACWI	N/A
<b>ICAPM<sup>EX</sup></b>	SA 90-day treasury bill	MSCI World index, MSCI ACWI	Spot exchange rates of the: US Dollar, British Pound, Japanese Yen and the Euro

### **1.3.2. Methodology**

There are three main methods which are used when evaluating the ICAPM models, as documented according to the empirical evidence in Chapter 2. The three methods are as follows:

- Unconditional approach, in which investors determine returns based on an unconditional assessment of expected returns (Harvey and Kirby, 1996: 36).
- Conditional approach, in which investors have time-varying expectations of the joint distribution of returns, which are dependent on the information available at that time (Harvey and Kirby, 1996: 36).
- Cost of equity approach, in which the effect of the model used on a firm's cost of equity estimate, is examined.

In order to provide a robust examination, a method from each of the three afore-mentioned approaches was utilised. Under the unconditional approach, the extremely popular method of Fama-Macbeth (1973) was used, whereas under the Conditional Approach, the modelling of second

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<sup>4</sup> Survivorship bias occurs when the sample being tested consists of only companies which were strong enough to survive the sample period of analysis, and excludes the companies which did not survive. This phenomenon distorts the results produced (Pawley, 2006: 21).

moments was made possible with the use of the GARCH model. Lastly, the cost of equity approach developed and used by Koedijk, Kool, Schotman and Van Dijk (2002) was used. The factor estimates produced were evaluated by making use of standard t-tests, whilst the overall results produced for each model were then analysed by making use of information criteria such as the Akaike Information Criterion (AIC), Schwarz-Bayesian Information Criterion (SBIC), Hannan-Quinn Information Criterion (HQIC),  $R^2$  and adjusted  $R^2$ .

### **1.3.3. Structure of the Study**

This analysis consists of six chapters, the outlines of which are contained below:

- *Chapter One - Introduction*

This chapter provides a background to the issues discussed in the study, and provides justification for an analysis of this nature in the South African environment. The specific research objectives are then outlined in detail, followed by a summary of the data and time period to be used in the study, as well as a brief discussion of the methodological approaches which will be used.

- *Chapter Two - Theoretical Foundations of the International CAPM models*

The theoretical foundations of the three models being investigated in this analysis are discussed here, together with a brief overview of the characteristics of the South African financial environment.

- *Chapter Three- Review of Empirical Studies*

This chapter contains a very detailed review of the empirical literature surrounding this topic, which is subdivided according to the methods used, and the models tested. The information contained in this chapter serves as the basic foundation upon which this particular study was based, and also serves as a basis for comparison when evaluating the results produced.

- *Chapter Four – Methodology*

The first part of this chapter outlines a justification of the methods chosen, after which each of the three models and the factors used in each are discussed in detail. This is followed by a discussion of the dataset and time period for the study, together with outlines of how returns will be calculated and what methods of preliminary data analysis will be used. The final sub-

section contains a detailed discussion of each of the three approaches used, together with an outline of the methods used to evaluate the performance of each model.

- *Chapter Five – Data Analysis and Results*

This chapter contains the results produced from each of the analytical methods used, together with a discussion of the results and appropriate conclusions.

- *Chapter Six – Conclusions and Recommendations*

This chapter contains a summary of the entire study and the results produced, and attempts to draw inferences from the data obtained, and provide answers to the research questions posed. The final portion of this chapter outlines the possible weaknesses of this study, together with recommendations for further research on the subject.

## **CHAPTER 2 : THEORETICAL FOUNDATIONS OF THE INTERNATIONAL CAPM MODELS**

### **2.1. Overview**

The preceding section outlined the popularity of the standard CAPM model in estimating expected return, and the issues faced when implementing the standard form of this model in the current financial environment. This chapter therefore looks at each of the three models which were introduced in Chapter one in more detail, and outlines the theoretical constructs of each. The three models which will be analysed theoretically in this chapter are therefore:

- The Domestic CAPM (DCAPM) derived by Sharpe (1964) and Lintner (1965);
- The single-factor International CAPM (ICAPM) derived by Grauer, Litzenberger and Stehle (1976); and
- The multifactor International CAPM with exchange rate risk (ICAPM<sup>EX</sup>) derived by Solnik (1974).

Whilst the DCAPM model takes the domestic market portfolio into account when estimating expected return, the ICAPM model uses a global market portfolio. The ICAPM<sup>EX</sup> model also utilises a global market portfolio, however this model also takes the presence of exchange rate risk into account, and thus allows for the inclusion of exchange rates as a risk factor. A discussion of each of these three models therefore ensues in the preceding chapter, after which the South African financial environment is examined, in order to develop a hypothesis about which model would be the best suited for use in this country.

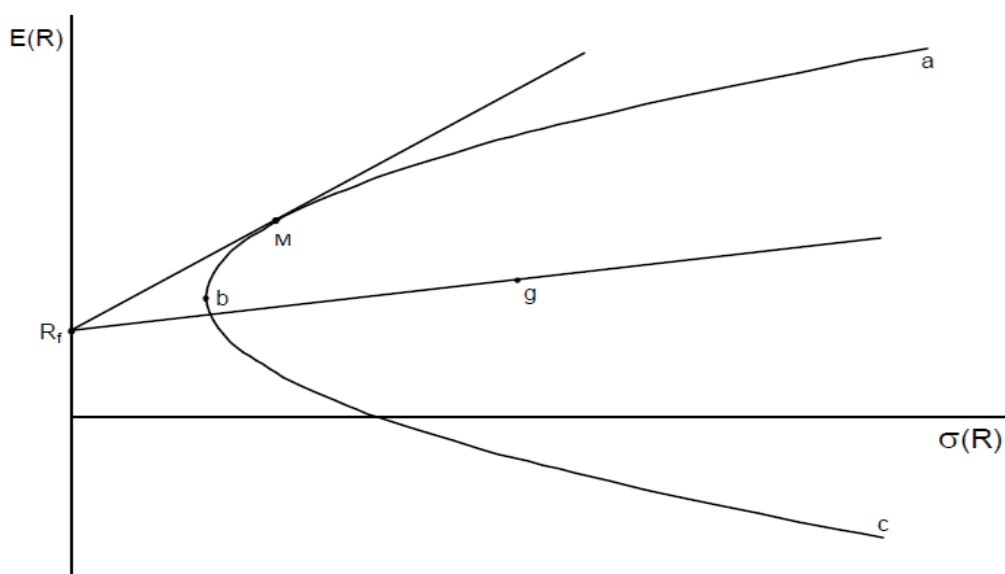
### **2.2. The Domestic CAPM model (DCAPM)**

The development of the standard CAPM model originated from the concept of mean-variance efficiency introduced by Harry Markowitz (1952, 1959). In Markowitz's model, investors are assumed to consider each portfolio with regard to its probability distribution of expected returns over a single holding period. Since the risk of each portfolio is based solely on its variance estimate, these two variables are therefore the only two used in an investor's portfolio decision, which implies that his utility curve will be a function of expected return and variance only. Since all investors are risk averse, for any given level of risk, investors will prefer higher returns to lower returns. In a similar fashion, for any given level of return, investors will prefer lower risk to higher risk.



The main result from the afore-mentioned assumptions is that the only portfolios relevant in the investment decision are those portfolios which offer the maximum expected return at a given level of risk, or the set of portfolios with the minimum risk at a given level of expected return, all of which are known as “efficient portfolios”. The set of all efficient portfolios is therefore known as the efficient frontier, which is represented by curve abc in figure 2-1 below:

**Figure 2-1. Graph of the efficient frontier**



(Source: Fama and French, 2004: 27)

The concept of the efficient frontier was thereafter utilised by Sharpe (1964) and Lintner (1965) in their development of the standard CAPM model. The additional assumptions upon which the model was built are therefore listed as follows:

- a) The capital market is perfect, which implies that there are no transaction costs or taxes.
- b) All investors attempt to construct portfolios that are on the efficient frontier.
- c) All investors are able to borrow and lend an unlimited amount at the risk-free rate and there are no restrictions on the short selling of an asset.
- d) Investors have homogenous expectations, which imply that any investment opportunities are viewed in exactly the same way by every investor.
- e) All investors plan for an identical investment period and are price takers (i.e. all investors make the assumption that prices cannot be affected by their individual trades).
- f) Asset prices are normally distributed.

- g) All portfolios are infinitely divisible, which means that investors will be able to purchase fractions of portfolios or assets.

(Bodie *et al*, 2007: 236) (Brigham and Gapenski, 1991: 301)

The assumption that investors are allowed to borrow and lend at the risk-free rate is a critical one which leads to Tobin's (1958) Separation Theorem. This theory implies that all investors will simply hold only two portfolios, viz. the risk-free asset and a specific risky portfolio. However, since all investors are assumed to have identical estimates of the expected return, variances and covariances of assets, this implies that every single investor will hold the same optimal risky portfolio, which should include all assets in the universe. This conforms to the market portfolio and is shown in figure 2-1 as point M. The new opportunity set available to investors is therefore represented by the straight line  $R_f$ -M in figure 2-1, which is known as the Capital Market Line (CML). The different investors will therefore fall at different places along the CML according to their differing ranges of risk aversion<sup>5</sup>.

The efficient frontier and CML can now be utilised to derive the CAPM model by considering an investor who chooses to invest a portion,  $\omega$ , in asset  $I$ , and the remaining portion,  $1-\omega$ , in the market portfolio  $M$ . The expected return and standard deviation of this portfolio can therefore be expressed as equations 2.1 and 2.2 below:

$$r_p = \omega r_i + (1 - \omega) r_m \tag{2.1}$$

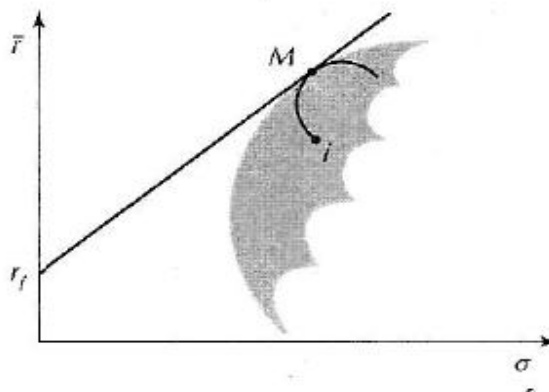
$$\sigma_p = [\omega^2 \sigma_i^2 + (1 - \omega)^2 \sigma_M^2 + 2\omega(1 - \omega)\sigma_{iM}]^{1/2} \tag{2.2}$$

As the different possible weightings of  $\omega$  vary, the expected return and standard deviation estimates trace out a curve as shown in figure 2-2.

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<sup>5</sup>Investors who are more risk averse will choose to invest at the risk-free rate, and will therefore fall at some point below the market portfolio M. Investors who are less risk averse however, will choose to borrow at the risk-free rate, and invest the proceeds in the market portfolio, and will therefore fall at some point higher than point M.

**Figure 2-2. The portfolio curve for the asset  $i$  and market portfolio M**



(Source: Luenberger, 1998: 178)

As shown in the preceding figure, a weighting of  $\omega=0$  corresponds to the market portfolio  $M$ , where the curve is also a tangent to the CML. It is therefore at this point that the slope of the CML is equivalent to the slope of the efficient frontier, as represented in the figure.

$$\text{Slope of CML} = \frac{r_m - r_f}{\sigma_m} \quad (2.3)$$

Whilst the slope of the CML (which is a straight line) can be easily conveyed by equation 2.3 above, the slope of the efficient frontier at point  $M$  needs to be calculated using the following formula:

$$\left[ \frac{dr_p}{d\sigma_p} \right]_{\omega=0} = \left[ \frac{dr_p}{d\omega} \right] \left[ \frac{d\sigma_p}{d\omega} \right]^{-1} \quad (2.4)$$

Where all the derivatives are calculated at  $\omega=0$ . For simplicity, each of the above components will now be outlined individually. Both expressions  $\left[ \frac{dr_p}{d\omega} \right]$  and  $\left[ \frac{d\sigma_p}{d\omega} \right]$  can be simplified by making use of equations 2.1 and 2.2 as follows:

$$\left[ \frac{dr_p}{d\omega} \right]_{\omega=0} = r_i - r_m \quad (2.5)$$

$$\begin{aligned}
\left[\frac{d\sigma_p}{d\omega}\right] &= \frac{d\sigma_p}{dr_p^2} \times \frac{d\sigma_p^2}{d\omega} \\
&= \frac{1}{2} (\sigma_p^2)^{\frac{1}{2}} \times [2\omega\sigma_i^2 - 2\sigma_m^2 + 2\omega\sigma_m^2 + (2 - 4\omega)\sigma_{im}] \\
&= \frac{1}{2} \cdot \frac{1}{\sigma_p} \times 2[\omega\sigma_i^2 - \sigma_m^2 + \omega\sigma_m^2 + (1 - 2\omega)\sigma_{im}] \\
&= \frac{\omega\sigma_i^2 - \sigma_m^2 + \omega\sigma_m^2 + (1 - 2\omega)\sigma_{im}}{\sigma_p}
\end{aligned} \tag{2.6}$$

However since at the point  $\omega=0$ ,  $\sigma_p = \sigma_m$ , equation 2.6 can be further simplified as follows:

$$\left[\frac{d\sigma_p}{d\omega}\right]_{\omega=0} = \frac{-\sigma_m^2 + \sigma_{im}}{\sigma_m} \tag{2.7}$$

Equations 2.5 and 2.7 can therefore be re-substituted into equation 2.4, to obtain the following:

$$\begin{aligned}
\left[\frac{dr_p}{d\sigma_p}\right]_{\omega=0} &= \left[\frac{dr_p}{d\omega}\right] \times \left[\frac{d\sigma_p}{d\omega}\right]^{-1} = \left[\frac{dr_p}{d\omega}\right] \left[\frac{d\omega}{d\sigma_p}\right] \\
&= (r_i - r_m) \times \frac{\sigma_m}{\sigma_{im} - \sigma_m^2} \\
&= \frac{(r_i - r_m)\sigma_m}{\sigma_{im} - \sigma_m^2}
\end{aligned} \tag{2.8}$$

As stated before, the slope of the CML (2.3) will be equal to the slope of the efficient frontier (2.8).

Therefore:

$$\frac{r_m - r_f}{\sigma_m} = \frac{(r_i - r_m)\sigma_m}{\sigma_{im} - \sigma_m^2} \tag{2.9}$$

If equation 2.9 is solved for  $r_i$ , the resultant equation takes the form of the standard CAPM model, which was introduced earlier (equation 1.1, page 3):

$$r_i = r_f + \beta_i(r_m - r_f)$$

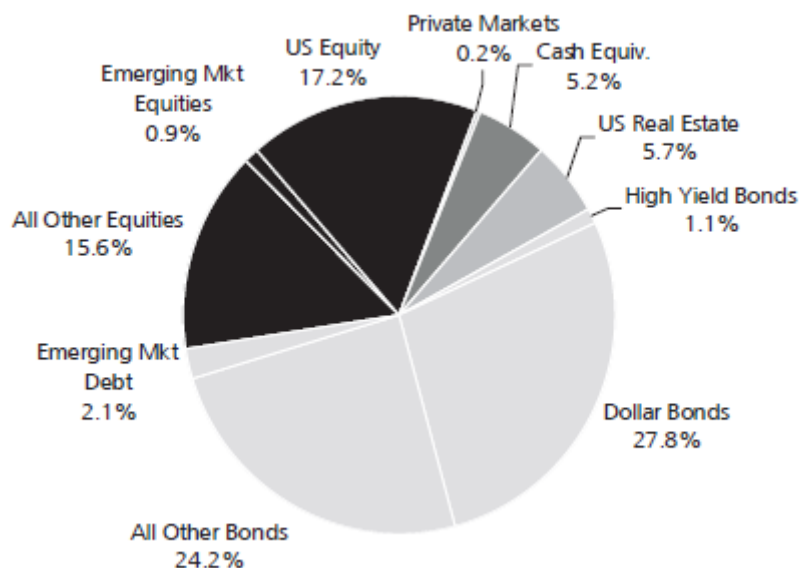
where:  $\beta_i = \frac{\sigma_{im}}{\sigma_m^2}$

The beta coefficient ( $\beta_i$ ) shown above is representative of the systematic risk present in asset  $i$ , measured by dividing the covariance between asset  $i$  and the market  $M$ , with the variance of the market portfolio. This standard CAPM model has succeeded in becoming the most popular model used to explain expected return due to its simplicity and intuitive appeal, as the entire risk of an asset is encapsulated by just one variable (beta). However, due to the unrealistic assumptions made in this model's derivation, it has also come under significant criticism. The most notable critique of this model to date has been that of Roll (1977) in which he questioned whether it is actually possible to test the empirical validity of the CAPM model.

The nature of Roll's (1977: 145) argument stems from the theory underlying the CAPM model, which states that the market portfolio (expressed as  $r_m$  in the preceding equation) should consist of all the risky assets in the economy. Furthermore, in equilibrium, the various different assets should be included in the portfolio in proportion to their market value. Therefore, the inclusion of land, human capital, gold coins etc., together with their proportionate weights are imperative in the formation of this market portfolio.

However, in the real world, testing of the CAPM requires the use of proxies for the market return, as the exact composition of the market portfolio is unobservable. For the standard form of this model, the market is assumed to be segmented and the proxy which is picked is usually the country-specific equity index, for example the S&P 500 index will be used in investigations of the US market, whereas the JSE ALSI will be utilised as the proxy for the South African market. However these indices constitute a minor percentage of the global risk asset portfolio. This can be seen in figure 2-3, which shows that even for the US, whose financial market is large and influential, as at 2005, their equity market only makes up 17.2% of the total investable assets in the world.

**Figure 2-3. Total investable assets available in the global financial market, as recorded in 2005**



(Source: UBS, 2005: 2)

The use of these indices as proxies for the market portfolio has very serious implications for tests of the model and therefore for use of the model when evaluating portfolio performance. According to Roll (1977), a mistakenly specified market portfolio can have the following two effects:

1. The beta calculated for alternative portfolios would be wrong because the market portfolio which was utilized to compute the portfolio's systematic risk was unsuitable.
2. The resultant risk-return relationship which was derived would be wrong because it goes from the risk-free rate to the improperly specified market portfolio.

Based on the afore-mentioned effects of using the wrong market portfolio, Roll (1977) concluded that a test of the CAPM will require an analysis of whether the proxy used to represent the market portfolio is mean-variance efficient and whether it is the true optimum market portfolio. Therefore, as noted in Elton and Gruber (1991: 375), any test which is performed with any portfolio other than the true market portfolio, are not tests of the CAPM, but simply tests of whether the portfolio chosen as the market proxy is efficient or not. A summary of Roll's (1977) conclusions is contained in figure 2-4.

**Figure 2-4. A Summary of Roll's (1977) critique**

	Market Proxy Ex-Post Efficient	Market Proxy Not Ex-Post Efficient
CAPM True	(1) Holds	(1) Fails
CAPM False	(1) Holds	(1) Fails

(Source: Balvers, 2001: 55)

In a market which is completely segmented from the rest of the world, and where investors only have access to investment opportunities from within their home country, the domestic market index may be found to be mean-variance efficient, in which case it will be regarded as a suitable proxy for the market portfolio. However, investors today are able to access assets from a variety of different countries across the world due to the phenomenon of globalisation. As a result, many barriers to trading which previously existed between countries have now been abolished, thus resulting in an even broader investment opportunity set for the investor (Krause, 2001: 104). In the presence of this internationally integrated world, a more suitable proxy for the market portfolio would be a global portfolio, which contains all the investable assets available in the world. Based on the Roll's (1977) criticism, a portfolio such as the world portfolio may be more suitable to conform to the theory underlying the CAPM, which is an issue outlined and discussed later on.

The increase in trading across country borders brought about by the decrease in barriers to investing, and the absence of a single global currency, brings about an additional risk factor to asset returns which is exchange rate risk. The presence and extent of this risk is also an aspect which has been fiercely debated in the academic literature, and the initial model developed for an internationally integrated world by Solnik (1974) incorporated this risk factor into the basic CAPM model. His model was later redefined and simplified by Grauer, Litzenberger and Stehle (1976) in order to develop an international CAPM model where the exchange rate risk factor was not considered. Whilst the Solnik (1974) multifactor model preceded the Grauer *et al* (1976) single-factor international model, since

both were derived from the same conditions, the Grauer *et al* (1976) model will be outlined first, as this is the simpler model which provides a succinct introduction to the Solnik (1974) model, which is slightly more complex.

### **2.3. The single-factor International CAPM model (ICAPM)**

The single-factor ICAPM model was developed by Grauer, Litzenberger and Stehle (1976), and builds its theoretical foundations on many of the same assumptions upon which the DCAPM model was formed. An integral assumption underlying the development of the ICAPM model and one that is essential in the formulation of any international asset pricing model is that of perfect international capital markets. Therefore, there are no taxes, transaction costs, or barriers to investing, which imply that the international capital market will be completely integrated. The derivation of this model therefore begins with the assumption that the price of asset  $i$  in country  $k$  ( $P_{ik}$ ) follows an Ito Process. The nominal rate of return on the asset  $i$  can be expressed as:

$$R_{ik} dt = \frac{dP_{ik}}{P_{ik}} = E(R_{ik})dt + \sigma_{ik} dz_{ik}$$

$$i = 1 \dots n$$
(2.10)

where:  $E(R_{ik})$  = the instantaneous expected rate of return on asset  $i$  in country  $k$ ;

$\sigma_{ik}$  = the instantaneous standard deviation of asset  $i$  in country  $k$ ; and

$dz_{ik}$  follows a standard Gauss Weiner process with zero mean.

In the development of the DCAPM model, it was assumed that all investors' opportunity sets fall on the efficient frontier, which implies that they hold portfolios of assets instead of single assets. In the development of the ICAPM model, it is assumed that when investors are forming their portfolios, they are only concerned with the real returns of financial assets (which are adjusted for inflation), rather than the nominal return expressed in equation 2.10 above. These investors will measure the risk of the individual risky assets by the degree to which they contribute to the variance of the return of the internationally diversified portfolio. Therefore, since under the assumptions of the CAPM all investors have homogenous expectations, they will invest their wealth in exactly the same way and the investor's home country is irrelevant, i.e. all investor's consumption opportunity sets are the same. Under such a condition, Purchasing Power Parity (PPP) must hold (Karolyi and Stultz, 2002: 10).



The concept of PPP implies that an identical good will be the same price, regardless of the market in which it is sold. Therefore, if  $e(t)$  is the spot price of the foreign currency at time  $t$ ,  $P_d(t)$  is the price of the commodity in the domestic currency, and  $P_f(t)$  is the price of the good in the foreign currency at time  $t$ , it should hold that  $P_d(t) = e(t) \cdot P_f(t)$ . Therefore, any fluctuations in the exchange rate are simply changes in the relative prices<sup>6</sup> of the goods which are offered by the different countries, whereas the real proceeds to a person from one country will be identical to the real proceeds of an investor in another country, who invests in the same riskless asset (Grauer *et al*, 1976: 252).

From the preceding discussion, it can therefore be seen that all investors will face the same investment opportunity sets, regardless of that investor's home country. Since it has already been established that all investors face the same consumption opportunity sets, it can be further assumed that every investor will calculate the returns on any assets held by using the same numeraire to form his/her portfolio of assets. Whilst theoretically, any numeraire could be used, if a currency is used as the numeraire it would serve as an additional asset, as each investors utility would be dependent on both the exchange rate, as well as the price of the consumption good in that particular currency (Stultz, 1994: 4).

In a world where there are multiple goods available, but all investors face the same consumption opportunity set, Grauer *et al* (1976: 238) find that it's appropriate to assume that all investors will choose to consume the same good. In order to convert the nominal returns in equation 2.10 to real returns, it is therefore necessary to specify the method in which the price of the consumption good can be calculated. Therefore, it is assumed that the price of consumption good  $C$  for country  $k$  will also follow a standard Brownian motion and can be computed as:

$$\pi_k = \frac{dI_k^C}{I_k^C} = \pi_k dt + \sigma_{\pi_k} dz_{\pi_k} \quad (2.11)$$

Where:  $I_k^C$  – is the price of consumption good  $C$  in country  $k$

$\pi_k$  - represents the expected inflation rate in country  $k$

$\sigma_{\pi_k}$  – is the variance of the inflation rate

$dz_{\pi_k}$  - follows a standard Gauss Weiner process with zero mean

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<sup>6</sup>A relative price can be defined as the price of a commodity in terms of another.

The real rate of return on an asset in terms of the numeraire (consumption good) can therefore be calculated as:

$$P_{ik}^r = \frac{P_{ik}}{I_k^c} \quad (2.12)$$

Using Ito's Lemma, equation 2.12 above can be shown to equal the following:

$$\frac{dP_{ik}^r}{P_{ik}^r} = \frac{d \frac{P_{ik}}{I_k^c}}{\frac{P_{ik}}{I_k^c}} = [E(R_{ik}) - \pi_k - \sigma_{ik,\pi_k} + \sigma_{\pi_k}^2]dt + \sigma_{ik} dz_{ik} + \sigma_{\pi_k} dz_{\pi_k} \quad (2.13)$$

where:  $\sigma_{ik,\pi_k}$  - represents the instantaneous covariance between the nominal returns on the asset and the inflation in country  $k$ .

In the above equation, the first term  $[E(R_{ik}) - \pi_k - \sigma_{ik,\pi_k} + \sigma_{\pi_k}^2]$  is representative of the real return of an asset  $i$  when considered in country  $k$  (Krause,2001: 101).

Two critical assumptions of the DCAPM which were outlined in the previous section are that investors are able to borrow and lend at the risk-free rate ( $R_f$ ), and all investors have homogenous expectations, which thus led to Tobin's (1958) Separation Theorem. Therefore, all investors, regardless of their specific preferences, will invest their wealth in the risk-free asset, as well as one single portfolio of risky securities which is available to all investors. Since this portfolio is the domestic market portfolio under the segmented model, under an integrated model this portfolio must be the world market portfolio (Stultz, 1994: 5). In this world, the real excess return of an asset should obey the following formula:

$$E(R_{ik}) - \pi_k - \sigma_{ik,\pi_k} + \sigma_{\pi_k}^2 - R_f = \beta_{ik}[E(R_W) - R_f] \quad (2.14)$$

where:  $\beta_{ik} = \frac{cov(R_i, R_W)}{var(R_W)}$ ; and

$R_W$  = the real rate of return on the market portfolio,  $W$ .

Equation 2.14 is therefore a form of the ICAPM in real terms. In order to convert this formula into nominal terms, two additional assumptions need to be made, viz:

- In country  $k$  there exists an asset which is riskless in nominal terms, which will have a beta of zero when evaluated in terms of the pricing equation 2.14.
- The growth in the price of the consumption good  $C$  (inflation) is uncorrelated with the nominal asset returns (i.e.  $\sigma_{ik,\pi_k} = 0$ ).

Taking the above assumptions into account, the excess returns of asset  $i$  in terms of the consumption good can now be written as:

$$\frac{d \frac{P_{ik}}{I_k^C}}{\frac{P_{ik}}{I_k^C}} - R_f dt = (E(R_{ik}) - \pi_k - \sigma_{ik,\pi_k} + \sigma_{\pi_k}^2 - R_f)dt + \sigma_{ik} dz_{ik} + \sigma_{\pi_k} dz_{\pi_k}$$

However, since  $\sigma_{ik,\pi_k} = 0$ ,

$$\frac{d \frac{P_{ik}}{I_k^C}}{\frac{P_{ik}}{I_k^C}} - R_f dt = (E(R_{ik}) - R_{fk} + R_{fk} - \pi_k + \sigma_{\pi_k}^2 - R_f)dt + \sigma_{ik} dz_{ik} + \sigma_{\pi_k} dz_{\pi_k}$$

$$\frac{d \frac{P_{ik}}{I_k^C}}{\frac{P_{ik}}{I_k^C}} - R_f dt = [E(R_{ik})dt + \sigma_{ik} dz_{ik} - R_{fk}dt] + [R_{fk}dt - \pi_k dt - \sigma_{\pi_k} dz_{\pi_k} + \sigma_{\pi_k}^2 dt - R_f dt]$$

$$\frac{d \frac{P_{ik}}{I_k^C}}{\frac{P_{ik}}{I_k^C}} - R_f dt = \left( \frac{dP_{ik}}{P_{ik}} - R_{fk}dt \right) + \left( R_{fk}dt - \frac{dI_k^C}{I_k^C} + \sigma_{\pi_k}^2 dt - R_f dt \right)$$

(2.15)

The assumption that inflation is uncorrelated with nominal returns therefore allows for the decomposition of the excess return of asset  $I$  in country  $j$  into a nominal excess return that does not depend on inflation  $\left( \frac{dP_{ik}}{P_{ik}} - R_{fk}dt \right)$ , as well as a real excess return which is not dependent on inflation  $\left( R_{fk}dt - \frac{dI_k^C}{I_k^C} + \sigma_{\pi_k}^2 dt - R_f dt \right)$ .

Under the assumption that any nominal risk-free asset will have a beta of 0, the  $\beta_{ij}$  of the asset which is calculated using real returns should equal to the  $\beta_{ij}$  of the asset when calculated using nominal

returns. Furthermore, the expected excess returns of asset  $i$  in country  $k$  when measured in nominal terms should be equal to its nominal excess return. Since this result will hold true for any asset, it should hold for the global market portfolio as well. Therefore the ICAPM in nominal form can be found and expressed as:

$$E(R_{ik}) - R_{fk} = \beta_{ik}[E(R_W) - R_{fk}] \quad (2.16)$$

One of the most integral and unrealistic assumptions underlying the preceding Grauer *et al* ICAPM model is that PPP holds. In reality, due to the presence of factors such as transaction costs, as well as the differentiation between goods in different countries (Holland, 1993: 170), PPP does not hold. This implies that changes in the exchange rate would not be offset by changes in the price levels of the countries involved. As a result of this, investors from different countries will estimate returns on the same asset differently, which stands in violation of the standard CAPM assumption that investors have homogenous expectations of returns (Ng, 2004: 192). This assumption was relaxed in the Solnik (1974) model, which will be discussed in more detail in the subsequent section.

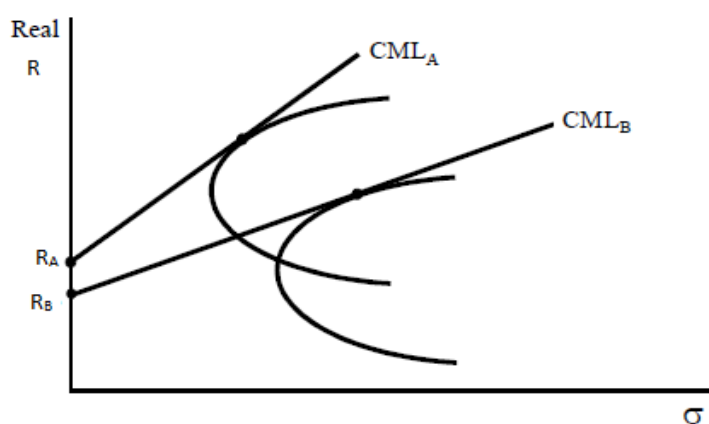
#### **2.4. The ICAPM with exchange rate risk model**

The ICAPM model which includes exchange rate risk factors was first developed by Solnik (1974), who pioneered the development of international asset pricing models at that time, and whose model served as a predecessor to the single-factor Grauer *et al* (1976) ICAPM model. The assumptions underlying this model, henceforth referred to as the ICAPM<sup>EX</sup>, consist of some of the basic assumptions of an international capital market that were listed under the Grauer *et al* (1976) model, as well as some refinements.

Under the single-factor ICAPM, it was assumed that there are no differences in consumption bundles or investment opportunity sets, which led to the assumption that all investors would choose to consume a single good. However, Solnik's (1974) model chose to assume that there will be a different consumption good in each country, and under the additional assumption that there is no inflation; this implies that the price of a domestic good will be fixed. Any changes in the exchange rates will therefore be representative of pure deviations from PPP. Therefore, whilst Grauer *et al* (1976) assumed that exchange rate risk is nominal, Solnik's (1974) model assumes that this risk is real. In a world of this type, investors will choose to hold their domestic consumption good as the numeraire.

Whilst with the Grauer *et al* (1976) model, the single consumption good available to investors had the same price in all countries which lead to homogenous expectations, this assumption no longer holds true under the Solnik (1974) model. Investors will not have the same expectations of risk and return as, for example, whilst a risk-free asset will be considered to be riskless to a domestic investor, a foreign investor will be exposed to exchange rate risk, and is therefore will not be considered riskless by the foreign investor (Karolyi and Stultz, 2002: 11). Investors from two different countries will therefore exhibit different consumption preferences based on their domestic country. Due to the differing consumption bundles, whilst investors are still assumed to have homogenous expectations when it comes to evaluating nominal returns, they now have heterogeneous expectations with regard to real returns (Sercu, 1980: 91). The investment opportunity sets of two investors in countries A and B can therefore be shown in the following figure:

**Figure 2-5. The different opportunity sets faced by investors in countries A and B according to Solnik's (1974) model**



(Balvers, 2001: 80)

The two final assumptions which were made are that in every country, there exists a riskless asset which may be used for borrowing and lending; and that the return on stocks are independent of fluctuations in the exchange rate (Sercu, 1980: 92).

In his derivation of the ICAPM<sup>EX</sup> model, Solnik further develops a “mutual fund theorem”, similar to Tobin’s (1958) Separation Theorem, which articulates that all investors in the market will be indifferent between choosing portfolios from the original assets, or from the following three funds:

- a) A portfolio of shares which are hedged against exchange rate risk (this portfolio is also known as the market portfolio).
- b) A portfolio of risk-free bonds from all countries, which represents a demand for bonds in excess of that which is used for hedging purposes.
- c) A risk-free asset from the individual investor's home country.

The desired level of risk can therefore be obtained by investing in only two risky mutual funds (which will be identical for everyone), whilst the risk free asset will be dependent on the individual's country of residence<sup>7</sup> (Solnik, 1974: 368).

The derivation of the Solnik (1974) model also begins from equations 2.10 and 2.11 in the previous section. However, the difference in this derivation is that everything is expressed in terms of a reference currency  $c$ . The expected utility maximisation function for an investor will therefore be:

$$\max E \int_t^T U(C, I, \tau) d\tau \quad (2.17)$$

$$s. t. \quad dW^c = \left[ \sum_{i=1}^n w_i (E(R_i^c) - R_f^c) + R_f^c \right] W^c dt - C dt + W^c \sum_{i=1}^n w_i \sigma_i^c dz_i^c$$

where:  $C$  = the nominal consumption flow;

$W^c$  = the level of nominal wealth of the investor;

$w_i$  = the proportion of wealth that is invested in asset  $i$ ;

$R_f^c$  = the rate of return on a risk-free asset, denominated in the reference currency; and

$U(C, I, \tau)$  = homogenous of degree zero in  $C$  and  $I$  to rule out money illusion<sup>8</sup>

<sup>7</sup> In Adler and Dumas's (1983: 946) paper, they find that there is no need to differentiate between the first two funds as outlined by Solnik (1974), as both these funds will be held in the same proportion by all investors. Therefore their later refinement of his model differentiated between just two portfolios, viz. a portfolio of stocks and bonds which is internationally diversified, as well as the risk-free asset from the investor's home country.

<sup>8</sup> Money illusion is a theory which states that people have an illusory picture of their wealth and income, based on nominal and not real terms.

If the preceding utility-maximisation problem is solved, the optimal asset allocation (or the demand for assets) for each investor will be obtained. Assuming the supply is fixed will allow us to derive the risk premium that each investor requires in return for holding a risky asset. The equilibrium relationship can then be obtained by aggregating the individual demands over all investors, and imposing the equilibrium condition that the demand for each asset should equal to the supply. This equilibrium relationship is represented by:

$$E(R_i^c) - R_f^c = \gamma \text{cov}(R_i^c, R_m^c) + \sum_{k=1}^{l+1} \delta_k \text{cov}(R_i^c, \pi_k^c) \quad \forall i \quad (2.18)$$

where:

$$\frac{1}{\gamma} = \sum_{k=1}^{l+1} \frac{W_k^c}{W^c} \times \frac{1}{\gamma_k} \text{ and } \delta_k = \gamma \left( \frac{1}{\gamma_k} - 1 \right) \frac{W_k^c}{W^c};$$

$R_m^c$  = the return on the market portfolio, which, in an international context, is the world market portfolio;

$\gamma$  = the international risk aversion coefficient;

$\gamma_k$  = the risk aversion coefficient specific to country  $k$ ; and

$W_k^c$  = the total market capitalisation of country  $k$ .

The derived relationship represented by equation 2.18 is similar to the ICAPM model in that it takes into account the return on the world market portfolio; however, this model has an additional component, which takes into account the covariance of the asset with the inflation rate of all the countries. Since  $\pi_k^c$  can be affected by both the local inflation rate of country  $k$ , or by changes in the exchange rate between country  $k$  and the reference currency, the component  $\text{cov}(R_i^c, \pi_k^c)$  can be considered as a measure of both inflation, as well as exchange rate risk.

However, one of the basic assumptions underlying Solnik's (1974) model is that investors only consume goods which have zero inflation; therefore there is no inflation present in any country. Therefore, equation 2.18 can be rewritten as:

$$E(R_i^c) - R_f^c = \gamma \text{cov}(R_i^c, R_m^c) + \sum_{k=1}^l \delta_k \text{cov}(R_i^c, v_k^c) \quad (2.19)$$

where:  $v_k^c$  – is the change in the price of currency  $k$ , in terms of reference currency  $c$ , i.e. the exchange rate between country  $k$  and the reference currency; and

$\delta_k$  – is known as the price of exchange rate risk for currency  $k$ .

(DeSantis *et al*, 1999: 4)

The preceding equation can be extended to include many currencies and rewritten in a format that conforms to the DCAPM and Grauer *et al* (1976) ICAPM as follows:

$$E(R_i) = R_0 + (\beta_{iw} \times RP_w) + \beta_{i1}SRP_1 + \beta_{i2}SRP_2 + \dots + \beta_{in}SRP_n \quad (2.20)$$

where:

$R_0$  = domestic risk-free interest rate;

$\beta_{iw}$  = the sensitivity of an asset  $i$ 's domestic currency returns to changes in the market;

$RP_w$  = the world market risk premium. This is equal to  $E(R_w) - R_0$ ;

$\beta_{in}$  = the sensitivities of asset  $i$ 's domestic currency returns to the exchange rate in factors 1 to  $n$ ; and

$SRP$  = foreign currency risk premiums on currencies 1 to  $n$ .

(Solnik and McLeavy, 2004: 153)

Equation 2.20 is known as the ICAPM<sup>EX</sup> model, which was derived first by Solnik (1974). It states that the rate of return on an asset is dependent on two factors: the covariance of the asset's return with the return of the world market portfolio, as well as the covariance with changes in the exchange rate. This relationship bears a similarity to the Grauer *et al* (1976) ICAPM, with the exception that here, the model takes into account both market risk, as well as currency risk.

As can be seen above, an integral aspect of this model is exchange rate risk, as "any investment in a foreign asset is a combination of an investment in the performance of the foreign asset and an



investment in the performance of the domestic currency relative to the foreign currency.” (DeSantis and Gerard, 1998: 376) This conforms to equation 2.20, which states that a foreign currency risk premium (SRP) also needs to be included in the ICAPM<sup>EX</sup> equation, however, there are no indications given on how to calculate this factor. A discussion of this concept is therefore given in the next few pages.

Consider a South African investor who wishes to invest in an American<sup>9</sup> asset. Due to the presence of exchange rate risk, there are two possible ways in this investor can hedge his exposure. These two methods are:

- He can enter into a forward contract in order to ensure that a pre-specified amount of Dollars will be delivered to him upon maturity of the contract.
- He can replicate a forward contract using Interest Rate Parity (IRP<sup>10</sup>). Therefore, he can borrow money in South Africa, exchange it for dollars at the current spot rate, and then invest his dollars in an American risk-free asset.

Since under the assumptions of CAPM, investors are able to borrow and lend freely in any currency, it is assumed that the second option will be undertaken by the investor. The concept of IRP (under direct exchange rates) can be expressed by the following equation:

$$\frac{F - S}{S} = r_{DC} - r_{FC} \quad (2.21)$$

where:  $F$ = the direct forward rate;

$S$ = the direct spot rate;

$r_{DC}$ = the risk-free rate in the domestic country; and

$r_{FC}$ = the foreign country's risk-free rate.

The preceding equation states in essence that the percentage forward premium on the exchange rate should be equal to the difference in the domestic and foreign risk-free interest rates. Whilst this

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<sup>9</sup> America is simply used as an example here, however, any alternative foreign country may be considered.

<sup>10</sup>This theory states that the premium or discount on the forward rate can be determined by the relationship between relative interest rates between the domestic and foreign currency.

relationship should hold in equilibrium, under the ICAPM<sup>EX</sup> model, it is assumed that unexpected changes in the exchange rate can occur. Therefore, the change in the exchange rate (SRP) can be measured as:

$$SRP = E(s) - (r_{DC} - r_{FC}) = E \left[ \frac{S_1 - S_0}{S_0} \right] - (r_{DC} - r_{FC}) \quad (2.22)$$

As can be seen above,  $s$  is the variable representing the percentage change in the direct exchange rate. Equation 2.22 therefore states that the foreign currency risk premium (SRP) will be equal to the expected movement in the exchange rate, minus the interest rate differential between the home and foreign countries (Solnik and McLeavy, 2004: 152). In a study which extended Solnik's, but relaxed the assumption that changes in stock returns are independent of exchange rate changes, Sercu (1980) derived a model which is similar to equation 2.20. This result was also echoed by Adler and Dumas (1983), who allowed for the presence of inflation.

The development of the preceding three CAPM models indicates that there are a variety of conditions which need to hold in the financial environment being tested in order for the models to work. More specifically, in the case of the international models, the level and extent of global integration present in the South African economy needs to be established. The next section therefore covers a brief history of the South African financial environment, together with an analysis of the conditions present.

## **2.5. The South African financial environment**

A key question which could be raised based on the preceding discussion is the level of international integration which South Africa displays at the current time in focus. This is largely because the financial environment in South Africa has fluctuated vastly over the past few decades, following a pattern which echoes that of the political one. In the years of apartheid, there were strict sanctions present which restricted the level of foreign involvement in the South African markets. In a purely segmented market such as this, the DCAPM model would be adequate.

However, when the political setting started changing in the early 1990's, this also led to the gradual abolishment of the restrictions which were previously present, leading to a decrease in the barriers to investment which foreign investors faced earlier. This therefore induced the process of globalisation

from which it can be inferred that the ICAPM models would now be appropriate for use. As documented earlier in chapter 1, Bekaert (1995: 95) identified three possible barriers to investment in emerging markets such as South Africa which would serve to inhibit the global integration process. These three factors were:

- a) Direct barriers, such as legal restrictions imposed by government on foreign ownership of assets. These are also referred to as capital/exchange controls
- b) Indirect barriers such as lack of availability of financial information on certain foreign markets, inadequate investor protection and poor accounting standards
- c) Market-specific risk factors which are not restricted to emerging markets, but which have a more significant effect on the activities in these countries, such as political risk and exchange rate risk

This section will therefore analyse each of these factors in order to determine if they are relevant to the South African economic climate.

### **2.5.1. Capital controls in SA**

The first capital control was introduced in 1939, upon the advent of World War II, in which South Africa (which was a member of the British Sterling Area) was asked to restrict the outflow of funds to any countries which were not part of this area. Whilst these controls were gradually relaxed after the end of WWII, after the Sharpeville massacre in 1961, the South African government reintroduced these restrictions in order to protect the domestic economy from massive outflows of capital. Due to the unstable political environment in South Africa at the time, in 1986, the United Nations imposed both economic and financial sanctions against South Africa, which further isolated the country from the global economy. By the time the political reformation started in the early 1990's, there was a very extensive system of capital controls present, which only began to be phased out upon the advent of democracy in 1994 (Stals, 1998: 1).

The chosen approach of the South African government was to gradually phase out the capital controls instead of a "big bang" approach, which would entail eradicating everything all at once. The progress that South Africa has made towards global integration over the post-apartheid years due to this gradual removal of investment barriers will now be documented in table 2-1:

**Table 2-1. Removal of barriers to investment implemented by the SA government<sup>11</sup>**

Year	Initiatives taken by the government to liberalise the economy
1994	<ul style="list-style-type: none"> <li>• South Africa joined the General Agreement on Tariffs and Trade (GATT<sup>12</sup>) which led to the reduction in barriers previously imposed on the trade of foreign goods.</li> <li>• The government applied for an international sovereign credit rating—which would have the effect of facilitating the availability of debt instruments to foreign investors.</li> </ul> <p style="text-align: right;">(Derek Keys, 1994)</p>
1995	<ul style="list-style-type: none"> <li>• The dual-exchange rate system which was present in SA since 1985 was abolished</li> <li>• All controls on non-residents of South Africa were removed.</li> <li>• The Johannesburg Stock Exchange (JSE) was liberalised.</li> <li>• South African institutional investors<sup>13</sup> were allowed to exchange part of their portfolios for foreign assets.</li> </ul> <p style="text-align: right;">(South African Reserve Bank, 2007)</p>
1997	<ul style="list-style-type: none"> <li>• The remaining controls which governed current account transactions were removed, which included an increase in travel allowances.</li> <li>• Private individuals were allowed to make a limited investment in any foreign country of their choosing, or in the form of property in the SADC countries.</li> <li>• South African companies were permitted to raise capital in foreign markets, as well as invest a percentage of their assets in foreign countries.</li> <li>• Regulated fund managers<sup>14</sup> joined the institutional investors in being able to exchange part of their portfolios for foreign assets, and institutional investors were granted the ability to invest up to 3% of their 1996 earnings in offshore accounts.</li> <li>• The restrictions faced by international companies when borrowing in South Africa were eased.</li> <li>• The country issued a rand/dollar futures contract which was monitored by the South African Reserve Bank (SARB).</li> </ul> <p style="text-align: right;">(Liebenberg, 1997)</p>

<sup>11</sup> There are some years for which no initiatives were recorded, as for that year the policy did not change.

<sup>12</sup> This was changed to the World Trade Organisation (WTO) in 1995.

<sup>13</sup> This refers to long-term insurers, and managers of unit trusts and pension funds.

<sup>14</sup> These included any portfolio managers who were registered with the Financial Services Board, as well as stock brokerage firms which were members of either the JSE LTD, the Bond Exchange of South Africa (BESA), or the South African Futures exchange (SAFEX).

Year	Initiatives taken by the government to liberalise the economy
1998	<ul style="list-style-type: none"> <li>• The limits to foreign investors placed on institutional investors were raised.</li> <li>• The amount of overseas investment permitted to South African companies was increased.</li> <li>• The limits placed on institutional investors were raised.</li> </ul> <p style="text-align: right;">(Manuel, 1998)</p>
1999	<ul style="list-style-type: none"> <li>• Regulated fund managers were also now allowed to invest a percentage of their previous year's earnings in offshore accounts. (Manuel, 1999)</li> </ul>
2000	<ul style="list-style-type: none"> <li>• The travel allowances and other limits which apply to individuals were raised.</li> <li>• There was further relaxation of the controls regarding companies and their foreign operations.</li> <li>• The limits placed on institutional and regulated investors were raised further.</li> <li>• South African companies were allowed to create their primary listings on exchanges outside South Africa subject to the meeting of certain conditions.</li> </ul> <p style="text-align: right;">(Manuel, 2000)</p>
2001	<ul style="list-style-type: none"> <li>• The amount of overseas investment permitted to South African companies was further increased. (Manuel, 2001)</li> </ul>
2003	<ul style="list-style-type: none"> <li>• The restriction faced by investors where previously they were only allowed to invest a certain proportion of their previous year's earnings in foreign accounts was removed completely.</li> <li>• The tax on foreign dividends was removed.</li> <li>• The limits faced by companies with regard to international investments was increased further.</li> <li>• The travel allowances offered to individuals was also increased.</li> </ul> <p style="text-align: right;">(Manual, 2003)</p>
2004	<ul style="list-style-type: none"> <li>• The restrictions faced by international companies when borrowing in South Africa were eased further, with plans to allow foreign companies to list on the JSE as well.</li> </ul> <p style="text-align: right;">(Manuel, 2004)</p>
2006	<ul style="list-style-type: none"> <li>• The individual offshore allowances for individuals were raised. (Manuel, 2006)</li> </ul>
2007	<ul style="list-style-type: none"> <li>• An allowance of a single Customer Foreign Currency (CFC) account to be utilised for both trade and service related payments in order to simplify the dispensation and management of accounts.</li> <li>• The government permitted the JSE to establish a Rand futures market, thereby increasing liquidity in the foreign exchange market.</li> </ul> <p style="text-align: right;">(Manuel, 2007)</p>

Year	Initiatives taken by the government to liberalise the economy
2008	<ul style="list-style-type: none"> <li>• Exchange controls faced by institutional investors were completely removed.</li> <li>• Administrative procedures were simplified and streamlined with the result that the former Exchange Control Division of the SARB was renamed the Financial Surveillance Division in accordance with their new directive.</li> </ul> <p style="text-align: right;">(Manuel, 2008)</p>
2010	<ul style="list-style-type: none"> <li>• The exit levy applied to emigrants was removed.</li> <li>• The offshore investment limit for individuals, which was previously a lifetime limit, was converted to a yearly limit.</li> <li>• The controls faced by exporters were relaxed.</li> <li>• The limit to offshore investments which are allowed for companies was raised.</li> </ul> <p style="text-align: right;">(Gordhan, 2010)</p>

The preceding table displays the extent to which the South African government have relaxed the stringent exchange controls which were present before the apartheid system was abolished. As can be seen from the table, extensive advancement has been made in this respect; there are still a few capital controls in place, which are listed below:

- Approval of the South African Reserve Bank (SARB) is required before a South African resident accepts a loan from a foreign financial institution.
- Similarly, the rate of interest which is payable on foreign loans must be approved first.
- Any dividends that are declared by South African subsidiaries of foreign enterprises may only be remitted abroad if it is declared out of realised reserves. Prior approval from the SARB or Department of Trade and Industry (DTI) must also be obtained when remitting licence fees or royalties earned in this country.
- Payments for any imports received must be facilitated by an Authorised Dealer. Export proceeds received by residents are also controlled by the SARB.
- If the proceeds of an export made are received in a foreign currency, this currency must be offered for sale to an authorised dealer within 30 days of receiving the funds.

(Deloitte, 2010: 29)

According to the OECD (2010: 77), the removal of these remaining barriers on residents of South Africa may provide further advancements in the globalisation process by removing any obstacles faced by investors in the formation of efficient portfolios.

The removal of the legal barriers which has been outlined in this section has also resulted in a reduction in the level of indirect barriers to investment which may have been faced before. The next section therefore outlines this effect in South Africa.

### **2.5.2. Indirect barriers in SA**

Indirect barriers to investment have been identified as the lack of availability of financial information, inadequate investor protection, poor accounting standards and lack of liquidity in the financial markets. However, the gradual removal of direct investment barriers which was outlined in the previous section has facilitated the removal of these indirect barriers as well. The advent of democracy led to the restructuring of financial structures in the country as well, with the government allowing more foreign banks to begin operation within the country, in order to increase competition in the market (Stals, 1998: 4). These institutions are extremely well-regulated and follow the guidelines of the international Basel Committee standards. Furthermore, during the removal of the exchange controls in the country, the financial market (in the form of the JSE) was also restructured in order to accommodate the increasing capital flows into the country. Since many of the indirect barriers listed above rely on the nature of the capital market, this section will therefore focus on the Johannesburg Stock Exchange (JSE) and its characteristics.

The JSE was formed in 1887 after the discovery of gold, as a device for the mining companies to raise capital for their ventures. Since then, this stock market has succeeded in becoming the largest, most developed, and most well regulated stock exchange in Africa (Hearn and Piesse, 2009: 43). Despite the fact that South Africa is classified as an emerging market, there is still active institutional investor participation, with ownership of shares on the JSE being well diversified (Bloomberg LP in Hearn and Piesse, 2009: 43).

Whilst the South African government have facilitated the globalisation of the country by removing critical barriers to investment that were previously present, as shown in table 2-1, the JSE has also facilitated globalisation with actions of its own. For example, in 2002, the JSE changed its trading system to the Stock Exchange Electronic Trading System (SETS), which is the electronic method utilised by the London Stock Exchange (LSE), and facilitates easier trading, both for South Africans as well as foreign investors. This resulted in the average daily number of trades on the JSE increasing by 140%. (Mauldin, 2007: 1) In the same year, the FTSE/JSE Africa index series was also introduced,

which aligned our indices with global standards in order to make them easier to understand (Marais, 2008: 8).

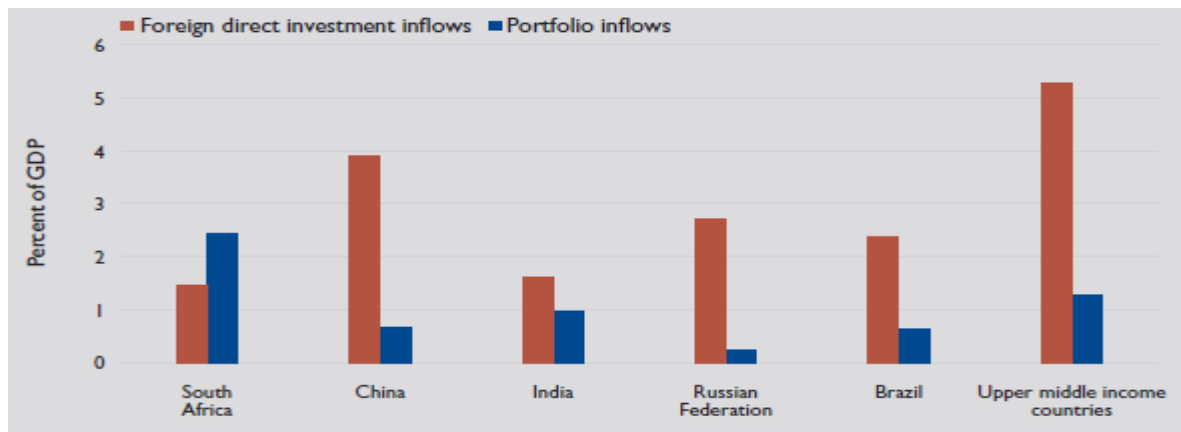
Furthermore, in 2005, the JSE was demutualised, which in effect led to decreased transaction costs experienced by investors (Hearn and Piesse, 2009: 44). During this transition period, support was also provided to those companies which wanted to dual list on both the JSE as well as international exchanges, which can be considered a facilitating factor in market liberalisation according to Bekaert (1995: 97). In 2007, the JSE upgraded its trading system again, to the TradElect system, which again increased the trading volumes. A further plan for the JSE is to change its system again; to the Millennium Exchange system in 2012 which will allegedly make the transaction processing times up to 400 times faster than it is now (Mawson, 2011: 1).

In addition to the JSE having trading platforms which conform to the worldwide standard, this exchange was also awarded the status of the best regulated exchange in the World Economic Forum's 2010/2011 Global Competitiveness Review. The WEF also found that South Africa has strong investor protection, and strong auditing and reporting standards, in which case the country ranked 1<sup>st</sup> in the world under that category as well. As at the end of 2010, the JSE was also found to be the 19th largest capital market in the world, based on market capitalisation. These results bode well for the future of portfolio flows into the country as it will serve to increase the interest in the South African market by offshore investors (Fin24, 2011).

All of the afore-mentioned actions have resulted in a large portion of capital flows entering the country, most of which stems from portfolio flows. This can be seen in figure 2-6, which shows the compositions of capital flows experienced by the five emerging markets that make up BRICS, viz. Brazil, Russia, India, China and South Africa. From the figure it can be seen that whilst South Africa exhibits the lowest level of FDI flows from the five countries, this country also shows the highest level of portfolio flows into the country, which is higher than the average of all upper middle income countries as well.



**Figure 2-6. Comparisons between the Capital flow compositions of the countries in BRICS over the period of 2002 - 2008**

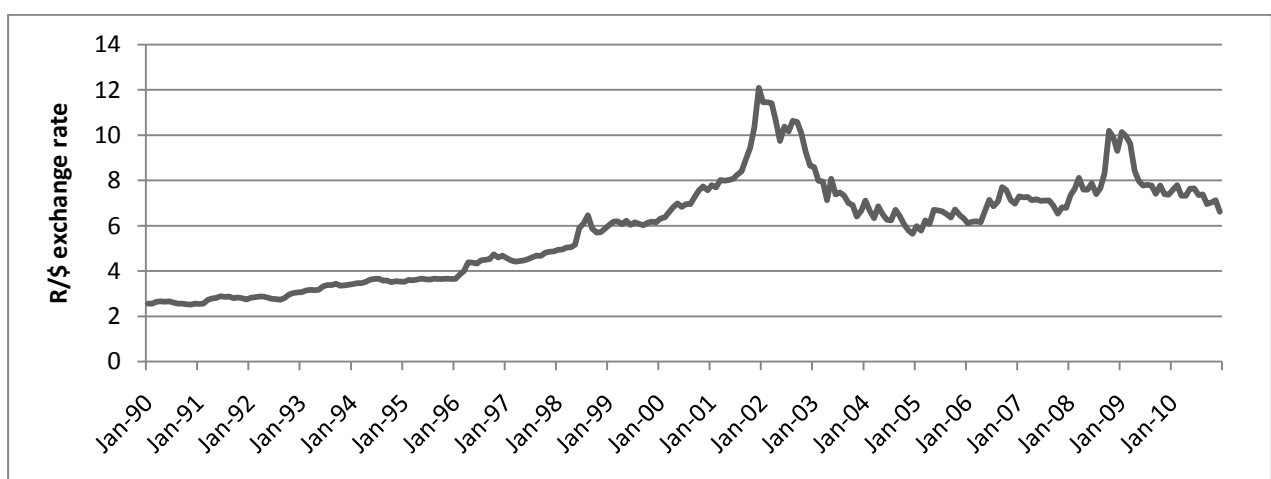


(Source: World Bank, 2010: 12)

### **2.5.3. Market-specific risks**

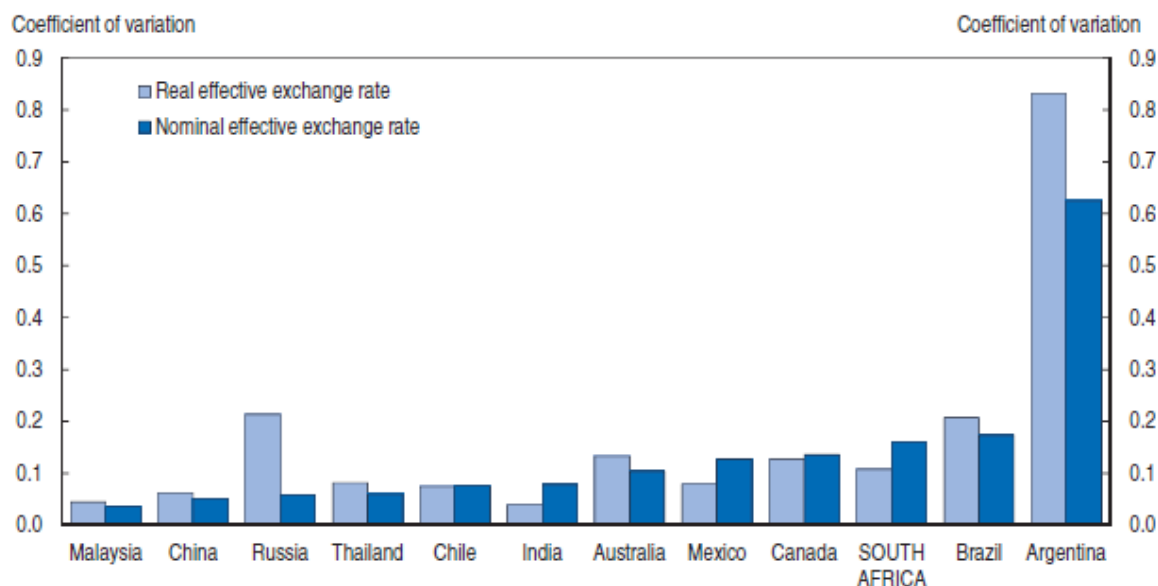
The final barrier to investment which may exist in South Africa is that of market-specific risks such as exchange rate risk and political risk. The exchange rate present in the South African economy is a particular deterrent to globalisation, as “the evolution of the rand since the mid-1990s points to the strong vulnerability of the South African currency to news affecting the global economy” (Grandes and Pinaud, 2005: 77). This volatility can be clearly seen when observing the Rand/Dollar exchange rate levels from the period of 1990 – 2010, as shown in figure 2-7:

**Figure 2-7. Fluctuations in the Rand/Dollar exchange rate over 1990-2010**



When the coefficient of variation was computed for the nominal and effective exchange rates of South Africa and other emerging and developed markets in Lysenko and Barnard (2011: 13) the following graph was produced:

**Figure 2-8. Variability in the nominal and effective exchange rates over the period of January 1999 – January 2010**



(Source: Lysenko and Barnard, 2011: 13)

The preceding graph shows that with a coefficient of variation for the nominal exchange rate of about 0.15 and a corresponding value for the real exchange rate of 0.1, this country exhibits high levels of exchange rate risk relative to other countries such as Malaysia, China and India. Whilst this discussion has shown that exchange rate risk is a very relevant factor in the South African economy, this may provide justification for testing the ICAPM<sup>EX</sup> model in this analysis. Since the Rand is highly volatile, it may have an influence on the returns experienced by assets traded in South Africa, in which case, its inclusion in an asset pricing model would be relevant.

Another risk factor which may be prevalent in South Africa is that of political risk. In their studies of emerging markets, Bekaert, Erb, Harvey and Viskanta (1997) and Perotti and Van Oijen (2001) found that political risk is a priced factor. As of late, the political risk has had a significant impact on the perceptions of foreign investors (Creamer, 2011: 1), and this factor may therefore be a very relevant one in deterring foreign investors and slowing down the process of globalisation. Therefore whilst the discussion contained in the previous two sub-sections shows that the first two barriers as listed by

Bekaert (1995) have largely been removed in the South African market, these market-specific risks are important ones which may lead to the country being more segmented from the global economy, than integrated. Whilst the preceding discussion has not led to a conclusive result on the issue of segmentation/integration, it has nonetheless provided sufficient evidence that there may be global risk factors which influence the returns of South African assets, in which case the issue should be investigated further.

## **2.6. Summary**

This chapter as a whole covered the theoretical foundations underlying the three models being evaluated here. The first model outlined was that of the domestic CAPM model (DCAPM), which serves as the basis upon which the international theories were modelled. The second model discussed was that of the single-factor ICAPM model developed by Grauer, Litzenberger and Stehle (1976). Due to Grauer *et al*'s (1976) assumption that the concept of PPP holds, their model looks identical to the DCAPM, with the exception that the world market portfolio is used instead of the domestic one.

The final model which was reviewed was the multifactor ICAPM model developed by Solnik (1974) in which he assumes that PPP does not hold. His model therefore takes both market risk as well as currency risk into account when estimating expected returns. This was thereafter followed with a discussion of the barriers to investment which are applicable to the South African economy in order to determine whether the economy is fully financially integrated into the global economy, or segmented. Whilst no strict conclusion could be found, sufficient evidence was provided for the use of this study in evaluating the risk factors applicable to South African assets. The next chapter therefore reviews some of the literature surrounding this subject.

## CHAPTER 3 : REVIEW OF EMPIRICAL STUDIES

### **3.1. Overview**

The preceding chapter outlined the theoretical foundations of each of the three CAPM models being studied here, and introduced each of the equations which will be used for empirical testing. This chapter reviews some of the empirical research that has already been conducted on the subject and outlines the specific methodologies utilised by each in order to develop an appropriate method upon which this study can be based. The discussion will therefore cover the single-factor ICAPM model first, which will be followed by studies focussing on the ICAPM<sup>EX</sup>. Thereafter some of the studies surrounding emerging markets similar to South Africa will be discussed, as well as empirical analyses which have been conducted in a South African environment.

### **3.2. Single-factor ICAPM model (ICAPM)**

A fundamental assumption underlying all three CAPM models outlined in chapter 2 is that all investors have identical expectations of the means, variances and covariances of the returns on assets. Most of the early empirical tests of these models have therefore involved a strengthening of this assumption by further assuming that distributions of these asset returns remain constant over time. This approach is known as the unconditional approach to asset testing (Bollerslev, Engle, Wooldridge, 1988:117).

An alternative to this unconditional approach was developed later and considers the possibility that, whilst investors may have common expectations on the moments<sup>15</sup> of expected future returns on assets, these expectations are conditional, which means that the values change over time periods, as the conditioning information changes (Bollerslev, Engle, Wooldridge, 1988: 117; Cochrane, 2001:158). Whilst under the unconditional approach to asset testing, it would be possible to estimate an investor's expected return on an asset by taking an average of the past returns, with the conditional approach, it would be necessary to have the information which is available to the investor at time  $t-1$ , in order to forecast the return at time  $t$  (Harvey and Kirby, 1996: 36).

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<sup>15</sup> The  $k$ th moment of a variable is the expected value of the variable, raised to the  $k$ th power. Therefore the mean of expected returns would be considered to be the first moment, whereas the variance and covariance of returns would be considered second moments (Hill, Griffiths and Lim, 2008: 277).

There are a variety of different statistical models which can be used under the two above-mentioned general approaches, which will be discussed in conjunction with the studies which utilise them. The final approach to model testing which is covered is the cost of equity approach. Since the CAPM models are most commonly utilised in calculating a firm's cost of equity value, this approach compares the cost of equity estimates of each of the different CAPM models in order to determine which model provides the best estimates overall. The chapter that follows therefore contains a description of each of these three methods, with reference to the studies which utilised these methods and their results.

### **3.2.1. Unconditional tests of the ICAPM model**

A very common method which is used under the unconditional approach is the Fama-Macbeth (1973) method of two-pass regression, which is designed to allow for both time series, as well as cross-sectional data. The first step to this method therefore involves a time series regression of the following form:

$$E(R_{it}) - R_{ft} = \alpha_{it} + \beta_i(R_{mt} - R_{ft}) + \varepsilon_{it} \quad (3.1)$$

where:

$E(R_{it})$ = the rate of return on asset  $i$  at time  $t$ ;

$R_{ft}$ = the risk free rate at time  $t$ ;

$\alpha_{it}$  = the intercept of the regression;

$\beta_i$ = the beta of stock  $i$ ;

$R_{mt}$ = the rate of return on the market portfolio at time  $t$ , which will be the domestic

market portfolio for the DCAPM, and the world market portfolio for the ICAPM

models; and

$\varepsilon_{it}$ = the random error term of the regression at time  $t$ .

Since the precision of beta estimates obtained are enhanced when using portfolios, as opposed to using individual assets (Fama and French, 2004: 31), once the beta of each individual asset is obtained

from equation 3.1, the assets are sorted into beta-ranked portfolios, after which the portfolio beta is computed by using the following equation:

$$E(R_{pt}) - R_{ft} = \alpha_{pt} + \beta_{pt}RP_{pt} + \varepsilon_{pt} \quad (3.2)$$

where:  $E(R_{pt})$  = the rate of return on the portfolio  $p$  at time  $t$ ;

$R_{ft}$  = the risk free rate at time  $t$ ;

$\alpha_{pt}$  = the intercept of the regression;

$RP_{pt}$  = the risk premium of the portfolio, which is equal to  $E(R_{mt}) - R_{ft}$ ;

$\beta_{pt}$  = the beta of the portfolio at time  $t$ ; and

$\varepsilon_{pt}$  = the random error term of the regression at time  $t$ .

Equation 3.2 is representative of the first pass of the Fama-Macbeth (1973) method. The second pass entails running monthly cross-sectional regressions of the excess returns of the portfolios against the betas obtained from the first pass, which take the form of the following equation:

$$E(R_p) - R_f = \alpha_0 + \alpha_1\beta_p + \varepsilon \quad (3.3)$$

The variable  $\alpha_0$  is representative of the portion of systematic risk present, which cannot be explained by the factors included in the model estimated. Therefore, if this variable is statistically different from zero, this would imply that the model cannot price assets well, as there are other factors which are not being captured appropriately. Similarly, the variable  $\alpha_1$  is interpreted in order to determine whether the market risk premium (either domestic or international) is considered statistically significant in the estimation of expected returns. This statistical significance is determined by making use of t-tests. Since these cross-sectional regressions are done on a monthly basis, there are a number of  $\alpha_0$  and  $\alpha_1$  estimates produced. This is accounted for by averaging the values in order to obtain single values, which can then be interpreted.

### **3.2.1.1. Stehle (1977)**

The first test of the single-factor ICAPM model was conducted by Stehle (1977: 493) using a variation of the afore-mentioned Fama-Macbeth (1973) method in order to evaluate how US assets were priced over the period of 1956 - 1975. The test conducted therefore evaluated whether the market was segmented by using the DCAPM, whereas the hypothesis of integration was tested by utilising the ICAPM model, where the world market portfolio was created by equally weighting the returns on the market indices of the following countries: Belgium, Canada, France, Germany, Italy, Japan, the Netherlands, Switzerland, the UK and the US.

If the ICAPM model holds empirically, this implies that the domestic market portfolio will not have any explanatory power when evaluating the returns of assets. However, as pointed out by Stehle (1977 :498), “the covariation of a security’s rate of return with the rate of return on the domestic market portfolio represents a systematic risk not only when markets are segmented, but also in an international capital market, when the rates of return on the domestic and the international market portfolio are positively correlated”. Therefore a cross-sectional regression which only makes use of the domestic beta( $\beta_{iD}$ ) would be insufficient, and a regression which takes into account both the domestic and world market indices would be inappropriate due to the presence of multicollinearity<sup>16</sup> (Jorion and Schwartz, 1986 :609).

Stehle (1977: 498) therefore began the formulation of his analysis by utilising the DCAPM and single-factor ICAPM equations to isolate the component of the domestic market index which is dependent on the global index, as shown below:

$$R_D = \alpha_{DW} + \beta_{DW}E(R_W) + e_D \quad (3.4)$$

where:  $\alpha_{WD} = E(R_W) - \beta_{WD}E(R_D)$ ;

$\beta_{WD} = \frac{cov(R_W, R_D)}{var(R_D)}$ ; and

$E(R_W)$  = the rate of return on the world market portfolio,  $W$ .

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<sup>16</sup> Multicollinearity is a phenomenon in which two or more variables in a regression are highly correlated. This therefore leads to the resultant beta coefficients being inaccurate. This problem was highly relevant during the earlier tests of the ICAPM which involved US assets, as the US market portfolio represented a large proportion of the global portfolio. Whilst this phenomenon is still relevant in recent years, the proportion of the US market portfolio in the world market portfolio has decreased to lower levels.

Equation 3.4 breaks down the rate of return on the domestic market portfolio into a portion that is perfectly correlated with the rate of return on the world portfolio, and a portion which is uncorrelated with the return on the domestic market portfolio ( $e_D$ ). By construction, the value of this variable should equate to zero, as  $E(e_D) = cov(e_D, R_W) = 0$ . Based on this equation, a test of integration would therefore entail focussing on the additional explanatory power of the asset's systematic risk ( $\beta_{DW}$ ), relative to the residual of  $e_D$ . The time-series regression equation for Stehle's (1977) study can therefore be represented as:

$$R_i = \alpha_i + \beta_{iW}R_W + \delta_i e_D + u_i \quad (3.5)$$

where:  $\alpha_i = E(R_i) - \beta_{iW}E(R_W)$ ;

$\beta_{iW} = \frac{cov(R_i, R_W)}{var(R_W)}$ , which is a measure of the systematic risk of the asset  $i$  in a perfectly

Integrated international market; and

$\delta_i = \frac{cov(R_i, e_D)}{var(e_D)}$ , which is a measure of the risk that can be diversified internationally,

but not domestically.

After this equation is computed, the method of Fama-Macbeth (1973) is followed with regard to beta-sorting and portfolio formation. The second-pass cross-sectional regression which is implemented thereafter is:

$$r_i = \alpha_0 + \alpha_1 \beta_{iW} + \alpha_2 \delta_i + w_i \quad (3.6)$$

The null hypothesis of integration will be rejected if  $\alpha_2$  is statistically different from the value which it should take on according to theory, i.e. 0 (Stehle, 1977: 499). Whilst the preceding discussion covers an explanation of how to estimate the ICAPM model, the DCAPM model can be estimated by following the same theoretical basis. The null hypothesis of segmentation was therefore implemented using an equation similar to equation 3.4 above, with the exception that the domestic beta ( $\beta_{iD}$ ) was used in place of the global beta ( $\beta_{iW}$ ). This equation therefore takes the following form:



$$r_i = \theta_0 + \theta_1\beta_{iD} + \theta_2\delta_i + \varepsilon_i \quad (3.7)$$

where the statistical significance of the coefficient  $\theta_2$  indicates that the null hypothesis of segmentation can be rejected. After carrying out the outlined analysis by making use of the Generalised Least Squares method<sup>17</sup>, Stehle (1977: 500) found that whilst both regression coefficients ( $\alpha_1$  and  $\theta_1$ ) were positive, which conforms to the theory underlying the ICAPM model, he also found that neither of the hypotheses applicable to each of the models could be rejected in favour of the other, as both the coefficients  $\alpha_2$  and  $\theta_2$  were statistically insignificant. This weak result in favour of the ICAPM may be attributed to the low power of Stehle's (1977) tests. This is due to the fact that, at that time, the US index constituted more than 40% of the world portfolio which resulted in strong collinearity between the US index and the world index (Karolyi and Stultz, 2002: 26).

### **3.2.1.2. Jorion and Schwartz (1986)**

The weakness inherent in Stehle's (1977) test prompted Jorion and Schwartz (1986: 604) to investigate whether the Canadian market is segmented or integrated over the period of 1963-1982 by examining 750 individual assets in Canada. Their study also took on an additional dimension due to a significant proportion of Canadian stocks which are also listed in the US, which allowed them to compare the performances of the interlisted stocks with the purely domestic ones. Whilst their regression equations resembled those of Stehle (1977) outlined earlier, they included an additional factor due to the phenomenon of thin trading present on the Canadian Stock Exchange. This was incorporated by converting each single regression on the market index to a multiple regression which made use of one lead value for the market index, as well as one lagged value. This therefore resulted in the following non-linear equation:

$$R_{it} = \alpha_0(1 - \beta_i^W) + \alpha_2\beta_i^{D.W} + \sum_{k=-1}^{+1} \beta_{ik}^W R_{W,t+k} + \sum_{k=-1}^{+1} \beta_{ik}^{D.W} V_{D.W,t+k} + e_{it} \quad (3.8)$$

where:  $\beta_i^W = \sum_{k=-1}^{+1} \beta_{ik}^W$ ;

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<sup>17</sup> The error terms were found to be heteroscedastic (i.e. the variance of the errors was not constant), which would lead to inefficient beta estimates if the regression is conducted using Ordinary Least Squares (OLS). The solution to this problem would therefore be to use Generalised Least Squares (GLS) (Maddala, 1992: 209). Whilst this method was apt for use in the earlier years, in later years the presence of heteroscedasticity was simply corrected for by making use of Newey-West (1987) standard errors.

$$\beta_i^{D.W} = \sum_{k=-1}^{+1} \beta_{ik}^{D.W}; \text{ and}$$

$V_{D.W}$  = the residual in a regression of  $R_D$  against  $R_W$ .

(Jorion and Schwartz, 1986: 610).

The parameters  $(\alpha_0, \alpha_2, \beta_{ik}^W, \beta_{ik}^{D.W})$  in their non-linear test equation 3.8 were thereafter estimated by making use of the Maximum Likelihood (ML) method, which is an alternative to the Generalised Least Squares (GLS) method used by Stehle (1977), and was specifically formulated for non-linear equations (Jorion and Schwartz, 1986: 610). This method involves a number of iterations being performed on the parameters specified on the model, and on the variance-covariance matrix of the residuals, until a point of convergence is reached. Whilst the theoretical underpinnings and results of the ML method and the Fama-Macbeth (FM) method are the same<sup>18</sup>, the method of Maximum Likelihood is considered to be superior as the betas and cross-sectional parameters can be estimated simultaneously with this methodology (Jorion and Schwartz, 1986: 605).

Similar to Stehle (1977), their test of integration versus segmentation made use of the null hypothesis that  $\alpha_2$  was equal to zero (i.e. Canada is integrated), against the alternative that its value was positive (i.e. Canada is segmented). Whilst one would expect the Canadian and US markets to be highly integrated, especially due to the presence of interlisted stocks, they found that whilst national factors were priced, the null hypothesis of integration was strongly rejected across all portfolios, thus implying that the ICAPM did not hold for both the domestic as well as the interlisted stocks.

### **3.2.1.3. Mittoo (1992)**

Mittoo (1992: 2035) later extended the Jorion and Schwartz (1986) study of the Canadian market by investigating both the International CAPM, as well as International APT models over the period of 1977-1986. The methodology employed by Mittoo (1992) was the same as that first used by Stehle (1977), and redeveloped by Jorion and Schwartz (1986) to accommodate for non-linear equations. The period of 1977-1986 was chosen due to the relative absence of capital controls in this time period, whilst the problem of thin trading experienced by Jorion and Schwartz (1986) was overcome by making use of all the stocks on the TSE 35 index. This index was chosen due to all the firms in the sample being large and highly liquid, in addition to being from a variety of different industries

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<sup>18</sup> If the Maximum Likelihood method was applied to linear equations, it would lead to the same estimates as that obtained from an OLS estimation (Maddala, 1992: 118).

(Mittoo, 1992: 2036). Of these 35 firms, some were excluded from the analysis in order to control for industry-wide effects, whilst others were eliminated due to insufficient data over the full sample period. The resulting sample therefore consisted of 21 stocks, 10 domestic and 11 of which were interlisted on US exchanges (Mittoo, 1992: 2040).

Mittoo's (1992: 2043) results were in conjunction with those produced by Jorion and Schwartz (1986: 612) as he found support for the hypothesis of segmentation over the period of 1977-1982, which is a time-period that overlaps with the dataset used by Jorion and Schwartz (1986). However, he also found that integration was present for the period of 1982-1986. These results were reinforced when paired with the results of the International APT model tested. Furthermore, he found evidence which is consistent with the hypothesis that interlisted stocks should be priced by making use of an international model, whilst a domestic model is appropriate for purely domestic stocks; which was a result captured by the APT model.

### **3.2.2. Conditional Tests of the ICAPM model**

The preceding discussion about unconditional tests revolved mostly around earlier tests of the ICAPM model. In later years, however, an increasing number of studies which investigated the topic chose to use conditional approaches and therefore allow expected returns, variances and co-variances to vary over time instead. The conditional ICAPM model, as adapted from Harvey and Kirby (1996: 37) can therefore be expressed as follows:

$$E(r_{pt}|I_{t-1}) = \frac{cov[r_{pt}, r_{wt}|I_{t-1}]}{var[r_{wt}|I_{t-1}]} \times E(r_{wt}|I_{t-1}) \quad (3.9)$$

where:  $I_{t-1}$  = the information set which is used by investors to form expectations;

$r_{pt}$  = the return on portfolio  $p$  from time  $t-1$  to  $t$ , measured in excess of the risk free

Rate;

$\frac{cov[r_{pt}, r_{wt}|I_{t-1}]}{var[r_{wt}|I_{t-1}]}$  = the conditional beta of the ICAPM model; and

$r_{wt}$  = the return on the world market portfolio, measured in excess of the risk-free rate.

Equation 3.9 shows that the beta of the conditional ICAPM model is dependent on the conditional moments of both  $r_{it}$ , as well as  $r_{wt}$  (Testing the CAPM, n.d.: 8). From the above it can be seen that the model allows cross-sectional variation, as the conditional expected excess return values vary with the differing conditional betas. It also allows for time-series variation as the conditional returns are allowed to fluctuate over time as there are changes in the market risk premium, the conditional variance of the market portfolio, as well as the conditional covariance between the return on the asset and the market portfolio (Hansson and Hordahl, 1998: 379).

### **3.2.2.1. Harvey (1991)**

The above representation of the conditional ICAPM model can be tested empirically using a number of different methods, some of which will be discussed here. One of the initial studies surrounding the conditional ICAPM model was conducted by Harvey (1991: 114), in which he used the Generalised Method of Moments (GMM) procedure to test the model.

The GMM method was first developed by Hansen (1982) as an alternative to the ML procedure, discussed earlier. This method overcomes the following limitations of the ML approach, as outlined in Jagannathan, Skoulakis and Wang (2002: 470):

- Under the ML method, researchers need to develop different tests for examining whether each model being studied is misspecified or not, which is sometimes a hard task, if not impossible.
- When studying non-linear asset pricing models, linear approximation is often necessary.
- In order to conduct the estimation process, researchers need to make strong distributional assumptions first. If these assumed distributions display autocorrelation<sup>19</sup> or homoscedasticity, the resultant parameters will be biased.

These limitations are overcome as with GMM, it is not necessary to convert non-linear models into linear approximations, and no distributional assumptions need to be made. Therefore, GMM has the ability to account for the presence of autocorrelation or heteroskedasticity without producing biased estimates (Jagannathan *et al*, 2002: 471).

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<sup>19</sup> Autocorrelation refers to the serial correlation of the resultant error terms in a regression.

Harvey (1991:112) therefore tests the ICAPM by rewriting equation 3.9 in the following form:

$$E(r_{pt}|I_{t-1}) = \frac{E(r_{wt}|I_{t-1})}{var[r_{wt}|I_{t-1}]} \times cov[r_{pt}, r_{wt}|I_{t-1}] \quad (3.10)$$

In this form, the factor  $\frac{E(r_{wt}|I_{t-1})}{var[r_{wt}|I_{t-1}]}$  is known as the world price of covariance risk, and represents the compensation which the investor expects to get for taking one unit of covariance risk. However, the above equation cannot be subjected to empirical testing in its current form, which means that if testing is required, the functional form of the model needs to be specified for conditional expectations<sup>20</sup>. In Harvey's (1991: 113) case, he chose a linear regression model in which the return on portfolio  $p$  can be written as:

$$r_{pt} = Z_{t-1}\gamma_p + u_{pt} \quad Z \in I \quad (3.11)$$

Where  $Z_{t-1}$  is representative of a row vector which consists of  $l$  instrumental variables (in this case both local and global variables<sup>21</sup>),  $\gamma_p$  is a  $l \times 1$  set of weights which remain constant through time, and  $u_{pt}$  represents the random error term produced when forecasting the return on portfolio  $p$  at time  $t$ .

Substituting (3.11) into (3.10) yields the following restriction:

$$Z_{t-1}\gamma_p = \frac{Z_{t-1}\gamma_m}{E[u_{mt}^2|Z_{t-1}]} \times E[u_{pt}u_{mt}|Z_{t-1}] \quad (3.12)$$

Where  $u_{mt}$  represents the random error term produced when forecasting the return on the market ( $m$ ) at time  $t$ ,  $E[u_{mt}^2|Z_{t-1}]$  is now the conditional variance and  $E[u_{pt}u_{mt}|Z_{t-1}]$  is the conditional covariance.

<sup>20</sup> For all the conditional tests which will be reviewed, the starting point is equation 3.6. The only difference lies in the functional forms chosen and testing methodology utilised by each empirical study.

<sup>21</sup> The global variables refer to factors which every country will face viz. the lagged value of the excess return on the world market portfolio, a dummy variable for the month of January, the term structure premium of the US, the default risk spread of the US and the dividend yield on the S&P 500 index.

The local variables are factors which are specific to each different country in the sample, viz. variations in the expected return on the world portfolio, changes in the volatility of the world market index and the time-varying conditional covariances of the specific country's return with the world market return (Harvey, 1991: 120).

When both sides of equation 3.8 are multiplied by the conditional variance, the following equation results:

$$E[u_{mt}^2 Z_{t-1} \gamma_p | Z_{t-1}] = E[u_{pt} u_{mt} Z_{t-1} \gamma_m | Z_{t-1}] \quad (3.13)$$

Since the expected returns on portfolio  $p$ , and market portfolio  $m$  are known values which are conditional upon the information of  $Z_{t-1}$ , they can be moved inside the expectation operators, as shown in equation 3.13. Any deviation from the expectations ( $d_{pt}$ ) can therefore be expressed as:

$$d_{pt} = u_{mt}^2 Z_{t-1} \gamma_p - u_{pt} u_{mt} Z_{t-1} \gamma_m \quad (3.14)$$

The variable  $d_{pt}$  is known as the pricing error of the model. If  $d_{pt}$  is divided by the conditional covariance of the world market portfolio, the resultant value can be seen as the deviation of the actual return from the return predicted by the model<sup>22</sup> (Harvey, 1991: 114). If the ICAPM model holds, the value for  $d_{pt}$  should be zero, however if it takes on a positive value, this implies that the asset/portfolio/country earned more than expected, given its level of riskiness; whilst a negative value would imply the opposite.

The GMM method was therefore applied to the restrictions formed from equation 3.11 and 3.14 in order to evaluate whether the conditional ICAPM model holds. The data used consisted of monthly returns of equity indices from seventeen countries over the period of 1970 to 1989. The results from the resultant  $R^2$  values showed that the global variables captured a large portion of the variability in the stock returns for 15 out of the 17 countries used in the sample. Harvey (1991: 155) therefore found that the conditional ICAPM model on the whole is useful in the prediction of expected returns, even though it was found that the model pricing error was significant at the 5% level of significance for 3 of the 17 countries. This rejection for the three countries could provide evidence that either those specific countries are not integrated with the world, or that the ICAPM model fails to account for additional factors which should be considered (Karolyi and Stultz, 2002: 27). An additional test conducted by Harvey (1991) is a multivariate test that was developed by Gibbons, Ross and Shanken (1989) in order to test the mean-variance efficiency of the chosen market portfolio. Harvey (1991: 154) therefore tested the MSCI world index and found that it is mean-variance efficient, which thus implies that this index is appropriate for use in a CAPM model.

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<sup>22</sup> This corresponds to the variable  $\alpha_0$  in the unconditional tests discussed earlier.

### **3.2.2.2. DeSantis and Gerard (1997)**

An alternative method of estimating the conditional ICAPM model was utilised by DeSantis and Gerard (1997), who found that the best way to model the conditional ICAPM would be to use a GARCH-in-mean<sup>23</sup> model in which the conditional mean for  $R_t$  is dependent on its conditional variance, and then to allow both the covariances and variances to be time-varying by using a multivariate GARCH (Testing the CAPM, n.d: 8; Brooks, 2008: 432). An advantage of the GARCH methodology over that of GMM which was used by Harvey (1991) is that a GARCH model allows one to obtain parameters from the conditional second moments of the equation, instead of the first moments which was used by Harvey (1991) (DeSantis and Gerard, 1997: 1888).

As mentioned before, the starting point of all conditional tests of the ICAPM lies with equation 3.10. In this equation, if the world price of covariance risk factor ( $\frac{E(r_{wt}|I_{t-1})}{var[r_{wt}|I_{t-1}]}$ ) is replaced by  $\delta_{t-1}$ , and the model was applied to individual assets instead of portfolios, the following equation would be obtained:

$$E(r_{it}|I_{t-1}) = \delta_{t-1} \times cov[r_{pt}, r_{wt}|I_{t-1}] \quad (3.15)$$

where:  $\delta_{t-1} = \frac{E(r_{wt}|I_{t-1})}{var[r_{wt}|I_{t-1}]}$ .

Since the ICAPM model requires equation 3.15 to hold for every single asset available, including the market portfolio, in an economy which consists of  $N$  risky assets (which equals  $N-1$  risky assets, plus the market portfolio), the following set of pricing restrictions will need to be satisfied at any point in time:

$$\begin{aligned} E(r_{1t}|I_{t-1}) &= \delta_{t-1} \times cov[r_{1t}, r_{wt}|I_{t-1}] \\ &\vdots \\ E(r_{N-1t}|I_{t-1}) &= \delta_{t-1} \times cov[r_{N-1t}, r_{wt}|I_{t-1}] \\ E(r_{wt}|I_{t-1}) &= \delta_{t-1} \times var[r_{wt}|I_{t-1}] \end{aligned} \quad (3.16)$$

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<sup>23</sup>GARCH stands for Generalised AutoRegressive Conditional Heteroskedasticity model, and is a generalised form of the ARCH model which was developed by Engle (1982) in order to allow the conditional covariance matrix to be dependent on both its own past values, as well as its past squared errors.

The preceding system can be rewritten as a single equation by allowing  $R_t$  to represent an  $(N \times 1)$  vector which contains both the  $N-1$  risky assets, as well as the market portfolio. Therefore:

$$R_t = \delta_{t-1} h_{Nt} + \epsilon_t \quad \epsilon_t | I_{t-1} \sim N(0, H_t) \quad (3.17)$$

where:  $H_t$  = the  $(N \times N)$  matrix of conditional covariance matrix of stock returns;

$h_{Nt}$  = the  $N$ th column of the vector  $H_t$ , which contains the value for each specific asset's conditional covariance with the market.

In order to correctly estimate the GARCH model shown above, it is necessary to model the conditional second moments (represented by  $H_t$ ). Whilst there are several different alternatives which have been proposed, such as the VECH model of Bollerslev, Engle and Wooldridge (1988), the factor ARCH (FARCH) model of Engle, Ng and Rothschild (1990), or the BEKK model of Engle and Kroner (1995), this study made use of a parametrization method developed by Ding and Engle (1994). There are two main features to this parametrization method, which are:

- It is assumed that the conditional second moments,  $H_t$  depends solely on the past squared residuals, as well as an autoregressive components; whilst the covariances are dependent on previous cross-products of residuals and an autoregressive element.
- The second assumption is that the entire system is covariance stationary (DeSantis and Gerard, 1998: 381).

Therefore,  $H_t$  can be written as (DeSantis and Gerard, 1997: 1885):

$$H_t = H_0 * (\mathbf{1}' - a a' - b b') + a a' * \epsilon_{t-1} \epsilon_{t-1}' + b b' * H_{t-1} \quad (3.18)$$

Where:  $H_0$  - represents the unconditional variance-covariance matrix of returns

$\mathbf{1}$  - is an  $N$ -dimensional vector of ones

$a, b$  - are vectors of unknown parameters

\* - denotes an element-by-element matrix product



This parametrization method was deemed suitable for the DeSantis and Gerard (1997) analysis, as it allows for a reduction in the number of parameters that needs to be estimated, and thus allows the model to be applied to relatively large systems without the additional assumption of constant correlations. Since  $H_0$  in equation 3.18 is unobservable, DeSantis and Gerard (1997: 1885) developed an iterative procedure in order to estimate its value. In the first iteration,  $H_0$  was therefore made to equal the sample covariance matrix of the asset returns and risk factors, which was subsequently updated at the end of each iteration with the covariance matrix of the estimated residuals for that iteration. Maximum likelihood was then utilised to estimate the model, with optimisation being performed using the BHHH (Berndt, Hall, Hall and Hausman (1974)) algorithm, and all tests were conducted by making use of the Quasi-Maximum Likelihood (QML) method<sup>24</sup>, first used by Bollerslev and Wooldridge (1992).

The aforementioned process was applied to the monthly index returns of 8 countries, viz. the G7 countries of Canada, France, USA, UK, Italy, Japan and Germany, as well as Switzerland (which is the largest European country not included in the G7), over the period of 1970 – 1994. According to the benchmark model expressed in equation 3.17, if the ICAPM holds, the price of covariance risk ( $\delta_{t-1}$ ) should be found to be positive, as well as equal across all the countries included in the study. The first analysis which was done was an investigation of the ICAPM model when the world price of market risk ( $\delta_{t-1}$ ) is constant. In this model, it was found that whilst the estimate produced for  $\delta_{t-1}$  was positive, this value was statistically insignificant, which thus implies that this variable does not have any explanatory power in the model. However, when this variable was allowed to vary over time, it was found that the coefficient produced was both positive, as well as highly statistically significant. Furthermore, the average pseudo- $R^2$  value<sup>25</sup> increased from 0.16% in the case of the constant world price of covariance risk, to 2.52% when this variable was allowed to vary over time (DeSantis and Gerard, 1997: 1898). This result therefore finds support for a conditional form of the ICAPM model, however the authors state that whilst “the conditional version of the traditional CAPM provides useful information on the dynamics of market premia, a more adequate model of international asset pricing should probably include additional factors” (DeSantis and Gerard, 1997: 1910).

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<sup>24</sup> This method allows for statistical inferences, even when the data concerned exhibits departures from normality. Since the assumption of normality is often violated when dealing with financial time series, this method is considered appropriate for the study concerned (DeSantis and Gerard, 1997: 1887).

<sup>25</sup> The Pseudo- $R^2$  value is also considered a measure of variability in asset returns that are explained by the variables included in the model, however this should not be confused with the traditional  $R^2$  value obtained from OLS regressions. In this study, the pseudo- $R^2$  values were obtained by dividing the sum of squared fitted values of the risk premia by the sum of squared excess returns (DeSantis and Gerard, 1997: 1894).

### **3.2.2.3. Chan, Karolyi and Stultz (1992)**

Chan, Karolyi and Stultz (1992: 137) also utilised a bivariate GARCH-in-mean process in order to estimate the conditional ICAPM model as represented by equation 3.6, to the excess returns of the S&P 500 index over the period of 1978 - 1989. Their test equation developed from equation 3.10 to take the form<sup>26</sup>:

$$R_t = \delta H_t \omega_{t-1} + \epsilon_t \quad \epsilon_t | I_{t-1} \sim N(0, H_t) \quad (3.19)$$

where:  $\omega_{t-1}$  - is an  $(N \times 1)$  vector of market weights for the risky assets, which are measured at time  $t - 1$ .

The conditional variance-covariance matrix  $H_t$  was parametrized by making use of the BEKK method. A possible disadvantage to the test equation represented by equation 3.19 is that the model can only be estimated provided that the market weights ( $\omega_{t-1}$ ) can be observed. It is because of this downfall that a different estimation equation (represented by equation 3.17) was utilised by DeSantis and Gerard (1997: 1888), which overcame this disadvantage by requiring just a market index, but not the individual asset weights, to be available for the study. The model used by DeSantis and Gerard (1997: 1884) can also be easily extended to include multiple factors on the right hand side of the equation, whilst this is not possible with the Chan, Karolyi and Stultz (1992) equation.

The afore-mentioned methodology was thereafter applied to the returns of US assets, with the domestic market portfolio being proxied by the S&P 500 index, whilst the global market portfolio was proxied by making use of three different indices, viz. the Nikkei 225 index, the Morgan Stanley Japan Index and the MSCI East Asia and Far East (EAFE) index. Each of these three different global market portfolios was tested separately against the returns of the US assets in order to determine which proxy was superior. Furthermore, Chan *et al* (1992: 142) chose to make use of daily data in order to allow for the average investor who is able to use today's return in order to determine tomorrow's actions.

Similar to the test conducted by DeSantis and Gerard (1997), Maximum likelihood was used in order to estimate the ICAPM model, with statistical inferences being performed by making use of the QML

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<sup>26</sup> Whilst the form of the test equation given is not identical to the one given in Chan, Karolyi and Stultz(1992), this one, as found in DeSantis and Gerard (1997: 1887) is given in order to provide a comparison between their study and that of Desantis and Gerard (1997).

method. When the resultant z-statistics of the coefficients of conditional covariance were examined, it was found that there was a statistically significant, positive relationship between the covariance of the S&P 500 index with both the Nikkei 225 and Morgan Stanley Japan Index. However the conditional covariance of the EAFE index was found to be statistically insignificant, along with the conditional variance of the US returns (Chan *et al*, 1992: 148). This therefore implies that there is no relationship between the excess returns of the S&P 500 index and its own conditional variance, or with the EAFE index.

When explicitly evaluating the ICAPM model by placing specific restrictions on their test equation, it was found that the ICAPM model could not be rejected at the 5% level of significance when using the Morgan Stanley Japan Index and the MSCI EAFE index as proxies for the world portfolio, however, when using the Nikkei 225 index, this model was rejected at the 10% level of significance. However, they also found that a two-factor model which includes both the domestic (US) market index as well as the foreign (Morgan Stanley EAFE index) as factors outperforms the ICAPM model (Chan *et al*, 1992: 155). Their results are therefore supportive of international integration, even though one of the inadequacies of their study is the low cross-sectional power of the tests (Karolyi and Stultz, 2002: 27).

#### **3.2.2.4. McKenzie, Brooks and Faff (2000)**

A conditional test of the ICAPM model which was conducted in a market similar to that of South Africa's is the study conducted by McKenzie, Brooks and Faff (2000: 92) in Australia<sup>27</sup>. They tested the conditional ICAPM and DCAPM models against 24 Australian industry portfolios over the period of 1974 – 1995. Their reason for using industry portfolios instead of individual assets is due to the finding by Ball and Brown (1980) that the returns on the industrial and resource sectors in Australia are fundamentally different.

The method used to test these portfolio returns is that of Kalman Filtering. The reason that this approach was used to model the conditional CAPM models instead of the alternate GARCH-M model which was used by so many other studies is due to the findings of the Brooks, Faff and McKenzie (1998) study, in which they evaluated the differences between using the GARCH-M and the Kalman Filtering approach in the estimation of the traditional CAPM model. Based on their analysis, it was

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<sup>27</sup> Australia and South Africa are both countries whose economies are heavily based on the resources they produce, viz. primarily gold.

found that the Kalman Filter method would be the optimal technique for use in the Australian environment.

This method is a special case of the general state-space model, which consists of a measurement equation (equation 3.20), and transition equations (equations 3.21 and 3.22):

$$R_{it} = \alpha_t + \beta_{it}R_{mt} + \varepsilon_t \quad (3.20)$$

where:

$$\alpha_t = \alpha_{t-1} + u_t \quad (3.21)$$

$$\beta_t = \beta_{t-1} + \eta_t \quad (3.22)$$

Given the prior condition:

$$\beta_0 \sim N(\beta_0, P_0)$$

The Kalman Filtering technique therefore recursively estimates the  $\alpha_t$  and  $\beta_t$  values from the prior condition, thus generating a series of conditional beta and alpha estimates in the market model (represented by equation 3.16). The estimates obtained were thereafter used to generate forecasts, after which the resultant Mean Absolute Error (MAE) and Mean Squared Error (MSE) values were compared in order to determine which of the two models is superior (McKenzie *et al*, 2000: 94).

When evaluating the results produced, and averaging the obtained MSE and MAE values across the industries, it was found that both the MAE and MSE values were minimised for the DCAPM model, which implies that this model is superior to the conditional ICAPM model (McKenzie *et al*, 2000: 104). Therefore, whilst one would expect that for the specific industries within which, the prices of their assets are determined globally (eg. Gold), the ICAPM would be preferred; their study found that the DCAPM is superior to the ICAPM in the Australian market across all industries.

### **3.2.3. Cost of equity tests of the ICAPM model**

Whilst the previous two sub-sections outlined tests which were conducted using both conditional as well as unconditional methods applied to portfolios or single assets, a number of studies have tested the DCAPM and ICAPM models based on their abilities to estimate the cost of equity of a specific company. Since an increase in integration across markets would mean that risks are now shared between both domestic and foreign investors, it is generally believed that an integrated financial market would result in the cost of capital decreasing (Stultz, 1999: 35). These studies therefore look at the effects on the cost of capital estimates in order to draw significant conclusions.

#### **3.2.3.1. Stultz (1995)**

The first study of this type was conducted by Stultz (1995: 13) in which he utilised the single-factor ICAPM and DCAPM equations in order to demonstrate the mistake in using a DCAPM model when the ICAPM should in fact be used. The DCAPM and ICAPM equations, which were introduced previously as equation 1.1 (page 3) and equation 2.16 (page 24) respectively, are as follows:

$$E(R_i) = R_f + \beta_{iD}(R_D - R_f) \quad (1.1)$$

And

$$E(R_i) = R_f + \beta_{iW}[E(R_W) - R_f] \quad (2.16)$$

where:  $E(R_i)$  = the expected return of asset  $i$ ;

$R_f$  = the risk-free rate;

$\beta_{iD} = \frac{cov(R_D, R_i)}{var(R_D)}$ , and is known as the domestic beta of asset  $i$  which is applicable

in a perfectly segmented international market;

$R_D$  = the return on the domestic market portfolio; and

$\beta_{iW} = \frac{cov(R_i, R_W)}{var(R_W)}$ , which is a measure of the systematic risk of the asset  $i$  in a perfectly

Integrated international market.

If a country is completely integrated with global financial markets, the return on the home portfolio ( $R_D$ ) can be computed as follows:

$$E(R_D) = R_f + \beta_{DW}[E(R_W) - R_f] \quad (3.23)$$

Where:  $\beta_{DW} = \frac{cov(R_D, R_W)}{var(R_W)}$  and is the international beta of the domestic market portfolio

If equation 3.23 is thereafter substituted into equation 1.1, equation 3.24 (below) will be produced.

$$R_{iDW} = R_f + \beta_{iD}\beta_{DW}[E(R_W) - R_f] \quad (3.24)$$

In the preceding equation, the variable  $R_{iDW}$  refers to the required return for firm  $i$  when the market is internationally integrated, and the DCAPM is used. An important conclusion which can be drawn from this equation is that, if the domestic model is used to compute the cost of capital, the effect of international risks are only accounted for in the risk premium of the domestic market index, and the international risk specific to firm  $i$  is not accounted for.

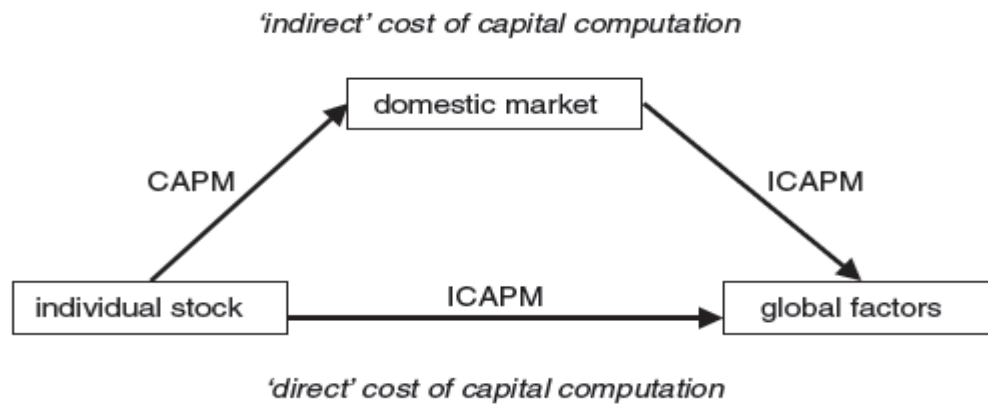
In order to identify under which circumstance the DCAPM will produce the correct estimate for the cost of capital, the point at which  $R_D = R_{iDW}$  needs to be determined. Therefore, from equations 2.16 and 3.24, the following is obtained:

$$R_W - R_{iDW} = [\beta_{iW} - \beta_{iD}\beta_{DW}][E(R_W) - R_f] \quad (3.25)$$

The above equation essentially means that when  $\beta_{iW} = \beta_{iD}\beta_{DW}$ , the DCAPM and ICAPM models will produce the same result. The pricing error test will therefore require the computation of  $\beta_{iW} - \beta_{iD}\beta_{DW}$ . Any result other than 0 will be regarded as a pricing error (Koedijk *et al*, 2002: 908). From this, it can be deduced that, if  $\beta_{iW} > \beta_{iD}\beta_{DW}$ , there are systematic risks present which are unaccounted for by the domestic market index, which will lead to the DCAPM underestimating the assets' expected return. Similarly, if  $\beta_{iW} < \beta_{iD}\beta_{DW}$ , the DCAPM model will tend to overestimate the expected return of the asset (Harris *et al*, 2003: 53).

The concept of pricing error can be illustrated by figure 3-1 as follows:

**Figure 3-1. Direct vs Indirect calculation of the cost of capital**



(Source: Koedijk and Van Dijk, 2004: 467)

In effect, as can be seen from the preceding diagram, a pricing error will arise for a company if the direct method of calculating the cost of equity through the ICAPM model results in an answer that is different from that which can be obtained by using the indirect approach (DCAPM). In their article, Karolyi and Stultz (2002: 8) used this relationship to show that if the domestic market portfolio contains all the information necessary in order to price domestic assets in an international environment, this will lead to the same cost of equity estimate by the two models. Therefore, if a regression of the local market index against the global market index produces a high  $R^2$  value, the domestic CAPM will yield an estimate which is closer to the ICAPM.

After developing this methodology, Stultz (1995: 18) thereafter applied it to Nestle as an illustration. The reason Nestle was chosen was because, in 1988, they chose to eliminate any restrictions on foreign ownership that were present, which in effect, made them openly available to international investors. Considering that Nestle makes up a substantial portion of the Swiss market, when monthly returns over the period of January 1990 to May 1993 were used, it was found that the company had a domestic beta of 0.9, whilst its global beta amounted to 0.6. From this result it can therefore be seen that the increase in integration across markets results in lower betas, and in the case of Nestle, the use of the domestic CAPM tends to overestimate the riskiness of their shares.

In addition to the beta being reduced when computed against an international market, the risk premium on the world market portfolio will also be lower due to this portfolio having a higher level of

diversification than that of the domestic market portfolio. Overall, the use of the ICAPM would therefore result in a lower cost of capital than if the DCAPM was used. This was proven in the case of Nestle as with the DCAPM, the cost of capital was found to be 0.6% higher than the value found when using the ICAPM. Based on his analysis, Stultz (1995: 20) therefore concluded that the ICAPM should be used instead of the DCAPM.

### **3.2.3.2. Harris, Marston, Mishra and O’Brein (2003)**

Harris, Marston, Mishra and O’Brein (2003: 51) conducted a study in order to evaluate which of the domestic or single-factor ICAPM is superior by making use of *ex ante*<sup>28</sup> expected return estimates for a sample of 489 firms listed on the S&P 500 over the period of 1983-1998. The reason that they chose to use *ex ante* estimates instead of realised returns was due to “the theory’s call for a forward looking measure” (Harris *et al*, 2003: 51). These estimates were produced by making use of the Discounted Cash Flow (DCF)<sup>29</sup> model, in which values for the growth rate of dividends was obtained from analysts’ forecasts. Therefore, for each month from January 1983 until August 1998, they utilise the DCF model to estimate the *ex ante* expected return.

Thereafter, the betas for each company in the sample was obtained by running a time-series regression of the excess asset returns on the excess market returns for the five years prior to the month of interest, using equation 3.1 which was discussed earlier. This regression was therefore conducted against both a domestic market index (for DCAPM), as well as a global market index (for ICAPM). These beta estimates were thereafter used in the DCAPM and ICAPM models in order to obtain an estimate of the expected return value for that specific share in the specified month. The preferred model would therefore be the one which provides a value closest to the *ex ante* estimate (Harris *et al*, 2003: 56).

There were three different methods of assessment used on the preceding data in order to determine which model has preference. These three methods are:

- The average of the absolute differences between the *ex ante* cost of equity estimates and the DCAPM and ICAPM model estimates. The model with the lower average absolute difference

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<sup>28</sup>*Ex ante* estimates refers to forecasted values of returns.

<sup>29</sup> DCF(constant growth model) states that:  $k_i = \frac{D_1}{P_0} + g_i$  where  $k_i$  is the *ex ante* cost of equity estimate for asset  $i$ ,  $D_1$  is the dividend expected in period 1,  $P_0$  is the current price of the share, and  $g_i$  is the expected growth rate of the dividend.



was therefore considered to be superior (Harris *et al*, 2003: 56). It was found that the absolute average difference for the DCAPM model was 270 basis points, whereas the value for the ICAPM was 290 basis points (Harris *et al*, 2003: 57). Whilst the difference is not large, the DCAPM model can still be considered marginally superior by these standards.

- The individual firm's estimates were analysed to provide a percentage value of how often the DCAPM was preferred, and how often the ICAPM was preferred (Harris *et al*, 2003: 57). In this analysis it was found that the DCAPM estimates were closer to the *ex ante* estimates produced 56% of the time (Harris *et al*, 2003: 58). This reinforces the result of the first analysis, that the DCAPM is superior.
- Cross-sectional OLS regressions of the *ex ante* risk premium estimates against the estimated domestic and global beta values was conducted, in a form reminiscent of equation 3.3. The resultant coefficients were then analysed to see if they were consistent with theory (i.e.  $\alpha_0$  should be 0, and  $\alpha_1$  should be statistically significant). Here, it was found that again, the DCAPM model was a better fit for the data than the ICAPM model as its resultant coefficients were better aligned with theory, and the  $R^2$  values were consistently higher for the DCAPM (Harris *et al*, 2003: 59).

Harris *et al* (2003) therefore found that the domestic version of the CAPM consistently fitted the *ex ante* return estimates better than the international model. It was also found that this result was consistent across different sub-periods; however, the difference in fit between the two models was small.

Whilst the preceding discussion involved only studies which took the single-factor ICAPM model into account, there are a variety of other studies which used similar methodological approaches in evaluating the ICAPM model with exchange rate risk. These studies are reviewed in the next section.

### **3.3. ICAPM model with exchange rate risk**

Section 3.2 discussed some of the evidence surrounding the single-factor ICAPM model, and from everything that has been reviewed, it can be seen that the overall results are mixed, with some being in support of the ICAPM model, whilst others favour the DCAPM. However, another key element which was mentioned in the discussion of DeSantis and Gerard's (1997) study is that there may be other factors which are relevant in the estimation of expected returns. This section therefore reviews the evidence surrounding the ICAPM<sup>EX</sup> model, which extended the single-factor ICAPM model to allow for the inclusion of exchange rate influences.

### **3.3.1. Unconditional tests of the ICAPM<sup>EX</sup> model**

#### **3.3.1.2. Solnik (1977)**

The first test of the ICAPM<sup>EX</sup> model was conducted by Solnik (1977). The purpose of his paper was to determine whether the single-factor ICAPM model developed by Grauer, Litzenberger and Stehle (1976) or his multifactor ICAPM<sup>EX</sup> was superior. The method which he used is based on each model's theoretical underpinnings. Since according to his mutual fund theorem<sup>30</sup>, every investor will choose to hold two portfolios (one portfolio of shares and one of bonds), whilst under the single-factor ICAPM, every investor chooses to hold the world market portfolio, he tested the efficiency of each of these alternatives in order to provide an answer to his research question. Solnik's null hypothesis that both models of the ICAPM yield identical portfolios could not be rejected, which therefore leads one to the conclusion that exchange rates are not necessary in the computation of expected return, and the single factor ICAPM is adequate (Dumas, 1977: 514).

#### **3.3.1.2. Jorion (1990)**

Jorion (1990) conducted a test in order to determine whether exchange rate exposures are significant in the explanation of expected return for the stock prices of 287 US multinational companies over the period of January 1971 to December 1987. The chosen companies in the sample were based on their levels of foreign exposure and therefore consisted of non-oil firms whose involvement in foreign activities accounted for more than 10% of their total operations. Whilst this study cannot be considered a direct study of the ICAPM model with exchange rate risk as he makes use of a domestic market portfolio instead of a global one, it nevertheless provides an important analysis of whether exchange rate risk should be included in asset pricing models or not.

The model therefore consisted of two factors, the return on the domestic market index, as well as a single trade-weighted exchange rate index, which was chosen in order to avoid the problem of multicollinearity<sup>31</sup> (Jorion, 1990: 335). The time-series regression method was therefore applied to the following test equation (Jorion, 1990: 336):

$$R_{it} = \beta_0 + \beta_{im}R_m + \beta_{is}R_{st} + \eta_{it} \quad (3.26)$$

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<sup>30</sup> Outlined on page 26 in section 2.4.

<sup>31</sup> The 15 country exchange rates which made up the single index is: Australia, Austria, Belgium, Canada, Denmark, France, Germany, Italy, Japan, Netherlands, Norway, Spain, Sweden, Switzerland, and the UK. The reason Jorion (1990, 335) is because many of these cross-rates are fixed relative to each other.

where:  $R_{st}$  = the rate of change in the trade-weighted exchange rate index.

Equation 3.26 was thereafter estimated by making use of Generalised Least Squares (GLS), the results of which showed that the exchange rate index was a statistically significant factor in the explanation of expected returns. This result therefore leads to the conclusion that an exchange rate risk factor should be included in asset pricing models (Jorion, 1990: 343).

### **3.3.1.3. Jorion (1991)**

Jorion (1991) later extended his 1990 study for the same sample of firms and the same sample period, but using a different empirical methodology (which was chosen to be maximum likelihood estimation). In addition, Jorion (1991: 364) chose to evaluate a multifactor APT model which included the change in exchange rates as an additional factor. Jorion (1991: 365) made use of two different test equations in his analysis, the first of which was equation 3.26 (which he used in his 1990 study). The second test equation used was a multifactor APT model which included the influences from economic variables such as industrial production and inflation, as well as an exchange rate factor.

He found that in the two-factor model in equation 3.26, the estimated exchange rate exposure coefficient was significant for only 15 of the 287 firms. When tested in the multifactor APT model, Jorion (1991: 374) again found that the exchange rate factor was statistically insignificant. He therefore concluded that exchange rate risk seems to be diversifiable, in which case it is not necessary to include this factor in asset pricing models. A possible reason for this conclusion however, is due to the unconditional nature of this study, and Jorion (1991: 375) admits that if a conditional approach was utilised instead, the results produced may be different. A further criticism of the Jorion (1991) study is that the sample of firms which were selected was not appropriate for the conditions. This is because; his chosen firms were only US multinational firms which have reported foreign exposures. This will therefore not necessarily lead to the selection of firms with high exposures as these firms are probably able to hedge their exposures at a low cost (Bartov and Bodnar, 1994: 1760).

### **3.3.1.4. Wu (2002)**

A more recent unconditional test of the ICAPM<sup>EX</sup> was conducted by Wu (2002: 7), who employed a variation of the Fama-MacBeth method of two-pass regression to evaluate both the domestic version of the CAPM as well as the international version with exchange rates. Whereas the Fama-MacBeth (1973) study made use of portfolio construction before the regressions took place, this analysis used already well-specified international portfolios such as the value, market and growth portfolios for the

US. Furthermore, whilst the original Fama-Macbeth (1973: 625) procedure allows one to test the model's out-of-sample forecasting power by using estimated betas from one time period in the first pass to the cross-section of returns in a later period in the second pass, Wu (2002: 7) chose to focus on whether the data supports the ICAPM<sup>EX</sup> model, rather than on the forecasting ability of each of the models, and therefore found that making use of the same period for both the time-series and cross-sectional regressions would be simpler and more appropriate for his study.

The data used in this study consisted of 16 countries, with the inclusion of the exchange rate information of the German Deutschmark, Japanese Yen and British Pound (with the dollar as the base currency). The ICAPM<sup>EX</sup> regression equation utilised in the first pass is therefore:

$$R_i - R_f = \alpha + \beta_1(R_W - R_f) + \beta_2SRP_{dmark} + \beta_3SRP_{yen} + \beta_4SRP_{pound}$$

When the results of the study were analysed, it was found that whilst the intercepts were statistically insignificant for both the domestic model as well as the international one, the beta coefficient of the world market risk premium was significant in the ICAPM<sup>EX</sup> model only, which is consistent with the hypothesis that the model holds, as outlined in section 3.2.1. Furthermore, the resultant R<sup>2</sup> value of the ICAPM<sup>EX</sup> was larger than that produced by the domestic version of the model. Therefore, whilst Wu's (2002: 21) results found that none of the exchange rate factors were priced, the international form of the model still consistently exhibited greater explanatory power than the domestic form.

#### **3.3.1.5. Wu (2008)**

Wu (2008: 176) later extended his 2002 study to evaluate the forecasting ability of both the domestic CAPM and the ICAPM<sup>EX</sup>. He performed an assessment of the out-of-sample forecasting power of the models by using lagged estimated betas to estimate expected future asset returns (Wu, 2008: 178). He found that the International CAPM model with exchange rate risk again performed better than the domestic CAPM when evaluating them in-sample. In addition, even though both models performed poorly in forecasting, the ICAPM still posted better results than the domestic CAPM with a higher R<sup>2</sup> value being produced.

### **3.3.2. Conditional tests of the ICAPM<sup>EX</sup> model**

#### **3.3.2.1. Dumas and Solnik (1995)**

A very influential conditional test of the ICAPM with exchange rate risk was conducted by Dumas and Solnik (1995: 445), in which they made use of Harvey's (1991) instrumental variable approach.

Since this conditional model includes more than one factor being tested, it will take the following form<sup>32</sup>:

$$(r_{pt}|I_{t-1}) = \delta_{w,t-1} \times cov[r_{pt}, r_{wt}|I_{t-1}] + \sum_{c=1}^L \delta_{c,t-1} \times cov[r_{pt}, r_{c,t}|I_{t-1}] \quad (3.27)$$

where:  $I_{t-1}$  = the information set which is used by investors to form expectations;

$L$  = the number of countries being included in the study;

$r_{pt}$  = the return on portfolio  $p$  from time  $t-1$  to  $t$ , measured in excess of the risk free rate;

$r_{wt}$  = the return on the world market portfolio, measured in excess of the risk-free rate;

$r_{i,t}$  = the exchange rate of country  $i$ ;

$\delta_{w,t-1} = \frac{E(r_{wt}|I_{t-1})}{var[r_{wt}|I_{t-1}]}$ , and is the time-varying, world price of market risk; and

$\delta_{i,t-1} = \frac{E(r_{i,t}|I_{t-1})}{var[r_{i,t}|I_{t-1}]}$ , and is the time-varying world price of exchange rate risk.

The functional form of the afore-mentioned equation was thereafter specified and tested according to the same method of Harvey (1991), in which he created a linear specification and utilised GMM to estimate the model. Dumas and Solnik's (1995) study therefore used this methodology to test the equity markets of the four countries of Germany, Japan, the United Kingdom and the United States over the period of 1970 – 1991. They tested both unconditional and conditional versions of both the domestic CAPM and ICAPM with exchange risk in order to determine which is superior.

Whilst the domestic CAPM performed better in the unconditional tests than the ICAPM<sup>EX</sup> did, it was also found that the exchange rate risk factors are priced. When testing the conditional models, it was again found that exchange rate risk is priced; however, in this case the ICAPM<sup>EX</sup> outperformed the domestic CAPM model. Therefore, the conclusion from this study is that any international asset pricing model which contains the world market risk as the only factor is misspecified (Dumas and Solnik, 1995: 477).

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<sup>32</sup> The form of this model was adapted from Dumas and Solnik (1995: 448).

### **3.3.2.2. DeSantis and Gerard (1998)**

Whilst the preceding study of Dumas and Solnik (1995) is an important one which provides valuable conclusions, it is also subject to certain weaknesses, as outlined in DeSantis and Gerard (1998: 376). The weaknesses arise from their use of the GMM methodology, which does not require any specification of the conditional second moments, and therefore does not allow them to evaluate the economic significance of the exchange rate risk premiums produced. Furthermore, important aspects which will be of interest to an investor such as conditional correlations, optimal hedge ratios and the expected gains from international diversification cannot be obtained from a model which does not specify the conditional second moments of an equation (DeSantis and Gerard, 1998: 383). Therefore, the Dumas and Solnik (1995) test “should be interpreted as a test of some of the unconditional implications of the conditional model rather than as a direct test of the conditional model” (DeSantis and Gerard, 1998: 376).

DeSantis and Gerard (1998) therefore extended the study of Dumas and Solnik (1995) by utilising the same parsimonious multivariate GARCH process which was used in their 1997 study of the single-factor ICAPM model. This method was applied to the same dataset as Dumas and Solnik (1995) over the period of 1973 – 1994. A further difference between the preceding study and this one is that whilst Dumas and Solnik (1995) compared the domestic CAPM model to both the ICAPM and ICAPM<sup>EX</sup> models, DeSantis and Gerard (1998) only test the ICAPM<sup>EX</sup> model. The test equation for this model follows on from equation 3.17 which was used in their 1997 study, and can be expressed as follows:

$$R_t = \delta_{m,t-1}h_{m,t} + \sum_{c=1}^L \delta_{c,t-1}h_{n+c,t} + \epsilon_t \quad \epsilon_t | I_{t-1} \sim N(0, H_t) \quad (3.28)$$

where:  $H_t$  = the  $(N \times N)$  matrix of conditional covariance matrix of stock returns;

$h_{n+c,t}$  = the  $(n+c)$ th column of the vector  $H_t$ , which contains the value for each specific

asset's exposure to foreign exchange risk with reference to foreign currency  $c$ ;

$h_{m,t}$  = the last column of the  $H_t$  matrix, and contains each assets exposure to market.

The covariance matrix  $H_t$  was modelled using the Ding and Engle (1994) method which was also utilised in their 1997 study of the single-factor ICAPM model. Maximum likelihood was then utilised

to estimate the model, with optimisation being performed using the BHHH algorithm, and all tests were conducted by making use of the QML method.

In order to overcome their above-mentioned criticism of the Dumas and Solnik (1995) model, DeSantis and Gerard (1998: 389) choose to first test a conditional ICAPM model in which the prices of risk are constant, as opposed to the unconditional model tested by Dumas and Solnik (1995). They found that in this model, both the market price of risk as well the exchange rates were statistically insignificant. When the model was changed in order to allow for time-variation in the risk factors, both market as well as exchange rate risk became priced factors. This suggests that the time variation of risk prices is important and should be included when empirically testing the multifactor ICAPM<sup>EX</sup> model. Since they found support for the ICAPM<sup>EX</sup> model, their results are consistent with those of Dumas and Solnik (1995).

DeSantis and Gerard (1998: 397) also found that the coefficient estimates that they obtained fell in a narrower range than those produced by Dumas and Solnik (1995). The proposed reason for this is because their model allows the accommodation of time variation in the risk premiums through variations in the price of risk, as well as the conditional second moments. This finding therefore leads the authors to conclude that the use of time-varying conditional moments will not be sufficient to detect market or currency risks, and that variation in the prices of risk should be incorporated as well.

Since one of the weaknesses of the Dumas and Solnik (1995) model was that the size of risk premiums could not be estimated by their model, as explained earlier, DeSantis and Gerard (1998: 410) chose to compute the risk premiums for each factor in each country as their methodology allowed this kind of analysis. The evidence produced showed that the risk premiums involved vary over time and across different markets. In the latter years of the sample, it was found that the portion of the relative risk premiums which can be attributed to exchange rate risk was 64% for Germany, 49% for the UK, 52% for Japan and 30% for the world market portfolio, whilst it was found that the US equity market risk premium was attributable entirely to the market risk factor. This result is interesting as it shows that the currency risk factor is a significant one in the estimation of expected returns, and this variable's significance has increased over time.

### 3.3.3. Cost of equity tests of the ICAPM<sup>EX</sup> model

#### 3.3.3.1. Koedijk, Kool, Schotman and van Dijk(2002)

The method of pricing error which was introduced by Stultz (1995) was extended by Koedijk, Kool, Schotman and van Dijk (2002: 906) in order to evaluate the ICAPM<sup>EX</sup> model. In addition, they used his analysis to derive a statistical test which can be used to determine pricing error significance. Koedijk *et al* (2002) then used these methods in order to evaluate between the DCAPM and the ICAPM<sup>EX</sup>. They utilised a sample which consisted of 3293 assets from nine different countries over the sample period of 1980 – 1999. The nine countries which were chosen were: the US, Germany, Japan, Australia, Canada, France, Netherlands, Switzerland and the UK. These countries were chosen because, collectively, at the time they represented a total of 91% of the world market portfolio, which validated the use of these nine exchange rates as factors in the ICAPM<sup>EX</sup> as well. Koedijk *et al* (2002: 908) choose to implement their variation of the test initially conducted by Stultz (1995) by adding the instrumental variable,  $Z'$  to the DCAPM model. Therefore:

$$R_i = \alpha_i + R_D \beta_{iD} + Z' \delta_i + v_i \quad (3.29)$$

where:  $R_i, R_D, R_W$  = to the return on the asset  $I$ , the domestic market portfolio  $D$ , and the world market portfolio,  $W$ , respectively;

$S$  = the vector of nominal exchange rates of the other  $N$  countries against the home country; and

$$Z' = (R_w S').$$

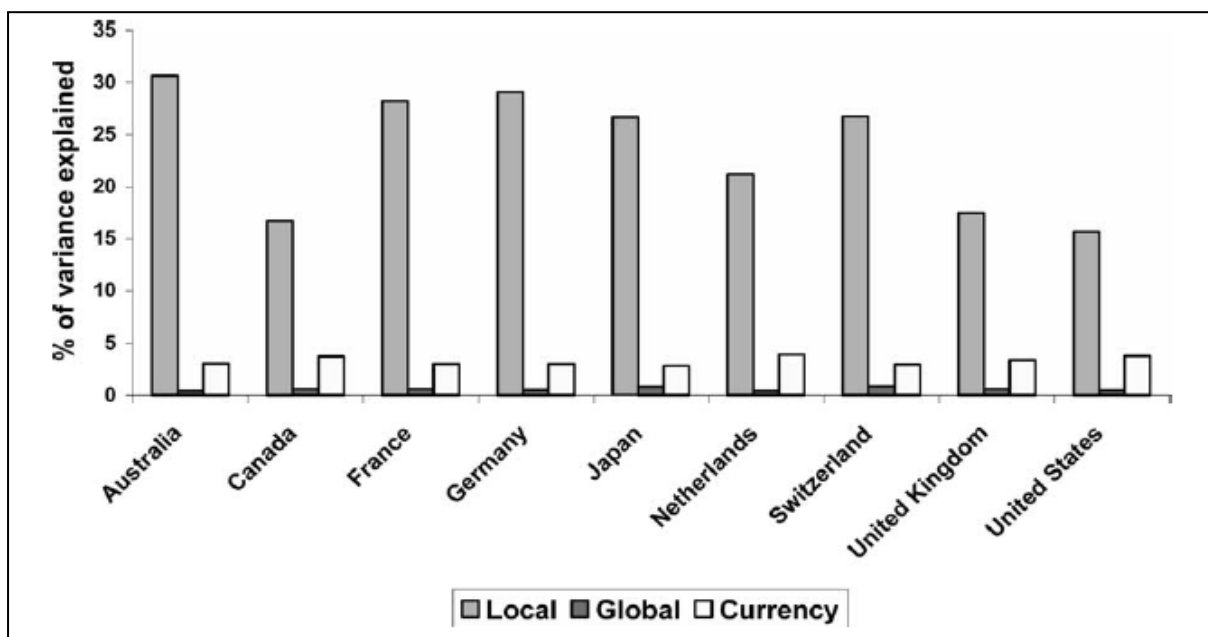
The null hypothesis ( $H_0: \delta_i = 0$ ) was thereafter tested in order to make inferences about the model. A failure to reject the null hypothesis would imply that the DCAPM model is sufficient to price assets as the domestic market portfolio contains all the relevant information that is required. Therefore, the use of the DCAPM model will not lead to a different cost of equity estimate from the ICAPM<sup>EX</sup> model. However, a rejection of the null hypothesis implies that the DCAPM model is not sufficient in the pricing of assets, and the ICAPM<sup>EX</sup> would be more appropriate to capture all the risks present (Koedijk *et al*, 2002: 908).



When the data was examined, they found that the null hypothesis was rejected for only 5% of the firms in the sample (Koedijk *et al*, 2002: 912). When tested over different sub-periods, this conclusion still held. This therefore implied that the DCAPM model will be sufficient for pricing assets in an integrated market. When the currency risk factors were tested, they found that there was statistically significant foreign exposure for, on average, 14% of the firms in the sample (Koedijk *et al*, 2002: 925). This therefore implies that exchange rate factors may have an influence on asset prices; however this risk factor may be captured by the domestic market index to some extent.

Therefore, an additional analysis conducted was that of a variance decomposition process in which the effect of the local market index, global market index and exchange rate factors on the asset's return can be broken down and quantified as a percentage. The results from this test are shown in figure 3-2 below:

**Figure 3-2. Variance decomposition of the different assets tested from each country included in the analysis**



(Source: Koedijk *et al*, 2002: 924)

Figure 3-2 shows that the local market index is the variable which accounts for the largest proportion of the variation in asset returns, whilst the currency factor affects firms, but not to a large extent, and the global market index has a negligible influence. This therefore reinforces the previous conclusions

that the DCAPM is suitable for pricing assets, and the domestic market portfolio adequately captures the international risks which each asset is exposed to.

### **3.3.3.2. Koedijk and Van Dijk (2004)**

The preceding study was extended by Koedijk and Van Dijk (2004) in order to include the single-factor ICAPM model in the analysis as well. They also found that the three CAPM models do not lead to significant differences in their estimates of the cost of capital, which reinforces the preceding conclusion that the DCAPM could be considered a sufficient model to compute the cost of capital.

### **3.3.3.3. Dolde, Giacotto, Mishra and O'Brein (2010a)**

A very recent study of this subject was conducted by Dolde, Giacotto, Mishra and O'Brein (2010a: 2) in which they assessed the difference in cost of equity estimates when using the DCAPM and the single-factor ICAPM model. Their sample consisted of US firms which were evaluated over the period of 2000 – 2007. Whilst this study follows the evaluation process of the previously mentioned studies under the cost of capital approach, an additional dimension which they added was to identify the firms which have low or high foreign exposures and identify the effects thereof. The way in which the foreign exposures of each firm was determined was by regressing the firm's returns against the Federal Reserve's trade-weighted index, which consisted of seven major currencies<sup>33</sup>. The domestic and global betas for each firm were thereafter obtained by regressing the firm's excess return against the excess return of the domestic (S&P 500) and global (MSCI World) indices. These estimates were therefore multiplied against the estimated risk premiums (obtained from other studies of the subject), to obtain the cost of equity estimates.

There were two important conclusions that arose from the results produced:

- The average difference in the cost of equity for firms which exhibited extreme foreign exposure was around 0.9%, compared to an average difference across all firms of 0.3%.
- Importers (firms which have a negative exposure to the currency index), tend to have a domestic beta that is higher than the global beta.
- Exporters (firms which have a positive exposure to the currency index), however, produced lower domestic betas than their global betas.

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<sup>33</sup> These currencies are from the following countries/regions: Europe, Canada, Japan, the UK, Switzerland, Australia and Sweden. (Dolde *et al*, 2010a: 10).

Their results were consistent with the theoretical expectation of this analysis, as they found that the DCAPM model underestimates the cost of capital for firms which exhibit more positive exposure to currency changes. Therefore, the cost of equity shares a statistically significant negative relationship with the level of foreign exposure of a firm. Whilst this relationship is statistically significant, it was found to be economically insignificant, as the average cost of equity difference was just 32 basis points (0.32%). Therefore, from an economic viewpoint, “the average difference does not seem significant. Cost of equity estimates are very noisy (eg. Fama and French, 1997), and so even differences of 100 basis points in the cost of equity estimate may easily fall within the wide confidence intervals around the point estimates” (Dolde *et al*, 2010a: 13). This finding therefore indicates again, that the DCAPM may be sufficient for use, even in firms which exhibit high levels of exposure (Dolde *et al*, 2010a: 16).

#### **3.3.3.4. Dolde, Giacotto, Mishra and O’Brein (2010b)**

The preceding study was extended by Dolde, Giacotto, Mishra and O’Brein (2010b) in order to include the ICAPM<sup>EX</sup> model. In an approach that has been seen with other studies, they chose to utilise a single currency index of all the major market currencies instead of using multiple currencies. The aim of their study was to determine how much of a difference the use of an ICAPM<sup>EX</sup> model would make in the estimation of the cost of equity, over the ICAPM or DCAPM models; instead of whether the ICAPM<sup>EX</sup> is empirically valid (Dolde *et al*, 2010b: 3).

They found that:

- The average cost of equity difference between the ICAPM and ICAPM<sup>EX</sup> was just 0.01%, whilst this value was -0.65% for importers and 0.9% for exporters. This therefore implies that the single-factor ICAPM model underestimates the cost of equity for importers and overestimates the cost of equity estimates for exporters, whilst for firms with a low-to-moderate exchange risk exposure either the ICAPM or ICAPM<sup>EX</sup> would be appropriate (Dolde *et al*, 2010b: 15).
- When testing the DCAPM against the two international models, the above results were echoed, as it was found that on average the DCAPM produces cost of equity estimates which are very similar to those of the ICAPM and ICAPM<sup>EX</sup> (Dolde *et al*, 2010b: 15). However, when analysing firms which exhibit high levels of currency exposure, it was found that the DCAPM model produces cost of equity estimates which are closer to those produced by the ICAPM<sup>EX</sup> model, than the ICAPM.

Their results therefore echo those of their preceding study, as the results produced show that the DCAPM model will be sufficient in the calculation of the cost of equity.

### **3.4. Evidence from Emerging Markets**

All of the preceding studies provided evidence on developed countries. However, the characteristics of an emerging market are different from those of developed markets, as emerging market equities generally have greater volatility and higher returns than developed markets (Harvey, 2000: 9). Since South Africa is classified as an emerging market, rather than a developed market, this implies that there may be other factors which should be assessed before conducting an analysis. This section will therefore outline the characteristics of emerging markets, together with empirical evidence on the subject.

#### **3.4.1. Characteristics of Emerging Markets and implications for International asset pricing**

In his study of emerging markets, Harvey (1995a) pointed out that there are a variety of different aspects which could lead to the statistical rejection of an asset pricing model when tested in an emerging market framework. This may occur because the characteristics of emerging markets may violate some of the theoretical foundations upon which these asset pricing models are based. These aspects are:

- Integration vs Segmentation

A market is considered to be completely integrated into the international market if identical assets are able to command the same expected return regardless of the country in which they are sold (Bekaert and Harvey, 2003: 4). In order for a market to be integrated, there therefore needs to be no barriers to investment across countries.

Bekaert (1995) identified three different barriers to investment which are prevalent in emerging markets. The first is known as a direct barrier and refers to legal barriers which advocate differential treatment of domestic and foreign investors. The other two barriers are referred to as indirect barriers, which arise due to information asymmetry in the market, as well as risks that cannot be ignored in emerging markets, such as currency risk, political risk and liquidity risk.

Whilst in recent times many legal barriers may have been removed, the indirect barriers are still very common in emerging markets. This therefore leads one to the conclusion that emerging markets may not actually be fully integrated into the global economy, instead, these countries can be considered as “partially segmented”, or “partially integrated” (Bekaert, 1995: 87).

Bekaert and Harvey (1995: 403) conducted a study of emerging markets by testing an asset pricing framework which allows for time-varying integration. They model the returns of twelve emerging markets (excluding South Africa) by using an ARCH-M model which is estimated by making use of the Maximum Likelihood method. This analysis was conducted over the period of 1975 – 1992. Whilst they found that emerging markets at that time were largely still segmented, they also found that evidence in support of the time-varying integration hypothesis as four out of the twelve countries in the sample displayed increasing integration over time (Bekaert and Harvey, 1995: 437). This was supported by their later study, Bekaert and Harvey (2000: 607), in which they found that over time, these markets have become more correlated with the global market, and therefore more integrated internationally.

There are a variety of different models which have been developed for use in emerging markets, as alternatives to the DCAPM (which assumes a completely segmented market), or the ICAPM (which assumes a completely integrated market). Von Jenner (2008: 21) discussed six such models<sup>34</sup>, together with their relative advantages and disadvantages, including the DCAPM and single-factor ICAPM models.

Based on his theoretical analysis, Von Jenner (2008: 24) concluded that the choice of model should be based on the method of diversification chosen by investors. If investors choose to diversify their portfolios internationally, then the ICAPM model should be used, whereas, if they choose to diversify domestically, the DCAPM should be used. The level of diversification which is possible will be directly attributed to the level of integration of a country, because if there are no barriers to investment and the country is internationally integrated with the global economy; international diversification will also be possible.

- Distribution of returns

One of the assumptions underlying the CAPM model, as noted in chapter 2, is that returns are normally distributed. However, Harvey (1995b) documents that this is not the case for emerging markets. Many studies have shown that emerging markets display high values for kurtosis and skewness, which indicates that the distributions of emerging markets exhibit fatter tails than those present in a normal distribution. (Bekaert and Harvey, 1997; De Santis and Imrohorglu, 1997;

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<sup>34</sup> The six models discussed are: (1) the Home CAPM, which takes into account an additional factor for the home country's risk, (2) the Domestic CAPM, (3) The Single-factor ICAPM model, (4) Country-Risk-adjusted CAPM, (5) Multifactor model which incorporates both local and global risks into the equation, and (6) The Credit Risk Model.

Worthington and Higgs, 2004). This phenomenon is known as leptokurtosis and implies that emerging markets are prone to large movements in prices, which occur relatively often (Marais, 2008: 14). In studies of the South African market, Page (1993), Hearn and Piesse (2002) and Mangani (2007), all found evidence of non-normality which therefore conformed with the results of other emerging markets.

### **3.4.2. Studies of Emerging markets which exclude South Africa**

The preceding sub-section looked at the characteristics of emerging markets, whilst this one will review some of the studies of the ICAPM models in this context. Since there are some studies of emerging markets which included South Africa in their analysis, and some studies which did not, those analyses which were conducted on emerging markets other than South Africa will be considered first. The next section will therefore cover the studies within which South Africa was included in the analysis.

#### **3.4.2.1. Harvey (1995a)**

The empirical studies surrounding this topic have provided many reasons to believe that the risk components that are applicable to emerging markets differ from those in developed markets. Harvey (1995a: 773) is one of the first examples of these studies. He tested both unconditional and conditional versions of both the ICAPM and ICAPM<sup>EX</sup> models in order to determine if the world market portfolio and exchange rate risk factors are priced for emerging markets. His study examined 20 emerging countries from around the world over the period of 1977 – 1992.

Similar to other studies of the ICAPM<sup>EX</sup> which have been reviewed thus far, Harvey (1995a: 778) made use of a single trade-weighted exchange rate index instead of many currency factors. When he ran unconditional tests of the ICAPM models, in the form of a cross-sectional regression which is similar to equation 3.3, he found that of his sample, the world market index was only priced for 7 countries, whereas the exchange rate factor added additional explanatory power for eight countries, which increased in the latter period of the analysis. Upon further analysis, Harvey (1995a: 791) concluded that these countries for which the global factors were priced are considered to be the most integrated countries in the sample.

The conditional approach used by Harvey (1995) was a replication of the GMM approach he utilised in his 1991 study of developed markets. The conditional analysis only included the 8 countries in the sample which had data from the 1977 onwards. The results of this approach, when applied to the single-factor ICAPM model, showed that the pricing errors for all eight countries were statistically different from zero, which implies that the conditional model does not hold. When applied to the ICAPM<sup>EX</sup> model, it was found that again, all the pricing errors were statistically significant, and for six of the eight countries in the sample, the average pricing error value was worse for the ICAPM<sup>EX</sup> than for the ICAPM model (Harvey, 1995: 804). Therefore, Harvey (1995: 812) concluded that the conditional ICAPM and ICAPM<sup>EX</sup> models are not able to accurately explain the cross-section of returns experienced in emerging markets.

An additional analysis which was conducted by Harvey (1995a: 800) is the multivariate test of Gibbons, Ross and Shanken (1989). His results are contrary to that of Harvey (1991) as he found that the world market portfolio is not mean variance efficient, and is therefore an inappropriate proxy for the market portfolio.

#### **3.4.2.2. Mishra and O'Brein (2001)**

In 2001, Mishra and O'Brein utilised cost of capital estimates for 2989 US assets, 70 ADRs<sup>35</sup> from developed countries, and 48 ADRs from emerging markets<sup>36</sup>, in order to determine which of the DCAPM, ICAPM, or ICAPM<sup>EX</sup> models is superior. The ICAPM<sup>EX</sup> model which they employed included just one currency factor, which was the Federal Reserve's Major Currency Index. This index is representative of a trade-weighted index that includes the most active (or major) currencies in the world. The betas needed to evaluate the cost of capital were obtained by making use of time-series regression analysis (as represented in equation 3.1), whilst the value for the market risk premium which was used was based on previous studies of this subject.

When evaluated over the sample period of 1995 – 1999, it was found that, for the US assets, the average absolute difference between the cost of capital estimates of the DCAPM and ICAPM models was 0.48%. This difference increased to 0.76% for all developed market ADRs, whereas this value was 0.57% for emerging market ADRs. When doing an industry analysis, it was found that the three industry sectors which displayed the highest average differences in cost of equity estimates were those

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<sup>35</sup> ADR – American Depositary Receipts – these are an alternative source for investing in international equity.

<sup>36</sup> The developed market ADRs came from Australia, Japan and the UK, whilst the emerging market ADRs were from Argentina, Chile and Mexico.

of Hardware (0.96%), Miscellaneous Services (0.70%) and Engineering and Management Services (0.68%).

When evaluating the difference between the cost of equity estimates of the ICAPM and ICAPM<sup>EX</sup> models, it was found that for US assets, the average absolute difference in estimates amounted to 0.61%. However, whilst this result held for the whole sample, it was found that for specific industry classes such as Mining (1.07%), Electrical equipment (0.83%) and Business services (0.8%), the presence of exchange rate risk did affect the cost of capital significantly. Developed market ADRs exhibited a smaller difference of 0.47%, whilst the emerging market ADRs displayed a difference of 0.7% (Mishra and O'Brein, 2001: 46). This therefore shows that the presence of an exchange rate factor has more significance for emerging market ADRs, than the developed market ones. Overall, the authors conclude that, on average, the three models do not differ much in their return estimates, which thus could lead to the conclusion that the simplest of the three models (DCAPM) would be the best model to use.

### **3.4.2.3. Mishra and O'Brein (2005)**

Mishra and O'Brein's (2005) study however did find some support for the use of the single-factor ICAPM in an emerging market. Their analysis was performed on 438 individual companies from 16 different emerging markets over the period of 1990 – 2000. Each of their data observations were then separated into different investment categories, based on the proportion of assets which are available to foreign investors. Their methodology entailed obtaining beta estimates by conducting OLS regressions of excess return on the asset against excess return on the market index. These betas were thereafter utilised in the residual income valuation model<sup>37</sup> in order to obtain the *ex ante* estimates of each company's cost of capital ( $k_i$ ). These estimates were then utilised in a panel regression against three variables, viz. global beta ( $\beta_W$ ), domestic beta ( $\beta_D$ ) and a measure of political risk ( $\sigma_i/\sigma_w$ ):

$$k_i = \alpha_1\beta_W + \alpha_2\beta_D + \alpha_3(\sigma_i/\sigma_w) \quad (3.30)$$

In equation 3.30, the measure of political risk utilised by the authors is taken as a ratio of the individual asset's volatility ( $\sigma_i$ ) to the return volatility of the world market index ( $\sigma_w$ ).

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<sup>37</sup> The residual income model is as follows:  $P_{i0} = \beta_{i0} + \frac{E_{i1}-k_i\beta_{i0}}{(1+k_i)} + \frac{E_{i2}-k_i\beta_{i1}}{(1+k_i)^2} + \dots + \frac{E_{i5}-k_i\beta_{i4}}{(1+k_i)^5} + \frac{(E_{i5}-k_i\beta_{i4})(1+g)}{(k_i-g)(1+k_i)^5}$   
 where:  $P_{i0}$  = current price per share of company  $i$ ,  $k_i$  = the *ex ante* cost of equity estimate for company  $i$ ,  $\beta_{it}$  = book value per share of company  $i$ ,  $E_{it}$  = is the earnings per share for company  $i$ , and  $g$  = the expected growth rate.



Mishra and O'Brein (2005: 116) found that all three variables in equation 3.30 were statistically significant. Furthermore, when equation 3.30 was separated into three different regressions with only one dependent variable being included in each, it was found that the adjusted  $R^2$  value for the domestic beta equation was 0.0127, whilst the value for the global beta equation was marginally better at 0.0136. This stands in stark contrast to the adjusted  $R^2$  value of the regression which contains only political risk as this value was 0.0883. Overall, Mishra and O'Brein (2005: 117) found that whilst the domestic beta is sufficient for companies which have some restrictions in terms of international investment, the global beta factor adds explanatory power to firms which exhibit significant international investment.

#### **3.4.2.4. Arouri (2006)**

Another empirical analysis which extended beyond investigating solely developed markets to include emerging markets is that of Arouri (2006). His study focused on the two developed markets of the US and UK, as well as two emerging markets of Hong Kong and Singapore. Arouri (2006: 70) utilised an asymmetric extension of the multivariate GARCH process which was used by DeSantis and Gerard (1997) in order to test a partially segmented ICAPM model in the four above-mentioned countries over the period of 1970 – 2003. The ICAPM model which he tested is referred to as “partially segmented” as he makes use of both the domestic market index, as well as the world market index as factors. This equation is derived from equation 3.13 utilised in the DeSantis and Gerard (1997) study and is represented as follows:

$$R_t = \delta_{t-1} h_{Nt} + \delta_{d,t-1} * q_t + \epsilon_t \quad \epsilon_t | I_{t-1} \sim N(0, H_t) \quad (3.31)$$

where:  $q_t = D(H_t) - \frac{(h_{Nt} * h_{Nt})}{h_{NNt}}$ , and is representative of an (N x 1) vector of systematic

local risk;

$D(H_t)$  = the diagonal components in  $H_t$ ;

$h_{NNt}$  = the conditional variance of the global market portfolio; and

$\delta_{d,t-1}$  = (N x 1) vector of prices of domestic risk which are time-varying.

His results found that the domestic market risk factor was not priced, and that all four countries were found to be internationally integrated. When the preceding test was then applied to two different sub-

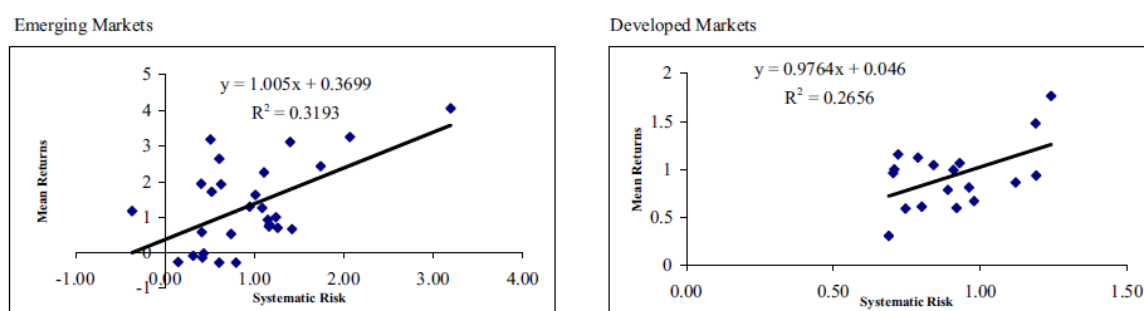
samples of 1970-1987 and 1987-2003, it was found that in the earlier sample period, only Hong Kong was partially segmented, whereas for the later sub-period, all the countries analysed were fully integrated (Arouri, 2006: 92). This therefore provides some evidence which shows that the degree of integration of emerging markets has increased over time.

### **3.4.3. Studies of the South African market**

#### **3.4.3.1. Harvey (2000)**

The first study which involved South Africa was conducted by Harvey (2000), in which he analysed 47 different markets (both developed and emerging) in order to determine which risk factors are most important in pricing expected returns. The total sample consisted of 18 developed countries, and 27 emerging markets, and it spanned from 1988 to 1999. He applied a bivariate analysis method similar to that of Black, Jensen and Scholes (1972), where the regression equation for the single-factor ICAPM model being investigated is represented as equation 3.1 (in section 3.2.1). When investigating the output of his analysis, Harvey (2000: 4) found the single-factor ICAPM model to be priced for both the emerging as well as developed markets in the sample. The resultant risk-return relationships for both the developed and emerging markets can be seen in figure 3-3:

**Figure 3-3. The resultant risk-return relationships from the single-factor ICAPM model**



(Source: Harvey, 2000: 8)

From the above figure, it can be seen that the average  $R^2$  value for emerging markets is 32%, and only 27% for developed countries, which is surprising, as one would expect the developed markets to exhibit a higher  $R^2$  value due to their levels of international integration. Since the results of this study show that the world market risk premium explains returns better in emerging markets than in developed markets, it could be concluded that the single-factor ICAPM model would be appropriate for use in the South African market.

### **3.4.3.2. Bansal and Dahlquist (2002)**

Bansal and Dahlquist (2002: 1) test the single-factor ICAPM model by using the GMM method for 46 different economies, both developed and emerging, over the period of 1984 – 2000. Their test accounts for sample selectivity bias<sup>38</sup>, and the test equation is presented as follows:

$$E(r_{it+1}) = \lambda_W \beta_{iW} + \lambda_{Wz} \beta_{iWz} + \gamma_i h_i \quad (3.32)$$

where:  $z_t$  = a known variable at time t that captures time variation in the market beta; and

$h_i$  = the inverse Mills ratio, or the hazard rate.

Upon analysing the data used, they found that whilst the average returns of developed and emerging markets were very similar, as the developed countries in the sample had an average return of 1.32%, whilst emerging markets had a return of 1.34%, the average standard deviation (and therefore volatility) of the emerging markets were twice as large as those for the developed markets. The correlation with the world market index was also found to be higher for developed countries than with emerging markets, which lends support to the view that emerging markets are partially segmented.

In the sample however, South Africa had a correlation of 0.53 with the MSCI world index, which was much higher than the average correlations of the emerging markets, which was found to be 0.29. Additionally, this correlation was higher than that of Austria (0.34), Australia (0.52), Italy (0.51), and New Zealand (0.47), all of which are considered to be developed economies. Whilst not noted by the authors, this may lead one to believe that South Africa is in fact integrated into the international economy. However, in contrast to the preceding studies, they find that the ICAPM model fails for both developed as well as emerging markets as the cross-sectional  $R^2$  value obtained for the static model is close to zero. When time-varying betas were allowed, this did not result in much change as the  $R^2$  value was still very low at 8%. Therefore, whilst their study provides some evidence that South Africa is integrated into the global economy; a rejection of the ICAPM model in any context was also found.

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<sup>38</sup> This arises when, under certain circumstances, a subset of data is excluded from a sample due to a particular attribute, which therefore produces distorted results. Heckman (1979) developed the “inverse Mills ratio” in order to correct for this bias.

#### **3.4.3.4. You (2006)**

A recent study which was conducted using the unconditional approach that is used in this study is that of You (2006). She used the Fama-Macbeth (1973) method outlined in section 3.2, in order to investigate weekly returns for 704 multi-listed companies from 59 different countries (including South Africa) in the world over the period of 1998 – 2005. The cross-sectional regression whose outputs would be interpreted therefore takes the form of equation 3.3 which was outlined previously:

$$E(R_p) - R_f = \alpha_0 + \alpha_1\beta_p + \varepsilon \quad (3.3)$$

When evaluating the DCAPM model, You (2006: 44) found that most of the  $\alpha_0$  values produced were positive and significant. Furthermore, the  $\alpha_1$  values were found to be statistically insignificant. This result goes against the theoretical foundations of the model which state that the  $\alpha_0$  should be statistically equal to zero, whilst the  $\alpha_1$  should be found to be statistically significant. When a similar analysis was conducted on the single-factor ICAPM model, it was found that half of the  $\alpha_0$  were statistically insignificant, whilst all of the  $\alpha_1$  values produced were statistically significant. Furthermore, the  $R^2$  values produced by the ICAPM model were consistently higher than those produced by the DCAPM. This study therefore provides support for the use of the single-factor ICAPM model.

#### **3.4.3.5. Bruner, Li, Kritzman, Myrgren and Page (2008)**

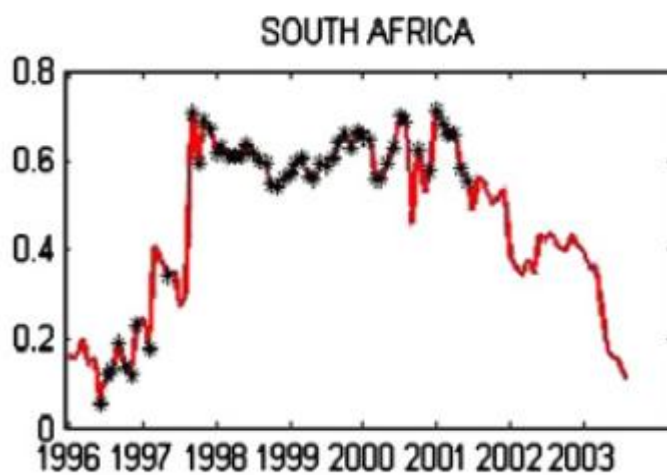
Whilst all four of the preceding studies used either conditional or unconditional approaches to testing the International CAPM models, Bruner, Li, Kritzman, Myrgren and Page (2008) conduct their study using the cost of capital approach. They try to establish which of the DCAPM or single-factor ICAPM models are superior by analysing 14 371 stocks from 48 different developed and emerging markets, over the period of 1994 – 2004. The first methodology utilised was that of cross-sectional regression analysis (similar to that of You (2006) discussed previously), in which they found that, for 99.5% of securities trading in emerging markets, the DCAPM model yielded a higher  $R^2$  value than the ICAPM. Similarly, the same result held true for developed markets as 79.8% of the sample supported the DCAPM over the ICAPM.

Their next method of analysis was to calculate the cost of capital with each model and document the differences in each, if there were any. It was found that on average, there was a 5.6% difference in the cost of capital produced for emerging markets, whereas for developed markets this value stood at 3.6%. South Africa however, produced a significantly lower difference in estimates, as its value of

1.3% was comparable to developed markets such as the UK (1.1%), Italy (1.23%), and Belgium (1.37%). In addition, this value was lower than those produced by many other developing markets, such as the US (3.3%), Japan (5.27%), and Australia (3.67%) (Bruner *et al*, 2008: 94).

When the level of integration was derived for each country, the graph displayed in figure 3-4 was produced for South Africa:

**Figure 3-4. South Africa's level of integration with the global economy over time**



(Source: Bruner *et al*, 2008: 99)

The preceding figure was obtained by regressing the domestic beta values obtained against the global beta values. This process was conducted over the first 36 months of the sample, after which the estimation period was rolled a month forward. The outputs were then graphed, as shown in figure 3-4. From the graph, it can be seen that whilst the level of integration in South Africa experienced an increasing trend over 1996 – 2001, thereafter the level of integration drastically reduced. This result is consistent with those produced for the other emerging markets in the sample, whilst the developed markets produced consistent increases in integration over time. Whilst there was no explanation for this observation provided in the study, a possible reason for the sudden decrease in integration could be due to the consequences of the technology bubble burst which occurred in 2000. Since emerging markets are considered riskier, this may have resulted in decreased flows and operations with these countries, with the result that these countries became less integrated with the global economy.

The final analysis conducted by Bruner *et al* (2008: 102) involved estimating a two-factor ICAPM model which included both the global market index, as well as the domestic index for each country. They found that this model yields a better fit for 99% of the emerging market securities, and 64% of the developed market securities. This study as a whole may therefore show that there is a degree of segmentation present in emerging markets like South Africa, which would best be captured by utilising a two-factor ICAPM model as illustrated above.

#### **3.4.3.6. Korkmaz, Cevic and Gurkan (2010)**

The final and most recent study which will be reviewed in this section is that of Korkmaz, Cevic and Gurkan (2010: 37). They utilised a Markov Switching model (MS) in order to evaluate the ICAPM model in 25 emerging markets from January 1995 to April 2009. The MS model was chosen as it is expected that beta coefficients in emerging markets may be “regime-switching due to the volatility” (Korkmaz *et al*, 2010: 38). Their analysis compares the results of a conditional ICAPM model against the MS model. The conditional ICAPM model is represented in their study as follows:

$$r_{it} = \alpha_i + \beta_i r_{wt} + \varepsilon_{it} \quad (3.33)$$

Similarly, the MS ICAPM takes the form:

$$r_{it} = \alpha_{s_t} + \beta_{s_t} r_{wt} + \varepsilon_{it} \quad \varepsilon_{it} \sim iid N(0, \sigma_{s_t}^2) \quad (3.34)$$

In the preceding equation,  $s_t$  refers to an unobserved state variable, which changed according to the first-order Markov-switching process which is outlined in Hamilton (1994). Therefore:

$$\begin{aligned} P[s_t = 1 | s_{t-1} = 1] &= p \\ P[s_t = 0 | s_{t-1} = 1] &= 1 - p \\ P[s_t = 0 | s_{t-1} = 0] &= q \\ P[s_t = 1 | s_{t-1} = 0] &= 1 - q \\ 0 < p < 1 \quad 0 < q < 1 \end{aligned} \quad (3.35)$$

where:  $p$  = the fixed transition probability of being in a low volatility regime; and

$q$  = the fixed transition probability of being in a high volatility regime.

In equation 3.34, the variable  $\sigma_{st}^2$  is assumed to change according to the different regimes. Maximum likelihood estimation was applied to the MS ICAPM in order to yield the coefficients required.

When the conditional model was applied to South Africa's dataset, the model did not hold, as both the alpha and beta coefficients were found to be statistically insignificant. Similarly, the MS ICAPM under both low and high volatility conditions was found to be deficient, as the alphas were statistically significant, whilst the betas were not. This therefore implies that there is no relation between South Africa's market index and the global index (Korkmaz *et al*, 2010: 43). However, an interesting result of the study is that it shows the correlation coefficient of South Africa with the world index to be 0.67, which is the highest correlation in the sample and implies that South Africa is the most integrated of the countries studied.

The preceding five studies which included South Africa in their analyses show that, as with the developed and emerging markets, the results are varying. However, of these five studies, three found support for the use of the ICAPM model in the South African economy, whilst the remaining two found no significant relationship between South African asset returns and the global market index. Furthermore, none of these studies investigated the presence of exchange rate risk in South Africa. Whilst there have been no studies which directly investigate the ICAPM<sup>EX</sup> model for the South African environment, there are a few which investigate the significance of exchange rate exposure on South African asset returns. These studies will now be reviewed.

#### **3.4.3.7. Barr and Kantor (2005)**

In 2005, Barr and Kantor investigated the returns of all the companies listed on the JSE Top 40 over the period of 2000 - 2003 in order to determine the relationship between the asset returns and the Rand/Dollar (R/\$) exchange rate. The companies tested were sub-divided into the following three different categories (Barr and Kantor, 2005: 6) for easier interpretation:

- Rand Plays – these are companies who incur all their costs and generate all their revenue in South Africa in Rands eg. Pick 'n Pay, Absa.
- Rand Hedge – companies which are listed on the JSE but are almost completely foreign based. Eg. Liberty International, Richemont.

- Rand Leverage – Companies which are based in South Africa, and incur their costs in South Africa, but which sell their products in a foreign currency, eg. Harmony.

This analysis therefore involved a time series regression of the asset's returns against the exchange rate factor (S) and the returns on the JSE ALSI Top 40 index (which is a proxy for the return on the market (Barr and Kantor, 2005: 7):

$$R_{ALSI} = \alpha + \beta_1 S + \beta_2 R_{ALSI\ Top\ 40}$$

When evaluating the results produced, it was found that 16 out of the 22 rand play stocks exhibited statistically significant foreign exchange exposure, whilst 4 of the 14 rand hedge stocks, and all of the 4 rand leverage stocks had statistically significant exposures (Barr and Kantor, 2005: 9).

It can therefore be seen that of the total sample used, 60% of the firms in the sample had significant currency exposures. However since this 60% proportion was obtained in a small sample, it cannot conclusively be stated that exchange rate risk factors should be accounted for in asset pricing models. However, this does indicate that there may be merit in investigating the issue further in order to provide some conclusive information to investors in South Africa. This study will therefore seek to solve this issue.

#### **3.4.3.8. Barr, Kantor and Holdsworth (2007)**

The preceding study was extended by Barr, Kantor and Holdsworth (2007) to utilise the GARCH method of analysis to the same sample of ALSI Top 40 companies, over the period of 1999 - 2005. Whilst the sub-categorisation procedure of the stocks used by Barr and Kantor (2005) was continued here, they included an additional sub-category of "Mixed" which refers to South African companies which have, over the years, established significant proportions of their assets offshore, eg. SAB Miller, Anglo-American.

The first analysis conducted by Barr *et al* (2007: 49) involved regressing each specific asset's returns against the JSE ALSI index (which is the market index), as well as an exchange rate risk factor proxied by the Rand/Dollar (R/\$) exchange rate. The second equation involved regressing the asset returns against the R/\$ exchange rate as well as the MSCI world index and an Emerging-Market-Index (EMI). A general form of the test equation utilised is therefore:



$$R_i = \alpha + \beta_1 S + \beta_2 R_{m1} + \beta_3 R_{m2} + \varepsilon_i \quad (3.36)$$

However, it was found that the  $R^2$  values obtained from the first equation with the JSE ALSI as the market index was consistently better than those from the second equation, in which case use of the second equation was discontinued. Since financial markets are generally characterised by the volatility clustering phenomenon, the authors recognise that a GARCH model would be appropriate to model the data. However, as noted in Barr *et al* (2007: 49), volatility persistence is more prevalent in high frequency data (eg. daily data), rather than the monthly returns which they utilised. Therefore, they consider it sufficient to adjust the error term ( $\varepsilon_i$ ) by utilising a GARCH (1,1) term. This model takes the following form:

$$\sigma_{it}^2 = \omega_{i0} + \omega_{i1}\varepsilon_{i,t-1}^2 + \omega_{i2}\sigma_{i,t-1}^2 \quad (3.37)$$

where:  $\sigma_{it}^2$  = the variance of the residual for share  $i$ , at time  $t$ .

In the above equation, the error term ( $\varepsilon_{it}$ ) is assumed to have zero expectations, and to be homoscedastic and independent over time.

Their results found that over an initial estimation period of February 1999 – January 2002, only 5 of the 40 companies displayed a statistically significant currency exposure coefficient. However, in the later estimation period of February 2002 – August 2005, this proportion increased to 19 out of the 40 companies in the sample. Furthermore, the resultant  $R^2$  values for the regression equation were consistently higher over the later period of 2002 – 2005, than the earlier period (Barr *et al*, 2007: 51). It could therefore be concluded that the exchange rate factors are time-varying and exhibit an increasing influence on South African asset returns.

#### **3.4.3.9. Doidge, Griffin and Williamson (2006)**

In their 2006 study, Doidge, Griffin and Williamson investigated the individual returns for different firms from 18 developing, and 29 emerging markets over the period of 1975-1999<sup>39</sup>. Their analysis made use of time-series regressions of two equations, the first of which included only the domestic market index, whilst the second contained both the domestic market index, as well as the exchange

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<sup>39</sup> The full sample period was not available for most of the emerging markets, in which case, whichever data which was available was used (Doidge *et al*, 2006: 555).

rate risk factor (a trade-weighted exchange rate index-  $R_{FX}$ ). These equations are represented by equations 3.38 and 3.39:

$$R_i = \alpha_i + \beta_i R_m + \eta_i \quad (3.38)$$

$$R_i = \alpha_i + \beta_i R_m + \beta_i R_{FX} + \eta_i \quad (3.39)$$

After these two regressions were estimated, the resulting  $R^2$  value of the first equation was subtracted from the corresponding value of the second equation. This method therefore allows one to see the increase/decrease in explanatory power of the asset returns added by the exchange rate risk factor (Doidge *et al*, 2006: 557).

An analysis of the results produced showed that on average, the inclusion of the exchange rate factor added 2.1% to the explanatory power of the models, whereas for the emerging markets this value increased to 6.3%. For South Africa in particular, it was found that the inclusion of the currency factor increased explanatory power of the model by 2.9% (Doidge *et al*, 2006: 558). This result therefore serves to reinforce those produced by the Barr and Kantor (2005) study. From all of the aforementioned articles reviewed, it can therefore be seen that there is significant scope for further analysis of this subject, which is an area that this investigation covers.

### 3.5. Summary

This purpose of this chapter was to provide a review of some of the studies surrounding the ICAPM and ICAPM<sup>EX</sup> models in order to form expectations for this study. This evidence is summarised as follows in Table 3.1 below:

**Table 3-1. Summary of the studies reviewed in this chapter**

Studies denoted by a “\*” are representative of studies surrounding emerging markets, whereas “\*\*” represents studies conducted in the South African environment.

Researcher(s)	Methodology used	Result
<b>Tests of ICAPM</b>		
Harvey (1991)	<i>Conditional</i> , GMM	Supportive of ICAPM
** Harvey (2000)	<i>Unconditional</i> , Black, Jensen and Scholes (1972) method	Supportive of ICAPM
** Bansal and Dahlquist (2002)	<i>Conditional</i> , GMM	Supportive of ICAPM
* Korkmaz (2010)	<i>Conditional</i> , Markov Switching (MS) model	No support for ICAPM found
<b>Tests of DCAPM vs ICAPM</b>		
Stehle (1977)	<i>Unconditional</i> , FM (1973) two-pass regression, implemented with GLS	Weak support of ICAPM
Jorion and Schwartz (1986)	<i>Unconditional</i> , FM (1973) two-pass regression, implemented using ML	DCAPM superior
Mittoo (1992)	<i>Unconditional</i> , FM (1973) two-pass regression, implemented using ML	ICAPM superior for International assets, DCAPM for domestic stocks
Chan, Karolyi and Stultz (1992)	<i>Conditional</i> , GARCH-M	ICAPM superior

<b>Researcher(s)</b>	<b>Methodology used</b>	<b>Result</b>
Stultz (1995)	<i>Cost of Equity approach</i>	ICAPM superior
DeSantis and Gerard (1997)	<i>Conditional, GARCH-M</i>	ICAPM superior
McKenzie, Brooks and Faff (2000)	<i>Conditional, Kalman Filter Approach</i>	DCAPM superior
Harris, Marston, Mishra and O'Brein (2003)	<i>Cost of Equity approach</i>	DCAPM superior
* Mishra and O'Brein (2005)	<i>Cost of Equity approach</i>	ICAPM superior
** You (2006)	<i>Unconditional FM (1973) two-pass regression</i>	ICAPM superior
* Arouri (2006)	<i>Conditional, GARCH-M</i>	ICAPM superior
** Bruner, Li, Kritzman, Myrgren and Page (2008)	<i>Cost of Equity approach</i>	DCAPM superior
Dolde, Giacotto, Mishra and O'Brein (2010a)	<i>Cost of Equity approach</i>	DCAPM superior
<b>Tests of Exchange Rate Exposure</b>		
Jorion (1990)	<i>Unconditional Cross-sectional regression using GLS</i>	Exchange rate exposure significant
Jorion (1991)	<i>Unconditional Cross-sectional regression using ML estimation</i>	Exchange rate exposure not significant
** Barr and Kantor (2005)	<i>Unconditional Time-series regression using OLS</i>	Exchange rate exposure statistically significant for a majority of the sample
** Doidge, Griffin and Williamson (2006)	<i>Unconditional Time-series regression using OLS</i>	Exchange rate exposure marginally increases explanatory power of model
** Barr, Kantor and Holdsworth (2007)	<i>Unconditional Time-series regression using OLS</i>	Exchange rate exposure increases over time

Researcher(s)	Methodology used	Result
<b>Tests of DCAPM vs ICAPM<sup>EX</sup></b>		
Dumas and Solnik (1995)	<i>Unconditional and Conditional, GMM</i>	<i>Unconditional – DCAPM superior</i> <i>Conditional – ICAPM<sup>EX</sup> superior</i>
DeSantis and Gerard (1998)	<i>Conditional, GARCH-M</i>	ICAPM <sup>EX</sup> superior
Koedijk, Kool, Schotman and Van Dijk (2002)	<i>Cost of equity approach</i>	DCAPM superior
Wu (2002)	<i>Unconditional FM (1973) two-pass regression</i>	ICAPM <sup>EX</sup> superior
Wu (2008)	<i>Unconditional FM (1973) two-pass regression</i>	ICAPM <sup>EX</sup> superior
<b>Tests of ICAPM vs ICAPM<sup>EX</sup></b>		
Solnik (1977)	<i>Unconditional Theory-based Portfolio efficiency test</i>	ICAPM better
* Harvey (1995a)	<i>Conditional GMM</i>	DCAPM superior
<b>Tests of DCAPM vs ICAPM vs ICAPM<sup>EX</sup></b>		
* Mishra and O’Brein (2001)	<i>Cost of equity approach</i>	DCAPM superior
Koedijk and Van Dijk (2004)	<i>Cost of equity approach</i>	DCAPM superior
Dolde, Giacotto, Mishra and O’Brein (2010b)	<i>Cost of equity approach</i>	DCAPM superior

The above table shows that there is no consensus and definite answer when evaluating the question of which of the DCAPM, ICAPM or ICAPM<sup>EX</sup> models are appropriate for use, and in which context. This is because, some studies are in favour of the ICAPM and ICAPM<sup>EX</sup> models, whilst others infer that the DCAPM model is sufficient. Whilst there is not much evidence provided on South Africa, the studies displayed in the preceding sections also provide mixed evidence on the subject. In addition, there is a lack of studies of the South African market which investigate the ICAPM<sup>EX</sup> model. This therefore provides a basis for further analysis, which will be covered in the next chapters.

## CHAPTER 4 : METHODOLOGY

### **4.1. Overview**

The objective of this thesis, as mentioned earlier, is to determine whether the sources of risk applicable to investors in South Africa are of a local or international nature. This therefore involves investigating the ICAPM models in order to determine if they hold in the South African context, as well as which of the three models (DCAPM, ICAPM, ICAPM<sup>EX</sup>) is superior. Whilst the preceding section outlined the theoretical foundations of each of these three models, as well as some of the empirical evidence surrounding the topic, this section develops the empirical analysis which were utilised in this study, and therefore outlines each of the above-mentioned models in detail, together with the needed inputs for each model. In particular, all employed methods were utilised to provide answers to the following questions:

- Is the world market index a priced risk factor for JSE-listed companies?
- Is exchange rate risk priced for JSE-listed companies or not?
- Which model has greater explanatory and forecasting power for JSE-listed firms: the domestic CAPM model, the single-factor ICAPM model, or the multifactor ICAPM with exchange rates model?

Since the empirical evidence outlined in the previous chapters showed that past tests of the subject matter are subdivided into three categories, viz. unconditional, conditional and cost of equity approaches, this study made use of all three analytical methods in order to provide a robust analysis of the topic. This also serves to highlight any differences that are applicable to each of these approaches, and the associated effect on the results produced. This chapter therefore contains a discussion of each of these three analytical approaches, and outlines how each was developed for use within this study.

### **4.2. Unconditional vs Conditional Approach**

There are two different approaches which can be used when empirically investigating the CAPM models discussed previously. These two approaches were introduced in the review of empirical studies found in Chapter 3, and are known as the Unconditional and Conditional Approaches to asset testing. The fundamental difference between these two approaches lies in the identification of the information which investors use in order to form their future expectations. Whilst under unconditional approaches, investors determine returns based on an unconditional assessment of the joint probability

of expected returns; conditional approaches imply that investors' have time-varying expectations of the joint distribution of returns, which are dependent on the information available at that time (Harvey and Kirby, 1996: 36).

Based on this definition, in developing a conditional test of the CAPM model, a requirement is to identify the "right" information variables upon which investors will form their assumptions (Lewellyn and Nagel, 2003: 2). This issue is addressed by Cochrane (2001: 139) as follows: "Models such as the CAPM imply a conditional linear factor model with respect to *investors'* information sets. The best we can hope to do is test implications conditioned on variables that we observe. Thus a conditional factor model is *not testable!*" When investigating the subject, Lewellyn and Nagel (2003: 49) found that the conditional CAPM model does not capture the variation in returns better than the unconditional CAPM. This result was echoed in Kan, Robotti and Shanken's (2008) study of the subject.

Despite this criticism of the conditional CAPM model, there have been many studies which made use of methods such as Maximum Likelihood, GMM and GARCH in order to model the conditional CAPM. Alternatively, a large number of studies have made use of unconditional approaches, with the most popular method being the Fama-Macbeth (1973) two-pass regression method. In determining the best approach to be used in this study, it is therefore necessary to analyse the options available with respect to their relative advantages and disadvantages.

Harvey and Zhou (1993) compared the very popular unconditional approach of Fama-Macbeth (FM), to the conditional approach of GMM in order to determine which is superior. As mentioned before, the FM approach makes use of a two-step procedure: the first pass involves estimating time-series regressions in order to obtain beta estimates, after which the obtained betas are used in a cross-sectional regression known as the second pass of the model. This use of estimated instead of observed parameters in the second pass leads to the problem of errors-in-variables (which will be discussed in more detail later). The GMM approach however, eliminates this problem by allowing for the estimation of all parameters in a single step (Skoulakis, 2005: 2).

When evaluating the two however, it was found that that there are very few differences in the results obtained with each method (Harvey and Zhou, 1993: 128). Ferson and Foerster (1994) also found that

the use of GMM leads to asset pricing models with abnormal properties. When Skoulakis (2005) investigated these two approaches, he found that when both models were tested under optimal conditions, the efficiency of the parameters obtained using OLS to estimate the FM method was equivalent to those obtained by the GMM method (Skoulakis, 2005: 33), which reinforces the aforementioned results and implies that neither model displays superiority over the other.

McKinlay and Richardson (1991), as well as Shanken (1992) both evaluated the differences between the FM method, GMM, as well as Maximum Likelihood. Both these studies found that the results of the FM method are equivalent to those obtained from ML and GMM when returns are independent and identically distributed (iid). A similar study was conducted by Shanken and Zhou (2007) where they also compared the FM method to ML and GMM. In addition, they estimated the FM method by making use of OLS, Weighted Least Squares (WLS) as well as Generalised Least Squares (GLS) in order to determine which of the three methods is optimal for use. They found that whilst the GLS estimators produced were more precise than those from the OLS regressions, they also displayed more bias. Furthermore, whilst ML performed the best amongst all the alternatives tested, it was found that the inferences produced were less reliable than those from the OLS procedure (Shanken and Zhou, 2007: 40). It could therefore be deduced that the FM method (estimated with OLS) would be sufficient for the testing of asset pricing models.

The preceding results show that in addition to the popularity of the FM method in empirical testing<sup>40</sup>, and the inherent simplicity of this methodology, the results from this method can also be found to be comparable to those found from more sophisticated techniques. It is therefore for these reasons that this approach was included as one of the methods to be utilised in this study. However, despite this, there are still a large number of recent studies which have chosen to utilise a conditional approach to asset pricing. Therefore this study makes use of the GARCH model as well, which will serve to increase the robustness in the results, as well as highlight any differences in the two approaches. The final method of testing the CAPM models will be the cost of equity approach which was also introduced in chapter 2. These three different methods will therefore be discussed in more detail later.

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<sup>40</sup> When researched by Shanken and Zhou in 2007 (41), it was found that applications of this method can be found in at least 1357 papers on Google which cite Fama and Macbeth (1973). At the present date, the number of citations was found to have increased exponentially to a value of 6051.



### **4.3. Models being tested**

#### **4.3.1. Domestic CAPM (DCAPM)**

In order to provide the answers to the research questions already posed, there were three different models which were estimated in this study. The first of these models is the domestic CAPM, or DCAPM, which takes the form:

$$E(R_i) = R_f + \beta_i(R_m - R_f) \quad (1.1)$$

In order for the preceding model to be estimated, there are two variables for which proxies are necessary. These two proxies are the risk-free rate, and the market index.

The risk-free rate of return ( $R_f$ ) refers to the rate of return on an asset with no risk (which implies that this asset will have neither a covariance nor variance with the return on the market) (Laubsher, 2002: 134). However, in reality, an asset of this sort is hard to find, with the result that various different proxies are used instead, such as Government bonds, Treasury Bills, Negotiable Certificates of Deposit (NCDs), or Bankers Acceptances (BAs) are used (Charteris, 2010: 7). Whilst there is no consensus on the appropriate risk-free proxy which should be used in South Africa, the proxy which was chosen for use in this study is 90 day treasury-bill rate which has been commonly used in empirical studies such as Affleck-Graves *et al* (1988), Page and Palmer (1991), Friis and Smit (2004), Samouilhan (2007). According to Grandes and Pinaud (2004 in Hearn and Piesse, 2009: 6), the use of this proxy for the risk-free rate is not optimal in South Africa due to the high and unpredictable risk premiums associated with it. However, as noted in Hearn and Piesse (2009: 49), the South African economy is subject to extremely volatile inflation levels and therefore this rate is the most stable one which is available.

The other issue involved in the implementation of the DCAPM model is that of the market portfolio. “In theory market capitalization weighted indices are preferred to equally weighted indices because they are superior proxies to the true market portfolio.” (Bradfield, 2003: 47). Therefore, it would be assumed that the JSE All Share Index (ALSI) should be used as the market proxy. However, there is a dimension to this debate in South Africa which is not prevalent elsewhere in the world. This is because some researchers in South Africa are of the opinion that segmentation exists between the resources index and the financial and industrial index on the JSE (Bradfield, 2003: 47). This is due to the share composition of the JSE, which comprises the broad categories of mining, financial and industrial.

However, research has shown that resources make up over 40% of the total market capitalization of the JSE (Correia and Cramer, 2008: 44). Therefore, according to Correia and Uliana (2004: 67), the parameter estimates which are obtained from the whole market may be biased and thus unreliable.

The debate surrounding this issue has yet to reach a consensus. Whilst Ward (1994) found that the ALSI is the most appropriate market proxy for South Africa, Bowie and Bradfield (1993), Van Rensburg and Slaney (1997) and Van Rensburg (2002) all advocate the use of the Financial and Industrial index as the proxy. However, the Correia and Cramer (2008: 45) study of company trends in South Africa found that only 23% of companies in SA use the Financial and Industrial (FINDI) index, whereas a vast majority of 77% utilizes the ALSI. Therefore, this study will make use of the ALSI as a proxy for the market index.

#### **4.3.2. International CAPM (ICAPM)**

The second model which was estimated is that of the single-factor ICAPM model, which can be represented mathematically as:

$$E(R_i) = R_f + \beta_{iw}(R_w - R_f) \quad (2.16)$$

Whereas the DCAPM made use of a domestic market index, this form of the CAPM makes use of a world market index. For the purposes of this study, the MSCI world index was utilized as a proxy for the global market. This is in accordance with studies conducted by Harvey (1991), and Harvey and Zhou (1993) in which they found that the MSCI world index is mean-variance efficient, and is therefore appropriate for use in the CAPM model. Therefore, since this index satisfies the necessary conditions for a market portfolio as stated by Roll (1977: 135) its use was considered appropriate for this study.

A possible problem faced in South Africa however, is that the MSCI World Index is made up of entirely developed countries<sup>41</sup>, which thus implies that it may not be able to sufficiently capture the risks present in an emerging market such as South Africa. However, since this index has been used by many other studies such as Harvey (1995a), Mishra and O'Brein (2001) and Arouri (2006) in the

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<sup>41</sup> The MSCI world index is made up of the following 23 countries: Austria, Australia, Belgium, Canada, Switzerland, Germany, Denmark, Spain, Finland, France, the UK, Greece, Hong Kong, Ireland, Italy, Japan, Netherlands, Norway, New Zealand, Portugal, Sweden, Singapore, and the US.

context of emerging markets, its use as a proxy in this study was retained. However, the MSCI All Country World Index <sup>42</sup>(ACWI) was chosen as a secondary world market proxy as this market portfolio is considered to be more appropriate for use in the South African environment. In Marais' (2008: 67) study he looked at the correlations of the JSE Top 40 with five other global indices over two different periods of 1997-1998 and 2006-2007 in order to see which indices the JSE was the most correlated with. Included in his analysis were both the MSCI World Index, as well as the MSCI ACWI. His results are summarized in table 4-1 below:

**Table 4-1. Correlations of the JSE Top 40 index with major world indices for the two samples of 1997-1998 and 2006-2007.**

Index Utilized	Correlation coefficient	
	1997 - 1998	2006 - 2007
MSCI World Index	0.523	0.776
MSCI ACWI	0.543	0.798
MSCI Emerging markets index	0.644	0.745
FTSE 100 (UK)	0.560	0.743
S&P 500 (US)	0.239	0.529

(Source: Marais, 2008: 67-68)

From the preceding table it can be seen that over recent years the correlation of both the MSCI World Index as well as the ACWI with the JSE Top 40 index has increased significantly. The interesting thing to note however is that the correlation of the ACWI exceeds that of the MSCI World Index for both periods, albeit by a small value. This nonetheless provides sufficient evidence that the ACWI may prove to be a more appropriate proxy for the world market portfolio than the MSCI World Index, and is an issue which merits additional analysis. Therefore, the two ICAPM models were estimated twice, the first time with the MSCI World Index as a proxy for the world market portfolio, and the second time with the MSCI ACWI. This was done in order to enhance the robustness of the analysis. It should also be noted that, in both the ICAPM models, the risk-free rate which was utilized is the same as that used for the DCAPM model. This is based on the underlying theory surrounding the models, where according to Solnik's (1974) mutual fund theorem, every investor's desired level of

<sup>42</sup> The MSCI All Country World Index is made up of 24 developed and 21 emerging market indices. The developed markets are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Singapore, Spain, Sweden, Switzerland, the United Kingdom and the United States. The emerging markets included are: Brazil, Chile, China, Colombia, Czech Republic, Egypt, Hungary, India, Indonesia, Korea, Malaysia, Mexico, Morocco, Peru, Philippines, Poland, Russia, South Africa, Taiwan, Thailand, and Turkey(MSCI Barra, n.d).

risk can be achieved by holding two risky mutual funds in his portfolio, as well as a risk-free asset, which will come from the individual's home country<sup>43</sup>.

#### **4.3.3. ICAPM with exchange rates (ICAPM<sup>EX</sup>)**

The third model was investigated in this study is the multifactor ICAPM model (ICAPM<sup>EX</sup>) which takes into account exchange rate risks as well as the world market premium. However, before the mathematical form of model is outlined, the exchange rate factors which were taken into consideration for this study need to be explained.

Since the ICAPM<sup>EX</sup> incorporates both the world market index as a factor as well as exchange rate risk, the decision was made to include the exchange rates which would have the most significant influence on the returns of the shares included in the market index. Since the two world indices used in this study are made up of a large number of companies from different regions, the currencies of the countries/regions which hold the largest proportions in these indices were chosen. Figure 4-1 shows the percentage held by each country in the MSCI world portfolio.

**Figure 4-1. Country Composition of the MSCI World Portfolio**

#### **COUNTRY WEIGHTINGS (AS OF TUESDAY, FEBRUARY 02, 2010 )**

COUNTRY	# COMPANIES	WEIGHT	COUNTRY	# COMPANIES	WEIGHT
Austria	8	0.2%	Hong Kong	41	1.1%
Australia	73	3.8%	Ireland	4	0.1%
Belgium	13	0.5%	Italy	33	1.6%
Canada	99	4.7%	Japan	345	10.3%
Switzerland	37	3.6%	Netherlands	20	1.3%
Germany	50	3.6%	Norway	8	0.4%
Denmark	13	0.4%	New Zealand	5	0.0%
Spain	29	2.0%	Portugal	9	0.1%
Finland	17	0.6%	Sweden	30	1.2%
France	76	5.0%	Singapore	29	0.7%
United Kingdom	104	10.0%	United States	599	48.6%
Greece	12	0.2%			
<b>TOTAL</b>				<b>1654</b>	<b>100.0%</b>

(Source: MSCI Barra, 2010)

<sup>43</sup> This concept was covered in depth in chapter 2 (page 26).

Figure 4-1 shows that the country which occupies the largest proportion of the MSCI World Index is that of the US (48.6%). This is followed by Japan (10.3%) and the UK (10%). It can also be seen from the figure that of the 23 countries included in the index, 11 are from the Eurozone<sup>44</sup>, and collectively, this region constitutes 15.2% of the MSCI World Index. The four afore-mentioned regions therefore occupy the largest proportion in the MSCI World Index, as collectively they account for 84.1% of the portfolio, which implies that each of these regions respective currencies will have a significant influence on the returns of assets priced in a global market. This result is echoed when viewing the composition of the MSCI ACWI as shown in table 4-2 below:

**Table 4-2. Allocation changes in the MSCI all country world index from 2003 to 2011**

	<b>31/12/2003</b>	<b>31/12/2006</b>	<b>31/12/2009</b>	<b>28/02/2011</b>
<b>USA</b>	52.5%	44.7%	41.9%	41.7%
<b>UK</b>	10.5%	10.4%	8.8%	8.3%
<b>Europe</b>	18.3%	19.9%	18.4%	17.3%
<b>Japan</b>	8.6%	9.9%	8.4%	8.7%
<b>Australia</b>	2.0%	2.4%	3.4%	3.5%
<b>Canada</b>	2.5%	3.2%	4.2%	4.6%
<b>Brazil</b>	0.4%	0.9%	2.2%	2.1%
<b>Russia</b>	0.2%	0.9%	0.8%	0.9%
<b>India</b>	0.3%	0.5%	1.0%	1.06%
<b>China</b>	0.4%	1.0%	2.3%	2.3%
<b>Korea</b>	0.8%	1.3%	1.7%	1.6%
<b>Taiwan</b>	0.6%	1.0%	1.5%	1.3%
<b>South Africa</b>	0.6%	0.7%	0.9%	1.05%
<b>Developed</b>	95.5%	91.8%	87.0%	86.0%
<b>Emerging</b>	4.5%	8.2%	13.0%	14.0%

(Source: Edmonds, n.d: 1; iShares, 2010)

Table 4-2 shows that the conclusions drawn from the observation of the MSCI World Index hold here as well. This is because, the four main regional components of the MSCI World Index (US, UK, Japan, Eurozone) are also the four main components of the MSCI ACWI, as shown above. Furthermore, it can be seen that over the years, the emerging markets (in particular South Africa) have displayed increasing weightings in the MSCI ACWI, which indicates that over time the influence of

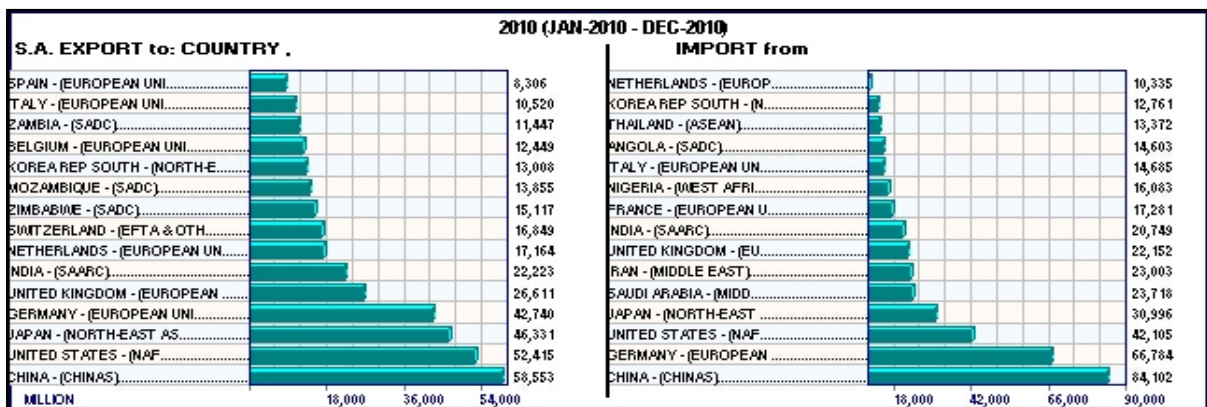
<sup>44</sup> This region is incorporated as a single unit in this study due to their use of a single unified currency, viz. the Euro.

emerging market risks on the global economy has increased, and remains on an increasing trend. This therefore leads to the hypothesis that the risks inherent in the South African environment will be adequately captured by the MSCI ACWI, and this concept will be investigated further in the section on data analysis.

Whilst the preceding analysis shows that the four regions selected have a substantial effect on the risks faced in the global environment, it is also found that specifically within the South African environment, these four regions are some of the main trading partners to the country, which implies that any fluctuations in their exchange rates will affect the country's economic position, and more specifically its asset returns.

From figure 4-2 it can be seen that the countries of the US, UK, Japan and a large number of countries forming a part of the European Union are the main trading partners of SA with regard to both imports and exports. Whilst China is both the largest importer and exporter for 2010, the use of their currency is not included in this study as it is pegged to the US Dollar. The inclusion of this variable is therefore considered to be redundant as the US dollar is already included in the analysis and the inclusion of the Chinese Yuan will therefore introduce multicollinearity into the analysis.

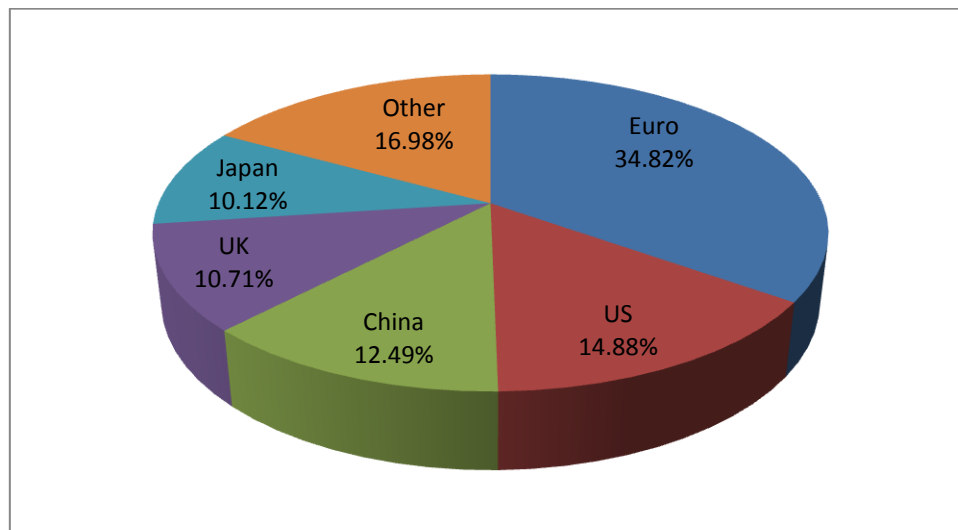
Figure 4-2. South African trading partners



(Source: DTI, 2010)

The effect of these four regions on the South African Rand is shown in the pie chart of the effective exchange rate shown below, which is expressed as a percentage weight of the different currencies:

**Figure 4-3. The % influence of the different currencies on the South African Rand**



(Source: SARB, 2011)

The preceding figure reaffirms the conclusions which have been drawn thus far. The four currencies which are used in this study are therefore the US dollar, British pound, the euro and the Japanese yen, all of which are expressed in terms of the numeraire currency<sup>45</sup>, which in this case is the Rand. The equation for the ICAPM<sup>EX</sup> model is shown as follows:

$$E(R_i) = R_f + \beta_w(R_w - R_f) + \beta_1SRP_{USA} + \beta_2SRP_{Japan} + \beta_3SRP_{Eurozone} + \beta_4SRP_{UK} + \beta_5SRP_{SA} \quad (4.1)$$

It is important to note that the fifth factor ( $\beta_5SRP_{SA}$ ) will equate to zero as it represents the R/R exchange rate.

The method used to calculate the exchange rate exposure factors (SRP) expressed in equation 4.1 differs across the empirical analyses surrounding this topic. In particular, many authors differ about:

- a. Whether bilateral rates should be utilised, or an exchange rate index.<sup>46</sup>

<sup>45</sup> According to the theory upon which the ICAPM models were built, the numeraire currency used should be the currency of the investor's domestic country. In this case, since the study is from the perspective of a South African investor, this currency is the South African Rand.

<sup>46</sup> A bilateral rate refers to the exchange rate between two countries, whereas a currency index is a method of measuring the performance of one currency against a basket of other currencies.

- b. Whether the data obtained should be sampled at a high or low frequency (i.e. daily/ monthly/ quarterly).

When dealing with the issue in a. it was found by Dahlquist and Robertson (2001), Fraser and Pantzalis (2004), as well as Parsley and Popper (2006) that the use of a single trade-weighted index may mask each individual currency effect present in the data. Therefore this study makes use of bilateral exchange rates for each of the four currencies included in the study. However, an additional concern is whether these rates should be spot exchange rates or forward exchange rates (as a proxy for the expected exchange rate). This issue was covered by Jorion (1991: 367), in which he hypothesised that the rate of change of the spot exchange rates would be appropriate if changes in the exchange rate are unanticipated. Since it is assumed that any changes in any of the four exchange rates are indeed unanticipated, his method of using the percentage change in each exchange rate factor was considered to be an easy and effective representation of the SRP variables. His method of utilising changes in the spot exchange rate was utilised by many other studies such as Barr and Kantor (2005), Doidge *et al* (2006), Barr *et al* (2007) and Wu (2008).

The other decision faced when dealing with exchange rate exposure is that of sampling frequency, as shown in point b. Whilst Chamberlain, Howe and Pepper (1997), and Di Iorio and Faff (2000) found that data should be sampled at a high frequency (daily), as their studies showed that this increases the possibility of detecting exposure, other studies such as Chow, Lee and Stolt (1997) and Bodnar and Wong (2003) found that the data should be sampled using a monthly frequency. In particular, these two studies found that the resultant exchange rate exposure coefficients are found to be more statistically significant when using data sampled at monthly intervals (Bodnar and Wong, 2003: 2; Chow, Lee and Stolt, 1997: 156). This study therefore utilised monthly returns, a concept which will be discussed further later on in the chapter.

#### **4.4. Dataset**

##### **4.4.1. Time period of the study**

An important assumption underlying all international asset pricing models is that the domestic market is integrated with the global market. Therefore, in order to determine the period over which the study should be implemented, an integral input is an identification of the time at which South Africa became integrated with the rest of the world.



It is well known that prior to the advent of democracy in 1994, the South African economy was segmented from the rest of the world due to the international sanctions imposed on South Africa, as well as the foreign exchange controls which were introduced by the government. However, as the political climate of the country started changing, so too did the economic one, which subsequently led to the liberalisation of the JSE in March 1995. Whilst many consider this date as being the beginning of our global integration process, there are others who identify different significant dates as possibilities. This is due to the fact that the date of liberalisation could be determined exogenously, by taking the official date on which the policy was decreed; or it could be determined endogenously. The endogenously determined date is the one which is obtained from the reactions of economic agents to political events (Makina and Negash, 2004: 2; Bekaert, Harvey and Lumsdaine, 2001: 297).

A study conducted by Makina and Negash (2004: 7) therefore identified 3 possible milestones which led to the integration of South Africa. These are:

- The unbanning of the African National Congress (ANC) in February 1990.
- The lifting of international economic sanctions in December 1992.
- The liberalisation of the JSE in March 1995.

The following table displays the studies conducted which focus on integration of South Africa, as well as the dates which they identify as being significant.

<b>Researchers</b>	<b>Date Identified</b>
Brooks, Davidson and Faff (1997)	February 1990
Bakaert, Harvey and Lundblad (2001)	December 1992
Fuchs-Schundeln and Funke (2001)	March 1995
Makina and Negash (2004)	February 1990, and December 1992

From the preceding table, it can be seen that the two dates of February 1990 and December 1992 were both selected the most number of times as the starting date of integration. Since the longest data period possible should be used in the testing of asset pricing models in order to produce the most reliable results, the starting date of this study was taken as February 1990, with an ending date of February 2010, in order to allow for twenty one full years of data.

#### **4.4.2. Frequency of data**

The return interval chosen for the asset data used can be of a shorter nature (eg. daily or weekly), or of a longer nature (eg. monthly, quarterly or annually). Whilst the advantage of using shorter frequency data is that more data observations will be available for testing, this could arise in a “thin trading” bias. This occurs because, not all assets are traded every single day, which could thus result in a decrease in the asset’s correlation with the market index, and consequently the estimate of beta obtained. Therefore, in a scenario like this, firms which have sufficient liquidity will display higher betas, whilst the opposite will be true for illiquid firms (Damodaran, n.d: 11). This issue is particularly relevant for emerging markets like South Africa, as noted in Harvey (1995a: 778).

Whilst a possible solution to this problem would be to utilise longer frequency returns, such as quarterly or annually, this would result in a dramatic reduction in the observations available for testing, with only 84 quarterly observations available in the sample period, and 21 available if the data is sampled annually. Therefore the use of monthly data should be sufficient to overcome the thin-trading problem, as well as ensure sufficient data observations for each asset (Damodaran, n.d: 11; Harvey, 1995a: 778).

Another issue faced when determining the sampling frequency of the data is the optimal frequency which would result in detection of exchange rate exposure, a problem which was stated earlier in the discussion. Whilst Chamberlain, Howe and Pepper (1997), and Di Iorio and Faff (2000) found that data should be sampled at a high frequency (daily), as their studies showed that this increases the possibility of detecting exposure, other studies such as Chow, Lee and Stolt (1997) and Bodnar and Wong (2003) found that the data should be sampled using a monthly frequency. In particular, these two studies found that the resultant exchange rate exposure coefficients are found to be more statistically significant when using data sampled at monthly intervals (Bodnar and Wong, 2003: 2; Chow, Lee and Stolt, 1997: 156).

This study therefore chose to utilise monthly returns in order to minimise any incidence of thin trading, as well as increase the possibility of detecting any influence exerted by the presence of exchange rates on the data. In a review of the eight South African studies of the ICAPM models outlined in chapter 2, it was found that, with the exception of You (2006) who used weekly returns, the rest of the studies followed the approach outlined of utilising monthly returns.

#### **4.4.3. Beta estimation period**

An important consideration before estimating any CAPM model is the time period over which the beta parameters should be estimated. The full sample period (in this case twenty one years) is clearly an unrealistic estimation period as this assumes that the conditions and risks faced by firms are constant throughout the sample period. Empirically, when estimating betas, there is a trade-off between more accurate beta estimates by increasing the estimation period, and misestimating the betas due to a drift in beta over time (Wu, 2008: 178).

Therefore, empirically, either 36 months (3 years) or 60 months (5 years) is used as the norm for beta estimation. This study chooses to utilize an estimation period of 60 months, in a similar vein to the studies of Fama-Macbeth (1973), Wu (2002), Wu (2008) and Bartram and Bodnar (2006). Furthermore, studies such as Gonedes (1973), and Kim (1993) found that betas generally tend to be more stable over five year periods. This time period therefore provides a satisfactory trade-off between ensuring beta stability, and ensuring a large enough sample size to provide reliable results.

#### **4.4.4. Assets included in the study**

There are a number of different assets which can be used when empirically testing the ICAPM models, such as equities which are either in the form of a national index, or individual stocks, fixed income securities, currency futures or even forward contracts (Karolyi and Stultz, 2002: 25). Since the purpose of this study is to provide some guidance to firms about which model would be best to compute the cost of equity estimate, the data utilised should be in the form of equity returns. Whilst many previous studies of the ICAPM models which focused on equities, such as Harvey (1991), Bekaert and Harvey (1995) and DeSantis and Gerard (1997) utilised national indices, it was stated by Zhang (2006: 276) that a national index cannot cover the entire investment opportunity set within a specific country. Therefore, since investors have direct access to all the individual securities available, it would be more relevant to utilise individual assets in a test of the ICAPM model. The route chosen in this study was therefore to make use of monthly returns on individual assets, reminiscent of the tests conducted by Mittoo (1992), Harris, Marston, Mishra and O'Brein (2003), Jorion (1990) and Koedijk, Kool, Schotman and van Dijk (2002).

In order to ensure that the results are robust, the largest possible number of firms should be chosen, as shown in the tests reviewed such as Mishra and O Brein (2001), Koedijk *et al* (2002), Koedijk and Van Dijk (2004) and Bruner *et al* (2008), with the number of assets being tested in these studies

ranging from 2989 to 14371. Whilst these studies investigated the ICAPM in many markets, this study focuses on South Africa only, which means that a smaller amount of assets will be available. Furthermore, the South African market is much smaller than, for example, the US market, which means that at any given time there is never more than a thousand stocks listed on the JSE. Therefore the decision was taken to utilise the returns of all the assets listed on the JSE in order to provide the largest sample possible.

The study therefore made use of the monthly returns on every single asset which was listed on the main board of the JSE from February 1990, up till February 2010, which had at least 60 consecutive months of data, in order to allow for beta estimation as outlined in section 4.4.3. Shares which are listed on the Development Capital and Venture Capital Boards, as well as the AltX<sup>47</sup> were not included in this analysis as these shares are considered to be illiquid and show signs of substantial unsystematic risk which may distort the results obtained (Mutooni and Muller, 2007: 17).

#### **4.4.5. Survivorship bias**

Survivorship bias is a phenomenon whereby companies which were delisted are excluded from empirical studies, thus resulting in an investigation that only involves companies which were strong enough to survive the period of analysis. This phenomenon results in skewed results (Pawley, 2006: 21). A common remedy for this problem is therefore to include the returns of delisted firms in the study as well. However, the evidence on whether this survivorship bias should be accounted for in empirical study is varying, with some conclusions suggesting that it is a relevant force which should be accounted for, whilst others suggest the opposite.

When investigated in the international environment, studies such as Brown, Goetzmann Ibbotson and Ross (1992), Kothari, Shanken and Sloan (1995) and Brown and Goetzmann (1994), all found that not accounting for this bias impacts on the results produced. Davis (1996) evaluated the difference in results produced from a sample which accounts for survivorship bias, and a sample which does not. He found that whilst the ultimate conclusions produced from the analyses do not differ, the inclusion of delisted firms did produce statistically significant differences in the regression results. Elfakhani and Wei (2003) also performed an analysis of survivorship bias by using two different samples: one with delisted shares, and one which excludes delisted shares. Their results found that the differences

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<sup>47</sup> The AltX was introduced by the JSE in 2003 as a vehicle for small and medium sized enterprises to raise capital in the open market. This exchange served as a replacement for the failed venture capital and development boards which were previously available.

produced in mean returns between the two samples was only statistically significant at an 11% level of significance (Elfakhani and Wei, 2003:400). Bundoo (2006) concurred with the preceding study, as he also that the effect of survivorship bias on the results is overemphasised.

When investigated within a South African context, Pawley's (2006: 25) study of unit trust performance found that the sample which included only survivors exceeded the one with delisted firms by an annualised figure of 1.05%. A later study conducted by Gilbert and Strugnell (2010: 41), also found that the presence of delisted shares in a sample has a significant effect on the results produced, with the authors reaching the conclusion that any empirical analyses conducted in South Africa should include the presence of delisted shares. This study therefore also made use of delisted shares, in order to counter any negative effects of survivorship bias.

#### **4.4.6. Acquisition of data**

Based on the preceding discussion, the required data for this study and its relative sources are:

- Price data of all listed and unlisted shares on the JSE for the full period of February 1990 – February 2010. These were obtained from the JSE Statistics and Records Department, as well as the McGregor BFA database.
- The returns on the domestic market index (JSE ALSI) were also obtained from the JSE
- The returns on the two world indices used, viz. the MSCI World Index and MSCI ACWI, were obtained from the MSCI Barra website<sup>48</sup>.
- The proxy for the risk-free rate is the 90 day treasury bill, and data for this was obtained from the South African Reserve Bank (SARB) website.
- The exchange rate data (of the Dollar, Pound, Euro and Yen) which will be needed for the full sample period was also obtained from the SARB website. Due to the unavailability of data on the Euro for the full sample period, as it was only introduced on the 1 January 1999 (Economics and Financial Affairs, 2009); data for the European Currency Unit (ECU) was also utilised here. The ECU was conceived on the 13 March 1979 by the European Economic Community (EEC) as an artificial “basket” currency which was utilised as an internal accounting unit for the member countries of the European Union (EU) (Economics and Financial Affairs, 2009). The ECU was therefore included in this study to fill in the gap of February 1990 – December 1998, during which time the Euro had not been introduced as yet.

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<sup>48</sup> Data on this website is freely available ([www.msclub.com](http://www.msclub.com)).

#### **4.4.7. Computation of returns**

Once all the data was collected, various adjustments needed to be made to the data before the returns were computed, in order to account for any share splits, name changes, share swaps, mergers or acquisitions which occurred over the period of the study. Whilst the data obtained from the JSE and McGregor BFA were already adjusted to account for any share swaps or splits, adjustments needed to be made manually to account for any mergers/acquisitions or name changes. The method in this respect was therefore the same as that utilised by Charteris (2010: 99), in which she utilised the McGregor's Who Owns Whom record of name changes in order to eliminate the double entry of certain companies whose name changed during the period being examined.

In the case of a merger or acquisition, the historical share prices of the acquiring company was merged with that of the newly formed merged entity only where "substantial similarities were apparent between the acquiring company and the merged entity" (Charteris, 2010: 100). However, if this was not possible, both the acquired and acquiring companies were recorded as delisted from the date of the merger, with the merged entity treated as a newly formed company from the same date.

The issue of whether dividends should be included in an analysis of the CAPM model is an issue which has not reached consensus in the literature. In their analysis of the domestic CAPM model, Sharpe and Cooper (1972: 50) found that the resultant beta estimates obtained do not change significantly in the absence of dividends, with a later study by Bartholdy and Peare (2004: 12) confirming this result. However they state that if the performance of the CAPM model is being evaluated, the dividends should be included as the presence/absence of dividend yields affects the intercept term produced (Bartholdy and Peare, 2004: 12). The literature surrounding the ICAPM model has not explicitly addressed this issue (some studies do not state whether dividends were included in their analysis or not), however, a few studies such as Harvey (1991), Jorion (1990), Dumas and Solnik (1995) and Harris *et al* (2003) do state that dividends were included in their analysis. Therefore, since the purpose of this study is to evaluate the performance of each of the CAPM models utilised, dividend values were included in the analysis.

There are two different methods which can be utilised when calculating returns, viz. simple returns or continuously compounded returns (log returns). The approach commonly utilised in the academic literature whilst investigating asset returns has generally been to use log returns, as these returns are regarded as more statistically tractable than simple returns (Tsay, 2005: 5). However, a possible

problem faced when using log returns in this study is that the returns of the individual assets will be combined into portfolios. Whilst with simple returns, the portfolio return would be the weighted average of each asset's returns, log returns constitutes a non-linear transformation, and therefore cannot be added across a portfolio (Brooks, 2006: 8). This study therefore calculated each individual assets return by using the simple return equation, as posed in equation 4.2 below, after which the simple portfolio return was calculated. This simple return was thereafter transformed into a log return by utilising the appropriate formula<sup>49</sup>.

The equation used to calculate the simple returns on each of the assets is therefore as follows:

$$E(R_{it}) = \frac{D_t + P_t - P_{t-1}}{P_{t-1}} \quad (4.2)$$

where:  $E(R_{it})$  - expected rate of return during period  $t$  for asset  $i$ ;

$D_t$  – dividend value expected from the asset investment in the time period  $t-1$  to  $t$ ;

$P_t$  – price (value) of asset at time  $t$ ; and

$P_{t-1}$  – price (value) at time  $t$ .

(Gitman, 2009: 228)

The dividend information which was obtained from both the JSE and McGregors BFA database was that of annual dividend yields, rather than the actual dividend for each share. The monthly dividend yield was therefore calculated by dividing the annual yield by twelve, an approach which has been utilised by both Mutooni and Muller (2007: 18), as well as Charteris (2010: 101). This value was thereafter substituted appropriately into equation 4.2 in order to calculate each assets return.

#### **4.4.8. Industry Portfolio formation**

As mentioned earlier, one of the methodologies employed was that of Fama-Macbeth (1973), which required the use of portfolios instead of individual assets<sup>50</sup>. Whilst Fama-Macbeth (1973) made use of beta-sorted portfolios, this study hypothesised that industry portfolios would be better suited to a study of the international CAPM models, as it would allow one to further analyse the results produced

<sup>49</sup> This will be discussed in more detail in section 4.5.7 which follows.

<sup>50</sup> This method was introduced in order to reduce the Error-In-Variables problem, which will be discussed further later.

with reference to each specific industry and its respective characteristics. This method is also more flexible than the beta sorting one as it can be easily applied to the other two methodological approaches utilised. This approach is similar to that used by McKenzie, Brooks and Faff (2000), who also made use of industry portfolios in the Australian environment.

The use of industry portfolios is also very important for the detection of exchange rate exposure. This result was confirmed by the studies of Bodnar and Gentry (1993), Marston (2001), Allayanis and Ihrig (2001) and Chaeib and Mazotta (2010), all of whom found that the presence and extent of exchange rate exposure is affected by the industrial structure exhibited by shares. Chaeib and Mazotta (2010: 22) conclude their study by stating that their results “indicate that, to uncover exposure, one should not look at firms in isolation and ignore the joint evidence provided by the cross sections of firms in the same industry”. Therefore, certain industries may exhibit a high, statistically significant exposure to exchange rate risks, whilst other industries may show no response to changes in the exchange rate. The division of the assets into portfolios thus allows the formation of hypotheses and further investigation of the results obtained.

This study made use of all the assets listed on the JSE from 1990 up to 2010. Therefore the sector division of the JSE should be a basic guideline for choosing the industry portfolios in this study. However, during the time period being considered, the JSE changed their industry classification method, resulting in the unbundling and creation of new sectors and sub-sectors, whilst some pre-existing sectors were consolidated (Theunissen, 2001: 3). This thus makes it substantially difficult to utilise an exact specification method, in which case the data was examined and then subdivided into twenty different industry portfolios, according to the specifications shown in table 4-3 below:

**Table 4-3. List of Industry Portfolios used in this study**

<b>Industry Name</b>	<b>Description</b>
<b>Insurance</b>	This sector contains companies offer insurance, life insurance or reinsurance, including brokers or agents
<b>Banks and Financial Services</b>	Consists of consumer banks, and companies which are involved in corporate banking and/or investment services
<b>Property</b>	Includes all companies which invest either directly or indirectly in real estate through development, management or ownership, including property agencies. Includes real estate investment trusts (REITs) and listed property trusts (LPTs)



Industry Name	Description
<b>Chemicals, Oils and Gas</b>	Encompasses companies which are engaged in the exploration, production as well as distribution of oil and gas, and suppliers of equipment and services to the industry. Also includes companies that produce and distribute both commodity and finished chemical products
<b>Health Care</b>	Companies which are involved in the provision of healthcare, pharmaceuticals, medical equipment as well as medical suppliers
<b>Media</b>	Covers companies which produce radio, television, films, broadcasting and entertainment. This includes media agencies as well as both print and electronic publishing companies
<b>Automobiles and Parts</b>	These are companies involved in the manufacturing of cars, tyres, and either new or replacement parts
<b>General Mining</b>	Companies involved in the exploration, extraction or refining of minerals not defined elsewhere within any of the other industry sectors
<b>Platinum, Diamond, Coal and Precious Metals</b>	Includes all companies involved in the exploration for, and production of platinum, coal, silver and other precious metals
<b>Gold Mining</b>	All companies involved in the extraction of gold
<b>Basic Resources</b>	These are companies which are involved in the extraction and basic processing of natural resources such as paper and steel
<b>Building and construction</b>	Includes companies which are engaged in the construction of buildings and infrastructure, as well as the producers of materials and services used in this industry
<b>Industrial Engineering</b>	Encompasses manufacturers and distributors of commercial vehicles and trucks as well as industrial machinery
<b>Industrial Transportation</b>	All companies which provide delivery services, marine transportation, railroads and trucking services. Includes companies which provide services to the industrial transportation sector such as companies which provide logistic services to shipping companies
<b>Other Industrial</b>	This industry group contains all companies which are involved in manufacturing, or the companies which provide services to manufacturers, that were not accounted for in any of the other industry sectors

Industry Name	Description
<b>Technology and Electronics</b>	Companies which provide computer and telecommunications hardware and related software and services, including internet providers. This also includes manufacturers of household electronic goods
<b>Food and Beverage</b>	All companies which are involved in the food industry, from crop growing and livestock farming, to production and packaging. This also includes companies which are involved in the manufacturing and distribution of beverages, both alcoholic and non-alcoholic, but excludes retailers
<b>Travel and Leisure</b>	Includes all companies which provide leisure services, including hotels, theme parks, casinos, restaurants, bars, cinemas and consumer travel services such as airlines and car rentals
<b>Personal and Household Goods</b>	This industry group encompasses companies which are engaged in the production of durable and non-durable personal and household products, which includes furnishings, clothes, recreational and tobacco products
<b>Retail</b>	Consists of companies that retail consumer goods and services including food and pharmaceutical products

(Source: JSE, 2004)

Similar to Fama-Macbeth (1973: 617), this study also has the condition that, in order for a security to be included in a specific portfolio; it should have five full years of data<sup>51</sup> available from the first month of the testing period. In addition, the portfolios were reformed on a monthly basis in order to account for any delisted or newly listed companies. The portfolio return was therefore calculated by taking a weighted average of each individual security return as follows:

$$E(R_{pt}) = \frac{1}{N} \times \sum_{n=1}^N E(R_{it}) \quad (4.3)$$

where:  $N$  - is the number of assets in the portfolio.

The simple return calculated in equation 4.3 was thereafter transformed into a log return ( $E(R_{log})$ ), as discussed earlier. The equation utilised is therefore:

<sup>51</sup> The period over which betas will be estimated.

$$E(R_{log}) = \ln[1 + E(R_p)] \quad (4.4)$$

(Tsay, 2005: 5)

The continuously compounded (logged) returns were thereafter utilised in all necessary empirical analyses.

#### **4.5. Preliminary Data Analysis**

Once the data was altered and transformed, it became necessary to analyse its distributional characteristics in order to determine if the data conforms to economic theory or not. As stated in chapter 2, a fundamental assumption underlying all the CAPM models is that the assets are normally distributed. The evidence presented in chapter 3 showed that in emerging markets such as South Africa, returns tend to be leptokurtic, due to emerging markets being prone to large movements in prices which occur often (Marais, 2008: 14). It was therefore necessary to analyse the data utilised in this study in order to determine if this phenomenon is present here as well, and if so, what the best method of dealing with it would be.

The descriptive statistics were analysed are therefore:

- *Mean*
  - this value is the average return of each portfolio, which is obtained by dividing the sum of the series by the number of observations.
- *Standard Deviation*
  - this is a measure of dispersion in the series, and is commonly used as an indication of the level of risk inherent in a portfolio
  - If  $N$  is the number of observations in the sample, and  $\bar{y}$  is the mean of the series, then standard deviation ( $\sigma$ ) can be represented as:

$$\sigma = \sqrt{\left(\sum_{i=1}^N (y_i - \bar{y})^2\right) / (N - 1)}$$

- *Skewness*

- Measures the asymmetry of the distribution of the portfolio returns around its mean value.

This value is calculated as:

$$S = \frac{1}{N} \sum_{i=1}^N \left( \frac{y_i - \bar{y}}{\hat{\sigma}} \right)^3$$

where:  $\hat{\sigma} = \sigma \sqrt{(N-1)/N}$ .

- The value of  $S$  for a normally distributed (symmetrical) distribution is 0. A positive value for  $S$  therefore implies that the distribution is right skewed as it has a long right tail, whilst a negative value for  $S$  indicates that the distribution is left skewed.

- *Kurtosis*

- This measures the “peakedness” or flatness of a distribution, and is calculated as:

$$K = \frac{1}{N} \sum_{i=1}^N \left( \frac{y_i - \bar{y}}{\hat{\sigma}} \right)^4$$

- The value of  $K$  for a normal distribution is 3; therefore if the value obtained exceeds 3, the distribution is regarded as leptokurtic (peaked). If the value obtained is less than 3, the distribution is referred to as platykurtic (flat).

- *Jarque-Bera Statistic*

- This test statistic is used to determine if the portfolio returns used are normally distributed or not.
- The null hypothesis of this test is that the series is normally distributed, and the test statistic is calculated as:

$$JB = \frac{N}{6} \left( \sigma^2 + \frac{(K-3)^2}{4} \right)^2$$

- The critical value for this test can be obtained from a chi-square distribution, with 2 degrees of freedom. The null hypothesis of normality will therefore be rejected if the test statistic calculated exceeds the critical value. An alternative method would be to look at the p-value associated with the JB statistic. In this case, the null hypothesis would be rejected if the calculated p-value is less than the level of significance (alpha) value specified.

(Eviews, 2007: 307)

## **4.6. Methodology Used**

### **4.6.1. Fama-Macbeth (1973) method of two-pass regression**

The nature of the data used in this study is that it crosses two dimensions, i.e. it consists of both cross sectional as well as time series data. Whilst empirically, there are a number of different methods which could be used in order to perform analyses on data of this sort, the most popular method, as mentioned before, is that of two-pass regression developed by Fama-Macbeth (1973). In addition to being easy to implement and widely utilised in literature<sup>52</sup>, an advantage of this method is that it allows for time-variation of the beta estimates (Cochrane, 2001: 228). Whilst the basics of the FM method were discussed in chapter 3, this section will now explain this methodology in more detail.

The first step of the FM method is to perform a time series regression of the CAPM on each individual asset being evaluated by using OLS estimation. Therefore, the general form of the equation which was used for all three of the CAPM models being tested is as follows:

$$E(R_{it}) - R_{ft} = \alpha_{it} + \sum_{j=1}^J \beta_{ij}(R_{jt} - R_{ft}) + \varepsilon_{it} \quad (4.5)$$

where:

$E(R_{it})$ = the rate of return on asset  $i$  at time  $t$ ;

$R_{ft}$ = the risk free rate at time  $t$ ;

$\alpha_{it}$  = the intercept of the regression;

$J$ = the number of parameters in the model;

$\beta_{ij}$ = the beta of stock  $i$  for parameter  $j$ ;

$R_{jt}$  = the rate of return of variable  $j$  at time  $t$ ;

$\varepsilon_{it}$ = the random error term of the regression at time  $t$ .

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<sup>52</sup>Some of the studies which have used the Fama-Macbeth (1973) method are: Chan *et al* (1991); Fama and French (1992); Davis (1994); Fama and French (1996); Jagannathan and Wang (1996); Daniel and Titman (1997); Welch (2004); Chung, Johnson and Schill (2006); Wu (2002) and Wu (2008).

Whilst for the DCAPM and ICAPM,  $J$  equals to 1 (as the only parameter considered is the respective market indices), for the ICAPM<sup>EX</sup> model,  $J$  is equal to 5 (the parameters are: the world market index and the four exchange rates of the Dollar, Pound, Euro and Yen).

Whereas in earlier studies of the CAPM model, the results of equation 4.5 would then be utilised in the second pass regression, this method introduces the error-in-variables (EIV) problem. This problem arises because the second-pass cross-sectional regression makes use of estimated betas (from the first pass regression), instead of true betas (Kan *et al*, 2009: 4). Therefore, the measured value of  $\beta$ , as estimated in equation 4.5, can be expressed as the sum of the true beta ( $\beta^*$ ) and a measurement error ( $v$ ).

$$\beta = \beta^* + v$$

This measurement error ( $v$ ) in the estimation of betas leads to two problems:

1. The resultant least squares estimates of the parameters in the cross-sectional regression will be biased.
2. The standard error estimates which are obtained in the cross-sectional regression will be inconsistent, which implies that the resultant t-statistics will lead to incorrect conclusions.

(Kan *et al*, 2009: 1)

This EIV problem has been recognised and addressed by Fama-Macbeth (1973), and they use portfolio construction in order to increase the precision of the beta estimates. The purpose of using portfolios instead of individual assets is because portfolios serve to diversify away most of the firm-specific risk which, in turn, enhances the beta estimates obtained (Yang and Xu, 2006: 18). Therefore, the FM method utilised the obtained betas in order to sort the assets into portfolios according to ranked betas. However, this study did not utilise portfolios which are beta ranked. Instead, industry portfolios were utilised, according to the discussion in sub-section 4.4.8.

Therefore, equation 4.5, which is the time series regression of each individual asset, does not need to be estimated. Instead, the returns of each of the portfolios formed were computed by making use of equations 4.3 and 4.4, which were outlined earlier. Thereafter the first pass entailed calculation of the portfolio betas by making use of the following general equation:

$$E(R_{pt}) - R_{ft} = \alpha_{pt} + \sum_{j=1}^J \beta_j RP_j + \varepsilon_{pt}$$

(4.6)

where:  $E(R_{pt})$  = the rate of return on the portfolio  $p$  at time  $t$ ;

$R_{ft}$  = the risk free rate at time  $t$ ;

$\alpha_{pt}$  = the intercept of the regression;

$J$  = the number of explanatory variables in the equation;

$RP_j$  = the risk premium associated with the  $J^{\text{th}}$  explanatory variable;

$\beta_j$  = the beta of the portfolio with respect to the  $J^{\text{th}}$  explanatory variable; and

$\varepsilon_{pt}$  = the random error term of the regression at time  $t$ .

Equation 4.6 therefore yields estimates of the *portfolio beta*, instead of the betas of the individual assets. In this case, since the errors are assumed to be independent and identically distributed (iid), this implies that averaging within portfolios results in a smaller measurement error which decreases with the addition of each new asset into the portfolio. Therefore, as postulated by Shanken (1992: 12), when the number of portfolios is kept constant, and the number of assets approaches infinity, the measurement error will converge to zero (Munesca, 2010: 20). This therefore effectively eliminates the issues which arise due to the error-in-variables problem. The use of portfolios in order to eliminate the EIV problem is documented and supported by many empirical analyses, including that of Fama and Macbeth (1973), Fama and French (1992), McKenzie, Brooks and Faff (2000), Wu (2002) and Zhang (2006).

As mentioned before, the domestic CAPM and ICAPM models were estimated according to equation 4.6 and had one explanatory variable (viz. the market risk premium), therefore only one beta estimate was obtained. However, for the ICAPM<sup>EX</sup> model, there were five different explanatory variables (the market risk premium and the four foreign currency risk premiums) which resulted in a vector of five different beta estimates for each portfolio.

If equation 4.6 was estimated over the full sample period, it would imply that the betas do not change over time. However, this is clearly an unrealistic implication as the full sample period is 21 years during which time the South African financial environment has fluctuated vastly. Therefore, time-variation of the beta estimates was included in the study. The first pass therefore entailed a regression of equation 4.5 over the first 60 months of data<sup>53</sup> (viz. Feb 1990 – Jan 1995). This provided the first set of beta estimates. Thereafter, a rolling period of one month was used, which means that the second set of beta estimates were produced by regressing equation 4.6 over the period of Mar 1990 – Feb 1995. Likewise, the third set of betas was obtained over the period of Apr 1990 – Mar 1995, and the process was continued until the final date of February 2010 was reached.

This data set produced for use in the second pass of the FM method again resulted in both cross-sectional and time series data, as each of the twenty portfolios used had beta estimates for each of the months spanning January 1995, up to February 2010. There are a number of methods in which data of this sort can be tested. The first such method is that of a pooled regression, in which the obtained excess return and beta estimates from the first pass would simply be stacked into vectors and estimated using OLS.

However, a pooled regression of this type relies on the fundamental assumption that the resultant variables and their relationships remain constant over time and across all portfolios used, which therefore implies that the resultant error terms are uncorrelated across observations (Brooks, 2006: 488). If this assumption is violated, it results in understated standard errors, and incorrect coefficient estimates (Cochrane, 2001: 230; Petersen, 2009: 435). The understated standard error estimates in turn lead to inflated t-statistics, which ultimately may lead to incorrect inferences about the model being tested (Skoulakis, 2006: 1). Fama-Macbeth (1973) chose to correct for this possibility by running monthly cross-sectional regressions and thereafter averaging the results to obtain statistical inferences about the data, however according to Brooks (2006: 488), this method may also be flawed as it does not allow for any differences in the variables over time.

An alternative method which can therefore be more feasible to incorporate for any unobserved heterogeneity in the data used, is the use of panel data models, which offer the following advantages:

- The panel data models are specifically structured to allow for any unobserved heterogeneity in the data, which thus eliminates the possibility of obtaining biased results.

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<sup>53</sup>This issue was discussed in section 4.4.3.



- Panel data allows for the following:
  - More informative data;
  - Greater variability;
  - Less collinearity amongst the variables;
  - More degrees of freedom, and
  - More efficiency.
- The use of panel data may reveal dynamics and complexities in the data set that would have been difficult to detect with any other method.

(Baltagi, 2005: 4)

There are two different approaches which can be utilised within panel data, viz. the fixed effects (FE), and random effects (RE) models. The FE model allows for variation of the intercepts of the model, either across the cross-sectional units (portfolios), or over time, or over both the portfolios as well as time. Any differences among portfolios or time periods are therefore assumed to be attributable to changes in the intercept term (Park, 2009: 4). The estimation equation can therefore be expressed as follows:

$$E(R_{pt}) - R_{ft} = (\gamma_0 + u_p) + \sum_{j=1}^J \gamma_{jt} \beta_{jpt} + \varepsilon_{pt}$$

where:  $u_p \sim IID(0, \sigma_u^2)$

(4.7)

A RE model on the other hand assumes that the intercepts of a model are constant, and any variation among portfolios or across time periods is due to changes in the variance of the error term. The resultant estimation equation for a RE estimation is therefore:

$$E(R_{pt}) - R_{ft} = \gamma_0 + \sum_{j=1}^J \gamma_{jt} \beta_{jpt} + (\varepsilon_{pt} + u_p)$$

where:  $u_p \sim IID(0, \sigma_u^2)$

(4.8)

In the above equation,  $\varepsilon_{pt}$  is representative of the conventional error term which is different for each observation, whilst  $u_p$  is an error term which indicates the extent to which the intercept of portfolio  $p$  differs from the overall intercept. An important disadvantage associated with the RE model however,

is the assumption that the error term  $u_p$  is not correlated to the betas in the model, which according to Kennedy (1996: 227) is “not likely to be the case”. Table 4-4 documents the fundamental differences between the FE and RE models:

**Table 4-4. Main differences between the FE and RE models**

	<b>Fixed effects</b>	<b>Random effects</b>
<b>Intercepts</b>	Allowed to vary over time or across cross-sectional units	Constant
<b>Error Variance</b>	Constant	Allowed to vary over time or across cross-sectional units
<b>Slopes</b>	Constant	Constant
<b>Estimation Procedure</b>	OLS	GLS

(Source: Adapted from Park, 2009: 4)

The theory surrounding these two models suggests that the choice of which model should be used is dependent on the nature of the data being used. Since the FE model produces results specific to the data set used, this specification would be considered appropriate if the data obtained constitutes an entire population; or inferences are only required about the sample of data being used, and do not extend to other members of the population. However, if the data consists of a small sample from a much larger population, and inferences are required not just for that sample of data, but for the entire population, a RE model is considered more apt (Brooks, 2006: 500; Kennedy, 1996: 227).

Whilst the decision between fixed and random effects can be made based on a subjective assessment of the data being used, there are statistical tests which have been developed specifically for this purpose. Eviews allows two such tests in order to determine which of these two models are best suited to the data utilised. These tests are:

- The Redundant fixed effects likelihood ratio test: In order to test for fixed effects, it was necessary to estimate equation 4.7 with both cross-sectional as well as period (time) fixed effects. The test, which has the null hypothesis that the fixed effects are redundant, was conducted, with Eviews yielding test results for three different restrictions, viz.
  - Only the Cross-sectional fixed effects are redundant;
  - Only the period fixed effects are redundant; and

- Both the cross-sectional and period effects are jointly redundant.

The resultant p-values produced were analysed, and if the p-value produced was found to be greater than the 5% level of significance, the conclusion reached was that the evidence was insufficient to reject the null hypothesis (Eviews, 2007: 568). It should however be noted, that a failure to reject the null hypothesis for this test simply indicates that the fixed effects model is inappropriate for the data utilised, and not that the random effects model should be used instead. The use of the RE model needs to instead be tested by making use of the Hausman (1978) test, outlined below.

- Hausman (1978) test: This test is used to compare between the FE and RE models in order to determine which is best for the data used. As outlined earlier, a fundamental assumption under the RE model is that the unobserved heterogeneity captured by  $u_p$  in equation 4.8 should not be correlated to the betas in the model. If these two variables are found to be correlated, estimation using FE would be consistent, whilst estimation using RE would be inconsistent. The null hypothesis of the Hausman (1978) test therefore states that error terms are not correlated with the explanatory variables in the model, in which case a RE model is appropriate, whilst the alternative implies that the two terms are correlated and only FE estimation should be used (Wooldridge, 2000: 453). This test is conducted in the same way as the redundant fixed effects model, with a p-value greater than the 5% level of significance again indicating a failure to reject the null hypothesis.

A possible problem encountered with the Hausman (1978) test is that, since calculation of the test statistic involves subtracting the variance-covariance matrices of the FE and RE estimators (Baltagi, 2005: 71), in some cases, the variance could be found to be a negative value. In a case where this occurs, Eviews sets the Hausman test statistic to zero and the probabilities cannot be calculated. If this is encountered, it implies that there are no random effects present in the data being tested (Eviews, 2007: 571).

The results of the above-mentioned tests therefore gave an indication of whether equation 4.7 or 4.8 should be used to regress the estimated betas from the first pass regression, against the average returns of each portfolio. In the original Fama-Macbeth (1973) study, two different time periods were used: one for the estimation of the betas, after which data from the second time period was used in order to run the cross-sectional regressions. However, this study follows that of Wu (2002: 7) by using the same sample period for both beta estimation (in the first pass), as well as the cross-sectional

regression in the second pass. Wu's (2002:7) reason for doing this is because his study is more focussed on whether the data supports the ICAPM model, and is "not concerned with the model's out-of-sample forecasting power". Whilst a primary focus of this study is to identify whether the data from the South African financial market supports the International CAPM models, the out-of-sample forecasting ability is also considered to be an important aspect of the analysis. However, the method outlined by Fama-Macbeth (1973) is not necessary in this study as the out-of-sample forecasting power can be assessed from the panel data regressions which were estimated for each CAPM model. This concept will be explained in further detail in section 4.6.1.2.

Once the panel data regressions were carried out, there were two hypotheses which were tested in order to draw inferences on the CAPM models being tested. These two hypotheses are as follows:

- *Hypothesis 1*

$$H_0: \gamma_0 = 0$$

$$H_1: \gamma_0 \neq 0$$

The variable  $\gamma_0$  is the intercept of the regression, which according to the CAPM theory should be statistically insignificant (i.e. the null hypothesis of  $\gamma_0 = 0$  should fail to be rejected), in order for any of the CAPM models to hold empirically.

- *Hypothesis 2a*

$$H_0: \gamma_{mt} = 0$$

$$H_1: \gamma_{mt} > 0$$

In the discussion of equation 4.6 previously, it was stated that in all of the CAPM models, a common parameter which is required is the return on the market portfolio,  $m$ , whilst in the ICAPM<sup>EX</sup> models; the additional variables which are necessary for estimation are the exchange rate factors. Since the theory surrounding the CAPM model implies that  $\gamma_{mt}$  (which is representative of the market risk premium) should be positive, the hypothesis test applied to this factor in each CAPM model differs from that of the other factors.

- *Hypothesis 2b*

$$H_0: \gamma_{jt} = 0$$

$$H_1: \gamma_{jt} \neq 0$$

The variables  $\gamma_{jt}$  were also be interpreted in order to determine whether the exchange rate risk factors that it represents are statistically significant in the estimation of expected returns, or not.

Each of the afore-mentioned hypotheses were tested by making use of the t-statistics which are applicable to each variable. This t-statistic can be calculated as follows:

$$t(\gamma_j) = \frac{\gamma_j}{\sigma(\gamma_j)/\sqrt{n}} \quad (4.9)$$

where:  $\sigma(\gamma_j)$ = the standard deviation of the coefficient estimates; and

$n$ = the number of months in the estimation period.

(Fama and Macbeth, 1973: 619)

Since both hypotheses 1 and 2b involve two-sided tests, at a significance level ( $\alpha$ ) of 5%, the critical value is 1.96. Therefore, if the absolute value of the calculated test statistic obtained from the panel regression was less than 1.96, this would lead to a failure to reject the null hypothesis. However, if the absolute value of the test statistic was greater than the critical value of 1.96, the null hypothesis was rejected in favour of the alternative. Since hypothesis 2a represents a 1 sided test, the critical value used with regard to this variable, at a 5% level of significance is 1.645. The purpose of the t-tests were therefore to indicate which variables are significant in the explanation of expected returns (and therefore should be included in the CAPM models), and which variables do not need to be included as they are statistically insignificant.

An important aspect which needs to be considered in the case of exchange rate factors is that there is a possibility that all four exchange rates used in the study may not be individually statistically significant, but may be jointly significant. In a case like this, where it is necessary to test multiple hypotheses simultaneously, the Wald Coefficient test in Eviews can be utilised. The output produced by Eviews contains both the F-statistic, as well as the chi-squared ( $\chi^2$ ) statistic.

- The critical value for the F-statistic is obtained from the F-distribution, with  $J$  degrees of freedom in the numerator, and  $N-K$  degrees of freedom in the denominator ( $J$  refers to the number of restrictions being tested, whilst  $N$  refers to the number of observations in the sample, and  $K$  refers to the number of parameters in the model) (Hill *et al*, 2008: 137).

- The critical value against which the computed chi-squared statistic will be compared can be obtained from the  $\chi^2(J)$  distribution (Hill *et al*, 2008: 155).

For both the afore-mentioned tests, if the computed test statistic is found to be greater than the critical value, this would lead to a rejection of the null hypothesis, which thus implies that the exchange rate factors jointly affect the rates of return in an asset.

Whilst the preceding analyses provide valuable insight with regard to the relevance of each individual variable used in this study, there is also a need to measure each different model as a whole in order to determine which of the three models are superior. Therefore, information criteria and forecasting analyses were used as well. Each of these two methods will now be discussed in detail.

#### **4.6.1.1. Information criteria**

Information criteria are commonly used in order to determine the best model which captures the features of the data effectively. These criteria are composed of two factors: the first of which is a function of the residual sum of squares (RSS), and the second term is a penalty term which accounts for the loss of degrees of freedom from adding extra parameters. Therefore, the addition of an extra term will reduce the value of the criterion only if the fall in the residual sum of squares is sufficient to more than outweigh the increased value of the penalty term.

The objective is to choose the model which minimises the information criteria over each of the second pass regressions. There are 3 such criteria to choose from, which are: Akaike Information Criterion (AIC), Schwarz's Bayesian Information Criterion (SBIC), as well as the Hannan-Quinn Information criterion (HQIC). The equations with which each of these criteria are calculated is as follows (Brooks, 2008: 233):

$$AIC = \ln(\sigma^2) + \frac{2k}{T} \tag{4.10}$$

$$SBIC = \ln(\sigma^2) + \frac{k}{T} \ln T \tag{4.11}$$

$$HQIC = \ln(\sigma^2) + \frac{2k}{T} \ln(\ln(T))$$
(4.12)

where:  $\sigma^2$  = the residual variance;

$k$  = the total number of parameters estimated; and

$T$  = the sample size.

Each of these models differs in the degree of strictness exhibited in the penalty term. Whilst SBIC has a much stiffer penalty term than AIC, the strictness of the HQIC penalty term falls somewhere in the middle. Although none of these models exhibit clear dominance, the Schwarz Bayesian model is the one which is the most strongly consistent (Brooks, 2008: 232). However, the results from all three criteria were displayed and compared in this study.

The  $R^2$  and adjusted  $R^2$  values were also reported as these are also forms of information criteria. The  $R^2$  value (also known as the coefficient of determination) is representative of the proportion of the total variation in the asset returns (dependent variable) which is explained by the explanatory variables (independent variables) in the regression model, and is calculated as follows:

$$R^2 = \frac{1 - RSS}{TSS}$$
(4.13)

where:  $RSS$  = the residual sum of squares in the regression (which measures the variation

attributable to the relationship between the asset returns and the explanatory

variables; and

$TSS$  = the total sum of squares (which measures the variation of the asset returns

around its mean value).

An advantage of using the  $R^2$  value is that it is easy to interpret; however, a disadvantage of this criterion is that its value increases with the number of explanatory variables in the model, which means that it often favours larger models. Therefore, the adjusted  $R^2$  was also reported as this is a measure of the goodness of fit of the model which is adjusted for the number of explanatory variables

in the model (Gujarati, 2006: 228). The equation for the adjusted  $R^2$  value can therefore be expressed as follows:

$$R_{adj}^2 = 1 - \left[ \frac{(1 - R^2)(n - 1)}{n - k - 1} \right] \quad (4.14)$$

where  $n$  is the number of observations, and  $k$  is the number of explanatory variables (Maddala, 1992: 165).

The different information criteria which were used and evaluated are therefore:

1. Akaike Information Criterion
2. Schwarz's Bayesian Information Criterion (SBIC)
3. Hannan-Quinn Information criterion (HQIC)
4.  $R^2$
5. Adjusted  $R^2$

The figures for each of these criteria were obtained from the results of the second-pass regression, which is a technique used by many other studies such as Fama and French (1992), Davis (1994), Fama and French (1996), Wu (2002) and Wu (2008). The results were thereafter evaluated, both independently and then together, whilst taking into consideration that both the AIC and  $R^2$  criteria tend to favour larger models (Barnes and Hughes, 2001: 9). The above-mentioned five criteria were collected for both the FM method of two pass regression, as well as the GARCH-in-mean method which will be explained later in section 4.6.2. The results from both methods were then evaluated together in order to determine which of the CAPM models being investigated are superior for the South African financial environment.

#### **4.6.1.2. Forecasting**

Whilst many of the studies outlined made use of some form of information criteria to evaluate their models being tested, only Wu (2008) made use of a forecasting analysis. However, this element is an important one when evaluating asset pricing models as some econometricians advocate that the statistical accuracy of a model (as measured by the regression output and information criteria), are "largely irrelevant if the model produces accurate forecasts" (Brooks, 2006: 244). Therefore each of the models being tested was subjected to a forecasting analysis in order to determine which of the five models produced superior forecasts.



When a model is analysed using forecasting, the current and past values are utilised in order to forecast future values (Hill *et al*, 2008: 246). There are two different methods of forecasting which can be chosen from. The first is in-sample forecasting, which involves generating forecasts for the same set of data which was used to estimate the model's parameters. The alternative to this is out-of-sample forecasts, where a few of the observations are not used in the parameter estimation. These observations are known as the holdout sample, and the forecasted values for this period are then compared to the actual observations which are in the holdout sample. This then provides a picture of the forecasting accuracy of the model.

The method which was chosen in this study is that of out-of-sample forecasting, as this would provide a better test of the models estimated (Brooks, 2008: 245), and is the form of forecasting chosen by other studies such as Louw (2008) and Charteris (2010). Therefore, the cross-sectional panel data regression discussed previously were estimated over the period of January 1995 – December 2007, whilst the 26 months between January 2008 – February 2010 was left as a holdout period.

The difference between the actual values for the holdout period and the obtained forecasted values is known as the forecast error (Hill *et al*, 2008: 247). If a forecasted value is too low, the value for the forecasting error is positive, whereas the opposite is true for a forecast value which is too high. Simply averaging the forecast errors across all the observations would therefore not be considered appropriate as the positive and negative errors will cancel each other out (Brooks, 2006: 251). In order to correct for this, before the forecast errors are totalled, they are usually either squared, or the absolute value of each is taken, which makes all the values positive, and thus allows for a subjective interpretation.

The two criteria which were therefore used to evaluate the models here, is the Root Mean Squared Error (RMSE) and Mean Absolute Error (MAE). The equation used to compute the RMSE is:

$$RMSE = \sqrt{\frac{1}{T - (T_1 - 1)} \sum_{t=T_1}^T (y_{t+s} - f_{t,s})^2}$$

(4.15)

where:  $T$  = the total sample size (in sample + out-of-sample);

$T_1$  = the first out-of-sample forecast observation;

$y_{t+s}$  = the actual value of the observation; and

$f_{t,s}$  = the forecasted value of the observation.

(Brooks, 2008: 253)

Since the RMSE criterion is calculated by squaring the forecast errors, as shown in equation 4.15, a possible disadvantage is that any large forecast errors are therefore weighted more heavily than small forecast errors. Because of this, the MAE criterion, which is less sensitive to extreme values, is sometimes preferred to the RMSE (Kennedy, 1996: 291). The equation used to calculate the MAE is shown below:

$$MAE = \frac{1}{T - (T_1 - 1)} \sum_{t=T_1}^T |y_{t+s} - f_{t,s}|$$

(4.16)

If the values of RMSE and MAE were taken individually, very little information can be obtained from this. Instead, the values from one model should be compared to the values of other models for the same data and forecast period in order to provide a basis for comparison. The model which has the lowest forecast error can therefore be considered to be the most accurate (Brooks, 2008: 252).

#### **4.6.2. GARCH-in-Mean model**

The disadvantage with linear models such as those tested in the Fama-Macbeth (1973) unconditional approach, is that these models are unable to explain a variety of different attributes which have been identified in financial time series, such as non-normality and leptokurtosis (which were discussed already in chapter 3), as well as volatility clustering<sup>54</sup> and leverage effects<sup>55</sup>. In cases such as these, where the assumption of homoskedasticity (constant error variance) is violated, non-linear models such as the GARCH model are able to capture these effects better than linear alternatives (Brooks, 2006: 381). This study therefore also made use of a GARCH-in-mean approach used by both Soufian (2004) and Javid and Ahmed (2009), as an alternative to the unconditional FM test, in order to test conditional versions of the five CAPM models being estimated.

<sup>54</sup> Volatility clustering refers to the affinity of the volatility inherent in financial markets to appear in clusters.

<sup>55</sup> Leverage effects refers to the propensity of the volatility of asset returns to increase more after a price decrease, than a price increase which is of the same size.

An important advantage of the GARCH model is that it is capable of capturing any serial dependence by allowing the conditional variance of the residuals at time  $t$  to depend on the squared residuals from previous periods (Brooks, 2006: 388). A method, by which this phenomenon can therefore be detected, is by examining the autocorrelation coefficients produced at different lags. If these coefficients are found to be statistically significant, it would imply that the GARCH model is an appropriate one for capturing the volatility effect. The investigation of the autocorrelation coefficients was therefore be regarded as a preliminary examination to the GARCH model estimation.

The autocorrelation of any series  $y$ , at  $k$  lags, where the mean is denoted as  $\bar{y}$  can be calculated using the following equation:

$$\tau_k = \frac{\sum_{t=k+1}^T (y_t - \bar{y})(y_{t-k} - \bar{y})}{\sum_{t=1}^T (y_t - \bar{y})^2}$$

At a 5% level of significance, any correlation coefficient which lies within the region of  $\pm 1.96 \times 1/\sqrt{T}$  (where  $T$  = the number of time-series observations) will be regarded as statistically insignificant, whilst any coefficient which lies outside this range will be considered to be statistically significant (Brooks, 2006: 234). Since for this study,  $T$  is equal to 241 observations, the range will lie between 0.1263 and -0.1263. Therefore if any coefficient was found to be less than -0.1263 or greater than 0.1263, that coefficient was considered to be statistically significant, which thus implies that serial dependence exists at that specific lag.

An additional test which was reported is that of the Ljung-Box (1978) Q-statistic, which tests the null hypothesis that all correlation coefficients up to a specific lag  $k$  are simultaneously equal to 0. This test statistic is calculated as follows:

$$Q = T(T + 2) \sum_{m=1}^k \frac{\tau_m^2}{T - m}$$

If the resultant p-value produced for the Q statistic is less than, or equal to the pre-specified level of significance, this would lead to a rejection of the null hypothesis, which would imply that autocorrelation exists up to lag  $k$  for that specific return series (Tsay, 2005: 27). This indication of serial dependence would therefore validate the use of the GARCH specification to model the returns on the market.

The Autoregressive Conditional Heteroskedasticity (ARCH) model was the model first introduced by Engle (1982), which was later extended by Bollerslev (1986) and Taylor (1986) who developed the Generalised ARCH (GARCH) model. The GARCH models allow one to model variance by making use of two equations, viz. the conditional mean equation, and the conditional variance equation. Whilst the conditional mean equation can take any form in order to conform to the topic being studied, the conditional variance equation depends upon  $p$  lags of the conditional variance, and  $q$  lags of the squared error. A general form of the mean equation for a CAPM model is expressed below in equation 4.17, whilst the conditional variance equation is represented by 4.18:

$$r_i = \theta_0 + \beta_i r_m + \varepsilon_i \quad (4.17)$$

$$\varepsilon_i \sim N(0, h_t)$$

$$h_t = \alpha_0 + \sum_{j=1}^q \alpha_j \varepsilon_{t-j}^2 + \sum_{j=1}^p \delta_j h_{t-j} \quad (4.18)$$

where:  $r_i, r_m$  = the excess returns on asset  $i$  and the market portfolio respectively;

$\theta_0$  = the intercept;

$h_t$  = the conditional variance;

$h_{t-j}$  = the lagged conditional variance for  $j$  periods; and

$\varepsilon_{t-j}^2$  = the lagged squared residuals from the mean equation

(Brooks, 2006: 394)

The specification chosen for the preceding model was that of a GARCH (1, 1) model. This specification was chosen as it is widely accepted by empirical studies of this sort as being sufficient to capture the volatility present in financial data (Bollerslev, Chou and Kroner, 1992: 52; Brooks, 2006: 394). In his study of emerging markets, Gokcan (2000) found that when returns exhibit a skewed distribution, this GARCH (1,1) model outperforms a more complex exponential GARCH model in modelling the volatility inherent in the returns. When this issue was addressed in the South African environment, Mangani (2008: 55) found that the GARCH (1, 1) model is a more suitable alternative

than other more complex models within the ARCH family. Samouhlan and Shannon's (2008) analysis of volatility forecasting found that whilst the GARCH (2, 2) model provided the best fit for in-sample estimates, the GARCH (1, 1) model provided the best out-sample results. Bakibir *et al* (2010: 4) in contrast found that the GARCH (1, 1) model provides superior results to the GARCH (2, 2) both in-sample, and out-sample. They also found that this simpler model outperformed more complex asymmetric GARCH<sup>56</sup> models such as the GJR model.

The preceding GARCH model was later extended by Engle, Lilien and Robins (1987) to a GARCH-in-mean, or GARCH-M model, in which the conditional mean equation 4.17 is extended to include a lagged term of the conditional variance (as represented by equation 4.19). The use of this model is common in studies of asset pricing relationships such as this one, as it incorporates the effect that risk has on returns experienced into the model. Therefore, this study makes use of a GARCH (1, 1)-M model which, when applied to the portfolio returns for the single-factor DCAPM and ICAPM models can be represented as follows:

$$r_p = \theta_0 + \beta_p r_m + \lambda h_{t-1} + \varepsilon_i \quad (4.19)$$

$$\varepsilon_i \sim N(0, h_t)$$

$$h_t = \alpha_0 + \alpha_1 \varepsilon_{t-1}^2 + \delta_1 h_{t-1} \quad (4.20)$$

The new mean equation (4.19) takes into account the previous month's conditional variance as an additional variable. The coefficient  $\lambda$  is representative of the coefficient of market risk aversion (Raputsoane, 2009: 4). According to the theory surrounding the CAPM model, the intercept  $\theta_0$  should be zero, whilst the coefficient  $\lambda$  should be positive. The conditional variance equation 4.20 shows that the volatility in each portfolio is a function of both volatility shocks from the previous month ( $\alpha_1 \varepsilon_{t-1}^2$ ), as well as past conditional variances from the previous month ( $\delta_1 h_{t-1}$ ).

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<sup>56</sup> The GARCH models are referred to as symmetric models as they assume a symmetric response to both positive and negative changes in volatility. Therefore whilst these symmetric models are able to account for both leptokurtosis and volatility clustering in asset returns, asymmetric GARCH models were developed in order to account for phenomena such as the leverage effect. Two popular asymmetric models are the Glosten, Jagannathan and Runkle (1993) model, also known as the GJR model, as well as the exponential GARCH (EGARCH) model (Brooks, 2006: 404-405).

Since the data in this study crosses both the time-series and cross-sectional dimensions, the two-pass method of Soufian (2004) and Javid and Ahmed (2009), in their studies of the conditional DCAPM, was utilised here. This method is similar to that of Fama-Macbeth (1973), which was the first approach chosen here, with the exception that the GARCH (1, 1)-M models were used for beta estimation, in order to allow for the volatility inherent in asset price and exchange rate data. The use of this method therefore allows for a comparison between the two approaches and their respective results. Equation 4.19 and 4.20 are therefore representative of the equations which were utilised for the first pass, which is the time series regression of the portfolio excess returns against that of the market index. Whilst under the first pas of the Fama-Macbeth (1973) approach, the first five years of data was lost due to the need to have five full years of data for beta estimation, the conditional approach here made use of the full sample period of February 1990- February 2010. This is therefore an example of one more advantage that this conditional approach has over the Fama-Macbeth (1973) approach.

The method used to estimate the pre-specified equations was that of Maximum Likelihood. The log-likelihood function for the first pass regression (equations 4.19 and 4.20) can therefore be specified as:

$$L = -\frac{T}{2}\log(2\pi) - \frac{1}{2}\log(h_t) - \frac{1}{2}\sum_{t=1}^T (r_{pt} - \theta_{0t} - \beta_{pt}r_{mt})^2/h_t$$

(Brooks, 2006:395)

The parameter values which maximise the preceding log-likelihood function, and their associated standard errors, were then computed using the statistical software Eviews. Whilst most previous tests of the conditional CAPM such as DeSantis and Gerard (1997, 1998) utilised the BHHH method of optimisation, this study made use of the Marquardt algorithm which was later developed as a modification of the BHHH method that corrects for the methods associated weaknesses<sup>57</sup>. In addition, the QML method of calculating standard errors which are appropriate in the event of non-normality was also utilised, in order to incorporate for the possibility that the returns may be non-normally distributed, as was previously documented in Page (1993), Hearn and Piesse (2002) and Mangani (2007).

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<sup>57</sup> Press, Teukolsky, Vetterling and Flannery (1992) contains an in-depth discussion of each of these methods.

Once the portfolio betas were obtained, these were collected and thereafter utilised in an OLS cross-sectional regression (expressed as equation 4.7 in section 4.6.1) reminiscent of the tests conducted by Soufian (2004) and Javid and Ahmed (2009), as well as Morelli (2003) in his similar study of the conditional CAPM model using a two-pass estimation procedure.

The same method of evaluation which was used for the Fama-Macbeth (1973) approach were utilised for the GARCH estimates. Therefore the parameters obtained from the second pass regression represented by equation 4.19,  $\gamma_0$  and  $\gamma_1$ , were evaluated to determine if they are statistically significant or not. However, whilst the OLS regression estimates produced in the Fama-Macbeth approach report t-statistics, the maximum likelihood approach to testing the GARCH models produce the z-statistic. Whilst the t-statistic is best utilised when it is assumed that the standard deviation is unknown, under GARCH estimation, the standard deviation can be calculated and is therefore regarded as a known variable (Hill *et al*, 2008: 513). Therefore since the z-statistic assumes that standard deviation is known, this computation is used for the GARCH models in Eviews. Since the resultant coefficients of the second pass in the GARCH-M approach will be the same as those of the FM method, the hypothesis tests which were outlined on page 124 apply to this context as well. In a two-tailed hypothesis test, the critical value for the z-statistic at a 5% level of significance is therefore 1.96, whilst the associated critical value for a one-tailed test at the same level of significance is 1.65. Therefore, if the absolute value of the computed z-statistic was found to be less than the critical value for the test concerned, that parameter was regarded as statistically insignificant.

Since an important feature of the study is determining which model is the best for use in South Africa, the information criteria which were used for the Fama-Macbeth (1973) approach were also tabulated for this method of analysis. The five information criteria which were reported are therefore: the  $R^2$  value, adjusted  $R^2$ , AIC, SBIC and HQIC, all of which were evaluated in order to determine which conditional model performed the best for this analysis.

#### **4.6.3. Cost of equity approach**

The third method of analysis used in this study was the cost of equity approach, a method which was first developed by Stultz (1995) to examine the difference between the DCAPM and ICAPM models. Stultz's (1995) method, which was outlined in chapter 3 (page 57), showed under which circumstances the cost of equity estimates produced by the DCAPM and ICAPM models would be different, thus resulting in a "pricing error". His approach was later extended by Koedijk *et al* (2002)

to incorporate the ICAPM<sup>EX</sup> model, who also developed a method to test for the statistical significance of the pricing error obtained.

The ICAPM<sup>EX</sup> model, which was discussed in chapter 2, can be represented as follows:

$$E(R_i) - R_f = \beta_{i1}(R_w - R_f) + S'\beta_{i2} \quad (4.21)$$

Where:  $S'$  - represents a vector of exchange rates of returns of the  $N$  countries included in the analysis, measured against the domestic currency

If equation 4.21 was used in a regression, it could be expressed as follows:

$$\begin{aligned} R_i &= \alpha_{1i} + R_w\beta_{i1} + S'\beta_{i2} + u_t \\ &= \alpha_{1i} + Z'\beta_{i2} + u_i \end{aligned} \quad (4.22)$$

where:  $R_i, R_w$  = the excess returns on asset  $i$  and world market portfolio  $w$  respectively; and

$$Z' = R_w S'$$

Whilst equation 4.22 can be utilised to calculate the rate of return on an asset according to the ICAPM<sup>EX</sup> model, the DCAPM model can be expressed as:

$$E(R_i) = R_f + \beta_{iD}(R_D - R_f) \quad (2.1)$$

In order to obtain  $\beta_{iD}$  in the above equation, a regression of the following form should be estimated:

$$R_i = \alpha_{2i} + R_D\beta_{iD} + e_i \quad (4.23)$$

The above regression is the same as the time-series regressions estimated under the Fama-Macbeth (1973) method outlined earlier. Whilst equation 4.23 indicates that the cost of equity of a firm is dependent only upon the risks inherent in the market portfolio, the ICAPM<sup>EX</sup> model in equation 4.21 shows that in an international environment, the risk associated with an asset is related to the risks



inherent in a global market portfolio, as well as exchange rate risks. These two models therefore have very different methods of decomposing the risks that assets in the marketplace face. In order to compare the two models, it is therefore necessary to relate the domestic risk factor  $R_D$  to the global risk factors contained in the vector  $Z'$ .

Since equation 4.22 can be applied to every individual stock ( $R_i$ ), it can also be applied to the domestic market portfolio. Therefore:

$$R_D = \alpha_D + \beta_{DZ}Z' + u_D \quad (4.24)$$

If equation 4.24 is substituted into 4.23, the following is obtained:

$$R_i = \alpha_{3i} + Z'\beta_{iD}\beta_{DZ} + u_D\beta_{iD} + e_i \quad (4.25)$$

Where:  $\alpha_{3i} = \alpha_{2i} + \beta_{iD}\alpha_D$

Equations 4.22 and 4.25 will only lead to the same breakdown of risks if the domestic risk in the error term  $e_i$  is orthogonal to  $Z$ . If this is the case, the combined error term of  $u_D\beta_{iD} + e_i$  will also be orthogonal to  $Z$ , therefore both equations 4.22 and 4.25 can be considered to be identical. This therefore implies that:

$$\beta_{iZ} = \beta_{iD}\beta_{DZ} \quad (4.26)$$

(Koedijk *et al*, 2002: 908)

The above expression is similar to the result produced by Stultz (1995) when applied to the DCAPM and single-factor ICAPM model. If the restriction expressed in 4.26 holds, this implies that the ICAPM<sup>EX</sup> and DCAPM models will produce the same cost of equity estimate. A simple way in which this test can be implemented empirically is to make use of the following regression, which adds the vector  $Z$  as an additional factor in the domestic CAPM model:

$$R_i = \alpha_i + R_D\beta_{iD} + Z'\delta_i + v_i \quad (3.29)$$

The moment conditions for equation 3.25 are:

$$\begin{pmatrix} \sigma_D^2 & \beta'_{DZ}\Omega \\ \Omega\beta_{DZ} & \Omega \end{pmatrix} \begin{pmatrix} \beta_{iD} \\ \delta_i \end{pmatrix} = \begin{pmatrix} \sigma_D^2\beta_{iD} \\ \Omega\beta_{iZ} \end{pmatrix} \quad (4.27)$$

Where:  $\Omega$  = an  $(N+1) \times (N+1)$  covariance matrix of  $Z$ ;

$\sigma_D^2$  = the variance of the domestic market portfolio  $R_D$ ;

$\Omega\beta_{DZ}$  = the covariance between  $R_D$  and  $Z$ ; and

$\sigma_D^2\beta_{iD}$  = the covariance between  $R_i$  and  $R_D$ .

(Koedijk *et al*, 2002: 927)

If the second line of the above matrix is utilised to solve for  $\delta_i$ , the following is obtained:

$$\delta_i = \beta_{iZ} - \beta_{iD}\beta_{DZ} \quad (4.28)$$

From the above, it can be seen that the restriction expressed in 4.26 is equal to  $\delta_i$ . This variable can therefore be regarded as the “pricing error” of the model, in which case, if it is found that the null hypothesis ( $\delta_i = 0$ ) cannot be rejected, this would indicate that there is no difference between the cost of equity estimates produced by the DCAPM and ICAPM<sup>EX</sup> models as the domestic market portfolio contains all the information necessary to price assets in the domestic country (Koedijk *et al*, 2002: 908). However if the null hypothesis is rejected, and  $\delta_i$  is found to be statistically different from 0, this would imply that the world market index and exchange rate risk factors should be included in the asset pricing model. Whilst the above demonstrates a test of the ICAPM<sup>EX</sup> model against the DCAPM, a test of the single-factor ICAPM model against the DCAPM will include only the return on the world index ( $R_w$ ) as a factor in the global vector instrument  $Z$ .

The regression of equation 3.25 was therefore conducted over the entire sample period, similar to Koedijk *et al* (2002: 907). In a vein similar to that of Stultz (1995b), Koedijk *et al* (2002) and Koedijk and Van Dijk (2004), the only analysis which was conducted is hypothesis testing on the pricing error ( $\delta_i$ ). This variable was therefore tested for statistical significance by making use of the two-sided t-test (which was outlined before in section 4.6.1). If the pricing error ( $\delta_i$ ) is found to be statistically significant, this could be either because the world market index is priced, or the exchange rate factors are priced, or both (Koedijk *et al*, 2002: 908).

The authors therefore conducted additional tests which isolated the exchange rate factors in order to determine if the inclusion of these variables affect the cost of equity estimate of a firm. This test therefore made use of equation 3.25, but the instrumental variable  $Z'$  contained only the exchange rate factors ( $S'$ ). This equation is similar to the test equation of Jorion (1990), Barr and Kantor (2005) and Doidge *et al* (2006), all of whom also added the exchange rate factor to the DCAPM in order to detect any exchange rate exposure present, while controlling for the effect of the domestic market portfolio. It should be noted that in a test of this sort, if the coefficient of the exchange rate factor is found to be statistically insignificant, this does not imply that the firm is not affected by exchange rate changes, instead it implies that the firm has the same amount of exposure as the domestic market portfolio (Doidge *et al*, 2006: 556).

Thereafter, Koedijk *et al* (2002: 909) conducted a test of the total exposure, by controlling for orthogonalised domestic and international return. This process involves three different regressions, the first of which regresses the returns of the world market portfolio against the vector of exchange rates. Therefore:

$$R_W = c_1 + \beta_S S' + \eta_W \quad (4.29)$$

The second regression involves regressing the domestic market return against the world market portfolio, as well as the vector of exchange rates as follows:

$$R_D = c_2 + \beta_W R_W + \beta_S S' + \eta_D \quad (4.30)$$

The above two regressions serve to eliminate any exchange rate exposure which is already captured by the domestic and global market indices. The final regression thereafter regresses each industry portfolios return, against both the vector of exchange rates, as well as the residuals of equations 4.29 and 4.30. Therefore:

$$R_i = c_3 + \beta_S S' + \beta_1 \eta_W + \beta_2 \eta_D + \varepsilon \quad (4.31)$$

The null hypothesis of  $\beta_S = 0$  was then tested in order to evaluate whether exchange rate exposure is considered a significant factor in estimating the cost of equity of a firm. A summary of all the regressions which were estimated under the cost of equity approach, as well as their purpose and the null hypothesis of each is contained in table 4-5 below:

**Table 4-5. Summary of regression models under Cost of Equity approach**

Test	Regression equation	Null hypothesis
Pricing error of the DCAPM against both ICAPM <sup>EX</sup> models	$R_i = \alpha_i + \beta_{iD}R_D + \delta_i Z' + v_i$ $Z' = R_W S'$	$\delta_i = 0$
Pricing error of DCAPM against both ICAPM models	$R_i = \alpha_i + \beta_{iD}R_D + \delta_i Z' + v_i$ $Z' = R_W$	$\delta_i = 0$
Exchange rate exposure	$R_i = \alpha_i + \beta_{iD}R_D + \delta_i Z' + v_i$ $Z' = S'$	$\delta_i = 0$
Total Exposure	$R_W = c_1 + \beta_S S' + \eta_W$ $R_D = c_2 + \beta_W R_W + \beta_S S' + \eta_D$ $R_i = c_3 + \beta_S S' + \beta_1 \eta_W + \beta_2 \eta_D + \varepsilon$	$\beta_S = 0$

#### **4.7. Summary**

This chapter provides a detailed description of the analytical methods which will be used in this study in order to evaluate the International CAPM models. Each of the three models which will be estimated was outlined in detail, together with a justification of each of the proxies chosen. The study therefore utilises the MSCI World Index and MSCI ACWI as proxies for the world portfolio, whilst the exchange rate factors used are those of the four most important trading partners to South Africa, viz. the US, UK, Japan and Europe.

The time period for the study was chosen based on previous studies' analyses which endeavour to find out the date upon which South Africa's global integration with the global economy began. Therefore, the study period chosen was that of February 1990 – February 2010, in order to allow for the maximum period possible of twenty one years. Each of the three analytical methods (unconditional, conditional and cost of equity approaches) was outlined, along with the different ways in which each of the estimated models will be evaluated. Whilst t-statistics and z-statistics will be used to evaluate the statistical significance of each factor used, five different information criteria will be utilised in order to determine the superiority of each model as a whole in the estimation of expected returns. The following chapter therefore outlines all of the results produced from each different method used.

## CHAPTER 5 : DATA ANALYSIS AND RESULTS

### 5.1. Overview

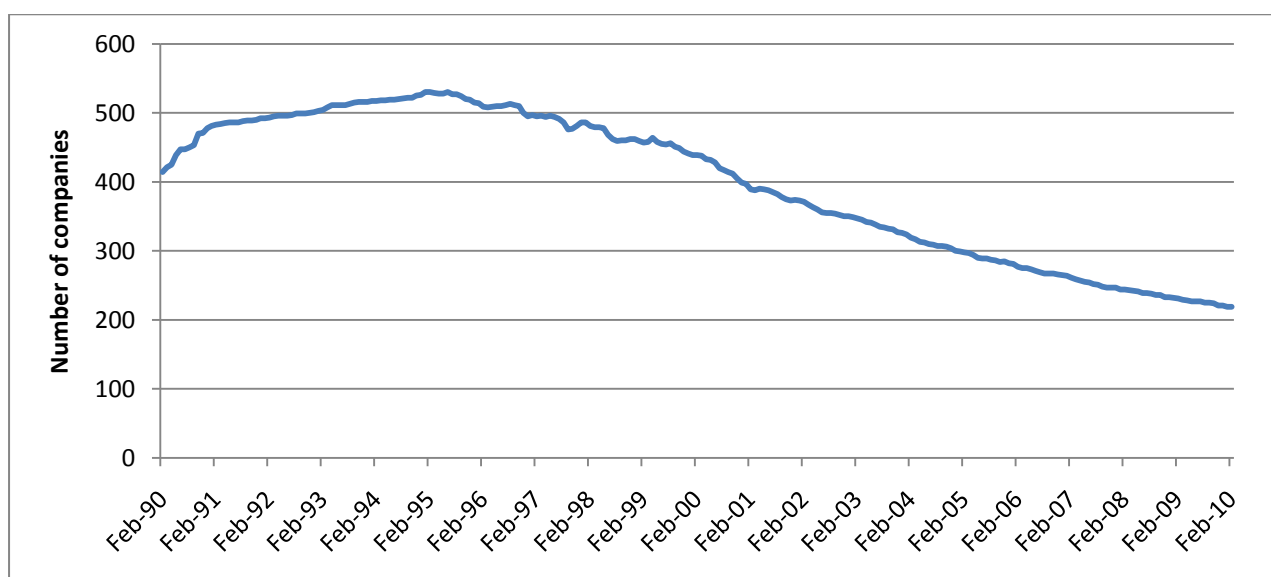
The preceding chapter outlined each of the CAPM models upon which this study is based, as well as each of the three methodological approaches which were utilised in order to empirically test each of these models. This chapter therefore outlines all of the results obtained from each analysis, in order to draw viable conclusions on the study. The preliminary data analysis is therefore reported first, after which the results of each of the three methods used are displayed and discussed.

### 5.2. Preliminary Data Analysis

#### 5.2.1. Number of companies included in the study

The initial starting point for the data was all of the companies which were listed on the JSE from the period of 1990 till 2010, including companies which had delisted during that period. However due to the data requirements of the study, any company which had less than five full years of data was removed from the sample. The delistings were also accounted for on a month-by-month basis. The resulting number of companies included in the sample overall is therefore shown in figure 5-1 below:

**Figure 5-1. Number of companies used in the analysis on a monthly basis.**



The number of firms in the analysis which adhered to the data requirements varies between 530 and 219 firms over the twenty one year sample period. Figure 5-1 shows that the number of firms declined towards the later period of the study. This is due to the number of firms listed on the JSE decreasing from an initial value of 769 at the end of 1990, to 396 firms at the end of 2009 (World Federation of exchanges, 2010).

### **5.2.2. Summary Statistics**

Table 5-1 contains summary statistics for the excess returns of each of the market and industry portfolios included in the analysis:

**Table 5-1. Summary Statistics of the market and industry portfolios used in this study**

<i>PANEL A</i>						
	Mean (%)	Standard Deviation (%)	Skewness	Kurtosis	Jarque-Bera Statistic	P-value (Jarque-Bera)
<b>JSE</b>	1.05	5.84	-1.13	8.53	359.07	0.00
<b>MSCI World Index</b>	0.95	4.96	0.01	4.09	11.98	0.002
<b>MSCI ACWI</b>	0.96	4.96	0.01	4.09	11.90	0.003
<i>PANEL B</i>						
<b>Insurance</b>	1.45	5.44	-1.36	11.95	878.29	0.00
<b>Banks and Financial Services</b>	1.85	5.73	-1.70	12.65	1050.04	0.00
<b>Property</b>	1.51	3.48	0.29	4.10	15.64	0.00
<b>Chemicals, Oils and Gas</b>	1.66	6.50	0.80	6.56	153.03	0.00
<b>Health Care</b>	2.19	7.17	0.24	3.45	4.41	0.11
<b>Media</b>	2.15	8.02	0.11	4.55	24.74	0.00
<b>Automobiles and Parts</b>	0.78	5.88	-0.50	4.21	24.90	0.00
<b>General Mining</b>	1.57	7.15	-0.018	3.85	7.29	0.026

	Mean (%)	Standard Deviation (%)	Skewness	Kurtosis	Jarque-Bera Statistic	P-value (Jarque-Bera)
<b>Platinum, Diamond, Coal and Precious Metals</b>	2.07	7.21	-0.74	7.32	209.69	0.00
<b>Gold Mining</b>	1.50	10.45	1.00	5.91	125.67	0.00
<b>Basic Resources</b>	1.78	6.62	0.13	4.74	31.10	0.00
<b>Building and construction</b>	1.91	6.60	0.38	4.64	32.98	0.00
<b>Industrial Engineering</b>	2.13	6.31	0.92	7.72	257.19	0.00
<b>Industrial Transportation</b>	1.74	6.64	0.68	8.38	308.75	0.00
<b>Other Industrial</b>	1.52	4.29	-0.69	5.71	92.80	0.00
<b>Technology and Electronics</b>	2.21	6.48	-0.95	8.22	309.36	0.00
<b>Food and Beverage</b>	1.72	4.24	0.33	5.33	58.80	0.00
<b>Travel and Leisure</b>	1.67	6.92	-0.19	6.50	124.65	0.00
<b>Personal and Household Goods</b>	1.41	5.35	0.016	5.76	76.42	0.00
<b>Retail</b>	1.76	5.78	-0.30	6.02	95.00	0.00

Panel A in table 5-1 shows the summary statistics for the three market portfolios which are utilised in this study. From this panel it can be seen that whilst the average monthly return of the JSE ALSI (1.05% monthly) is higher than those of the MSCI World or MSCI AC world indices (0.95% and 0.96% respectively), it also exhibits a higher standard deviation of 5.84%. As noted before in Chapter 4, if the obtained value for skewness is positive, this implies that the distribution is right skewed, whilst if value is negative, this means that the distribution is negatively skewed. When evaluating the

kurtosis values, a value of 3 represents a normal distribution. A value of higher than 3 implies that the series is leptokurtic, whilst a value of lower than 3 implies the series is platykurtic.

In Marais (2008: 56) study, he found that over the period of January 1997 to December 2007, the skewness values for the MSCI World and ACWI were -0.108 and -0.155, with kurtosis values of 5.172 and 5.144 respectively. The results produced here, as displayed in Panel A, show that whilst the kurtosis values produced for the two world indices are similar to those from Marais (2008) study, and both indices are found to leptokurtic, the skewness values are very close to 0, which indicates that over the longer period of 1990 – 2010, the returns approximated a normal distribution. This stands in contrast to the values from Marais (2008) analysis where he found that the returns were negatively skewed. The skewness and kurtosis values for the JSE ALSI are -1.13 and 8.53 respectively, which shows that the returns on the JSE are both negatively skewed and leptokurtic. This result is similar to that of Hearn and Piesse (2002: 1718), who found a skewness value of -1.9680 and kurtosis value of 9.6796 over the period of August 1993 to January 2000. Mangani (2007: 66) also found that over his study period of 1983 – 2002, the skewness value was -1.042 for the JSE ALSI, whilst the kurtosis value was 9.294.

The final value which is important in determining if the returns are normally distributed or not is that of the Jarque-Bera statistic. If the level of significance ( $\alpha$ ) is set at 1%, and the p-values are evaluated, it can be seen that for all three of the market portfolios the null hypothesis of normality can be rejected as the p-value produced is less than the alpha. This result conforms to DeSantis and Gerard (1997: 1890), Korkmaz *et al* (2010: 40), Arouri (2006:77), who also found that the MSCI World Index is non-normally distributed, whilst Page (1993, 90) and Korkmaz *et al* (2010: 40) all found that the JSE ALSI is also non-normally distributed. In Marais (2008: 77) study, he evaluated the normality of the series by using the Shapiro-Wilk W Normality test on a yearly basis instead of using the Jarque-Bera test on the full sample which was used here, but also found that both the MSCI World and ACWI were consistently found to be non-normally distributed.

Panel B in table 5-1 indicates the associated descriptive statistics for each of the industry portfolios utilised. From the table, it can be seen that all the industries exhibit positive returns over the twenty one year sample period, and for the industries which have higher returns such as Platinum and Technology, this is also accompanied by higher standard deviation values. Whilst a majority of the portfolios exhibit standard deviation measures which are higher than that of the market (JSE ALSI),



there are a few which are less risky than the market, viz. Insurance, Banks and Financial Services, Property, Automobiles, Other Industrials, Food and Beverage companies, Personal and household goods as well as the Retail industry.

When analysing the obtained values for skewness, it can be seen that the two portfolios of General Mining and Personal and Household Goods are the only two which seem almost symmetrical as both their values are very close to 0. Of the remaining portfolios, eight have negative values which indicate that they are negatively skewed, whilst ten of the portfolios are positively skewed. It can also be seen that all of the portfolio values obtained for kurtosis are greater than 3, which indicates that all the portfolios are leptokurtic. When alpha is set at 5% and even 10%, the p-values for the Jarque-Bera statistic indicate that for all portfolios besides Healthcare, the returns are not normally distributed.

### **5.2.3. Correlations**

The correlation of the variables used in this study viz. the three world portfolios, as well as the currencies, all of which are expressed in Rands, are reported in table 5-2 below:

**Table 5-2. Correlations between the market indices and the currencies used in the study**

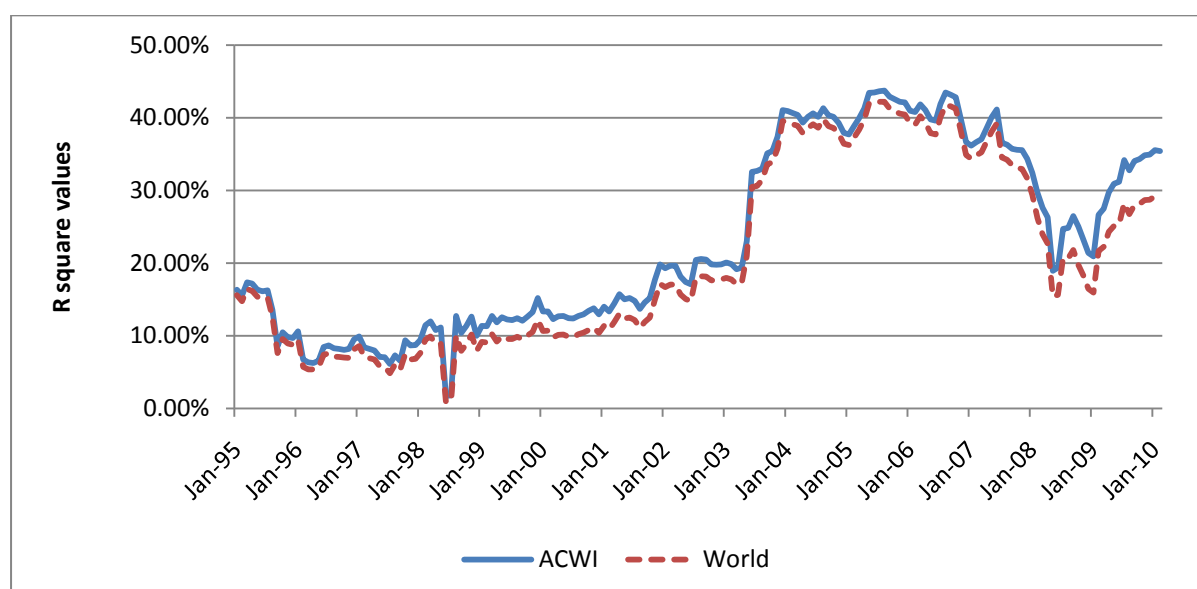
	<b>JSE</b>	<b>MSCI World</b>	<b>MSCI ACWI</b>	<b>Dollar</b>	<b>Euro</b>	<b>Pound</b>	<b>Yen</b>
<b>JSE</b>	1.00						
<b>MSCI World</b>	0.442	1.00					
<b>MSCI ACWI</b>	0.470	0.998	1.00				
<b>Dollar</b>	0.098	-0.53	-0.51	1.00			
<b>Euro</b>	0.070	-0.46	-0.44	0.745	1.00		
<b>Pound</b>	0.096	-0.50	-0.48	0.783	0.862	1.00	
<b>Yen</b>	0.073	-0.46	-0.44	0.772	0.723	0.679	1.00

The correlations produced for the currency factors, as displayed in table 5-2 indicates that whilst the currencies share high correlations with each other, their correlations with the JSE ALSI is quite low. The values produced for the MSCI World and MSCI ACWI are higher, albeit they are negatively correlated with all the currencies. The preceding table also shows that the MSCI world and MSCI ACWI are almost completely correlated, which is a result that is expected in light of the fact that their

descriptive statistics in table 5-2 did not differ much. The JSE has relatively low correlations with both the World indices, with the correlation value at 0.442 for the MSCI World Index and a slightly higher value of 0.470 with the MSCI ACWI. Whilst the correlation value was only marginally higher for the ACWI than the MSCI World Index, this result is expected as the ACWI includes various emerging markets including South Africa, whilst the MSCI World Index does not.

However the low values obtained for both indices may indicate that for South African companies which are exposed to foreign risks in the global market, the JSE alone may not be a satisfactory factor as it will be unable to capture all the risks present. This matter can be investigated further by regressing the domestic market index (JSE) against the two world market indices (MSCI World and MSCI ACWI), in a method reminiscent of Karolyi and Stultz (2002). In their study, Karolyi and Stultz (2002: 8) postulate that if a regression of the local market index against the global index produces a high  $R^2$  value, this indicates that the domestic market index is sufficient for pricing assets. The analysis was done over a rolling period, similar to the first pass regressions in Fama-Macbeth's (1973) method, and the following graph was obtained:

**Figure 5-2. Graph of the rolling  $R^2$  values in a regression between the JSE and the MSCI World Index, and the JSE and the MSCI ACWI**



The preceding graph was obtained by regressing the JSE ALSI returns against the MSCI World Index, and then the MSCI ACWI. The initial regression was performed over the period of February 1990 to January 1995 (60 full months of data), after which the sample was rolled one month forward, and the

regression was re-estimated. This process was performed until the final date of February 2010, at which point the resulting  $R^2$  values were graphed, as shown in figure 5-2.

An interesting observation from the graph is that whilst in the initial years of the study, the difference in  $R^2$  estimates between the MSCI World Index and the ACWI was small, this difference increased as time went by, particularly from 2008 onwards. This phenomenon may be due to the US subprime crisis which occurred at that time and resulted in a worldwide financial crisis. An analysis of the actual figures shows that the difference in  $R^2$  estimates increased from 0.77% in Jan 1995, up to 6.3% in February 2010. This may be an indication that the ACWI will be a better proxy for the world market index in South Africa than the MSCI World Index. This issue will be examined further in later sections.

### **5.3. Fama-Macbeth (1973) two pass regression approach**

The first method of analysis which was conducted was the unconditional approach of Fama-Macbeth (1973). The first and second passes will be discussed separately.

#### **5.3.1. First pass regression results**

The first pass regression consisted of rolling time-series regressions of the excess returns of each of the assets, against the excess return on the market. Whilst the rolling beta estimates were used as inputs for the second pass of the estimation process, the rolling adjusted  $R^2$  estimates were also obtained, and then averaged across each model and for each industry portfolio. The results are displayed in table 5-3.

**Table 5-3. Average Adjusted  $R^2$  values for the FM first pass regressions**

	DCAPM	ICAPM (MSCI World)	ICAPM (ACWI)	ICAPM <sup>EX</sup> (MSCI World)	ICAPM <sup>EX</sup> (ACWI)
<b>Automobiles &amp; Parts</b>	32.78%	5.35%	5.76%	16.86%	17.10%
<b>Banks &amp; Financial Services</b>	41.67%	4.45%	5.46%	25.05%	26.02%
<b>Basic Resources</b>	24.19%	3.99%	4.85%	8.88%	9.70%

	DCAPM	ICAPM (MSCI World)	ICAPM (ACWI)	ICAPM <sup>EX</sup> (MSCI World)	ICAPM <sup>EX</sup> (ACWI)
<b>Building and Construction</b>	27.71%	1.15%	1.60%	8.78%	9.40%
<b>Chemicals, Oils &amp; Gas</b>	30.44%	3.01%	3.50%	7.55%	8.23%
<b>Industrial Engineering</b>	21.19%	1.59%	1.91%	8.65%	9.01%
<b>Food and Beverage</b>	31.31%	2.68%	3.39%	8.80%	9.36%
<b>General Mining</b>	29.75%	5.11%	5.94%	13.25%	14.06%
<b>Gold Mining</b>	18.36%	0.50%	0.79%	1.92%	2.32%
<b>Healthcare</b>	9.94%	-0.01%	0.32%	9.12%	9.44%
<b>Insurance</b>	41.48%	4.14%	5.01%	28.21%	28.98%
<b>Media</b>	12.76%	1.41%	1.74%	9.90%	10.10%
<b>Other Industrial</b>	40.54%	2.24%	3.08%	16.92%	17.58%
<b>Personal &amp; Household Goods</b>	16.14%	-0.12%	0.22%	9.00%	9.38%
<b>Platinum, Diamonds, Coal and Precious Metals</b>	24.74%	7.64%	8.50%	7.51%	8.05%
<b>Property</b>	18.81%	-0.56%	-0.29%	12.75%	13.21%
<b>Retail</b>	29.89%	0.90%	1.37%	23.25%	23.64%
<b>Technology &amp; Electrical</b>	36.70%	6.17%	7.23%	21.22%	21.96%
<b>Industrial Transport</b>	27.79%	1.72%	2.34%	13.70%	14.19%
<b>Travel and Leisure</b>	20.28%	0.57%	0.97%	7.71%	7.99%
<b>Average</b>	<b>26.82%</b>	<b>2.60%</b>	<b>3.18%</b>	<b>12.95%</b>	<b>13.49%</b>

From this table, it can be seen that over the full sample estimation period of February 1990 to February 2010, the domestic CAPM outperformed all of the international models in terms of explanatory power. This result holds true for all twenty portfolios, with the Banks and Financial Services industry displaying the highest explanatory power (41.67%); and the Healthcare industry group displaying the lowest explanatory power of 9.94%, with all five models performing very poorly

for this industry group. Whilst the average  $R_{adj}^2$  value for the DCAPM model is not that high at 26.82%, this value is still approximately 13% greater than the second ranked model in the analysis, the ICAPM<sup>EX</sup> (ACWI) – which has an average  $R^2$  value of 13.49%. Furthermore, as stated in Duke University (2008: 1), an  $R^2$  value of about 25% is respectable when applied to differenced (stationary) return series, such as the ones used in this study.

The model which displayed the next highest  $R_{adj}^2$  values was that of the ICAPM<sup>EX</sup> (ACWI), and the ICAPM<sup>EX</sup> (MSCI) which displayed marginal differences in their respective values. Whilst for some industry groups such as Food and Beverage, as well as Automobiles and Parts, the DCAPM displayed much larger  $R_{adj}^2$  values than the ICAPM<sup>EX</sup> models, for others such as Healthcare and Media, the difference between the two estimates was very small, which suggests that the presence of exchange rate risk factors are important influences in these two industry groups. The performance of both single-factor ICAPM models was dismal as the average  $R_{adj}^2$  values for both models fell at less than 4%. Whilst the Technology, Platinum, General Mining and Banking industries did exhibit the highest  $R_{adj}^2$  values for the single-factor ICAPM models, these industries were still dominated by the DCAPM model. This may suggest that the DCAPM model is sufficient for use in the South African environment.

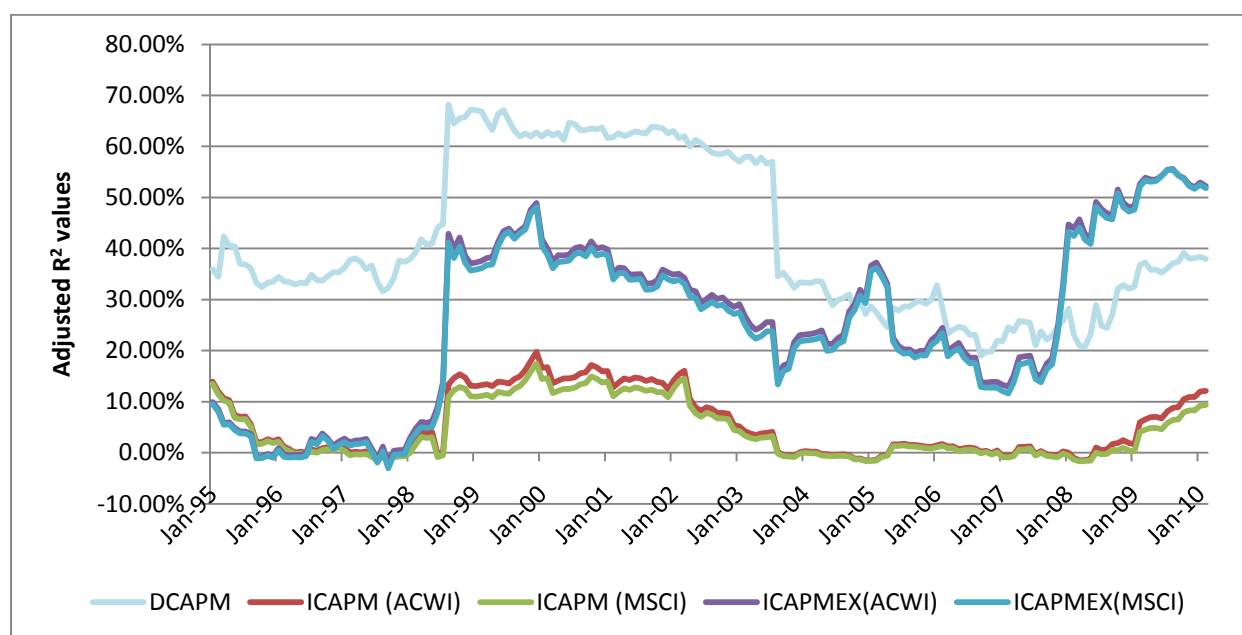
The rolling  $R_{adj}^2$  values were also graphed for each industry portfolio. Since there are twenty different industries in this study, twenty different graphs were obtained; however in order to save space only four are displayed and discussed here. The remainder are displayed in appendix A.

The four industry graphs which were chosen to be presented here are those of:

- Banks and Financial Services;
- Automobiles and Parts;
- Platinum, Diamonds, Coal and Precious metals, and
- Healthcare.

These four were chosen as they represented to a large extent what was observed in many of the other industry groups. The respective graphs are shown as follows:

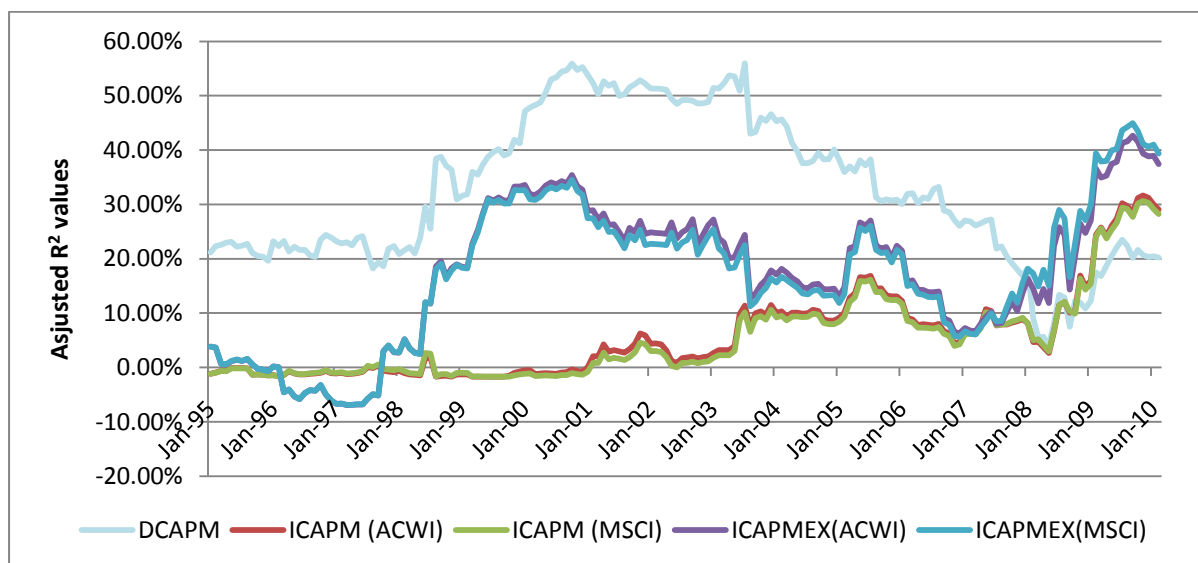
**Figure 5-3. Graph of Rolling adjusted R<sup>2</sup> estimates for the Banks and Financial Services Industry Group.**



The above graph shows that in the earlier years of the analysis, the DCAPM consistently produced the highest R<sup>2</sup> values, and therefore displayed the greatest explanatory power from all five of the models tested. However this models superiority started declining from June 2000, and in November 2007, the ICAPM<sup>EX</sup> models overtook the DCAPM in explanatory power. When observing the ICAPM and ICAPM<sup>EX</sup> models, it can be seen that the model with the MSCI World Index produces R<sup>2</sup> estimates which are the same/very similar to those produced by the ACWI. This result is expected as these two indices are very closely correlated, as shown in section 5.2.3.

In the earlier years of January 1995 up till 1998, the ICAPM and ICAPM<sup>EX</sup> models displayed similar values, all of which were very low. However in August of 1998, the explanatory power of the ICAPM<sup>EX</sup> models increased drastically in significance, with the R<sup>2</sup> value increasing from 12.91% in July 1998, to 41.16% in August 1998. This result is interesting as the dates coincide with the Asian crisis of 1998, and it shows that the presence of exchange rate risk has an important effect on asset returns, especially in times of financial crises. It can also be seen that from the latter half of 2007, the ICAPM<sup>EX</sup> models overtook the DCAPM model in terms of explanatory power. This again coincides with the sub-prime crisis in the US, which reinforces the previous conclusion that exchange rate risk has a larger effect when the South African economy faces a crisis.

**Figure 5-4. Graph of rolling adjusted R<sup>2</sup> estimates for the Automobiles and Parts Industry**



The preceding graph is similar to that produced for the Banks and financial services industry group, as the DCAPM model is consistently superior up till 2008. Similarly, the ICAPM<sup>EX</sup> model's explanatory power increases drastically during the 1998 year. However, for this industry group the ICAPM models display greater significance, with the ICAPM model surpassing the superiority of the DCAPM during 2008. However, similar to the previous result, it was found that the ICAPM<sup>EX</sup> model provides the highest explanatory power from January 2008 onwards.

**Figure 5-5. Graph of rolling adjusted R<sup>2</sup> estimates for the Platinum, Diamonds, Coal and Precious metals industry**

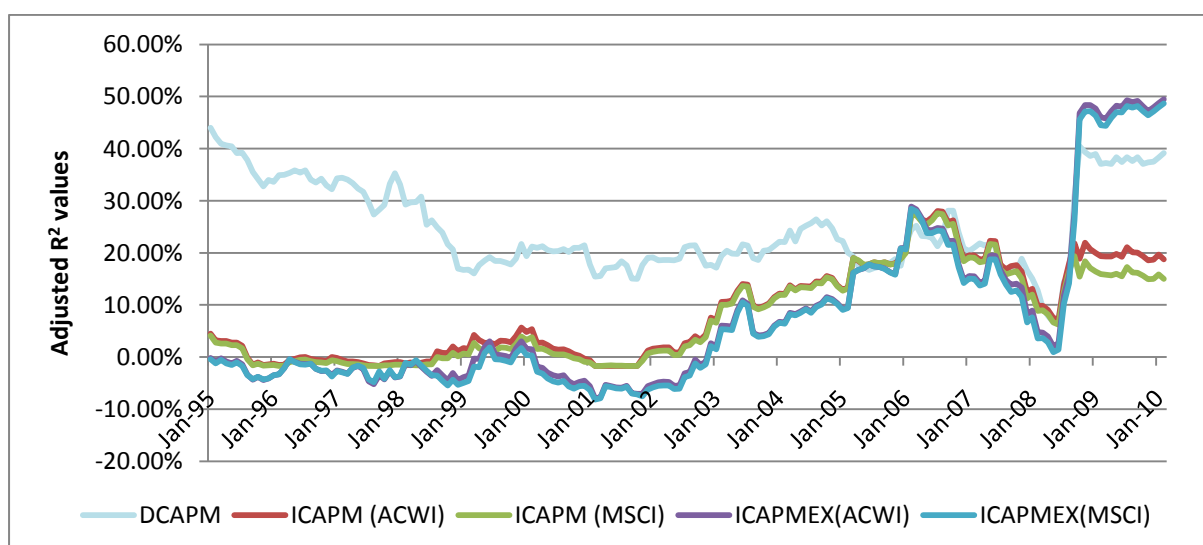
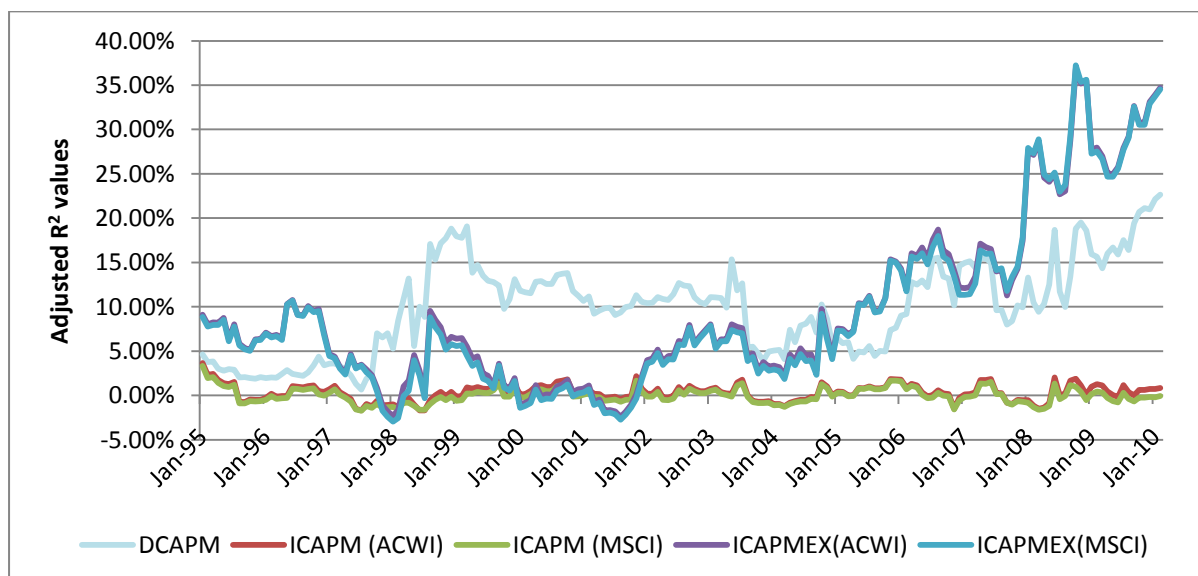


Figure 5-5 shows that whilst the DCAPM model was superior from 1995 till 2005, the adjusted  $R^2$  values were on a declining trend, which shows that the explanatory power of the DCAPM on the precious metals portfolio was decreasing over time. Similarly, whilst the ICAPM and ICAPM<sup>EX</sup> models exhibited extremely low values in the earlier years, after 2003, the values for these models started increasing. Whilst the single-factor ICAPM models displayed superior explanatory power to the ICAPM<sup>EX</sup> models consistently from 1995 till 2005, all five models estimated displayed comparative values from 2005 until 2008, after which the explanatory power of the ICAPM<sup>EX</sup> model increased significantly, to become the superior model of the five which were examined. The results found for the Precious metals industry were similar to those produced in the General Mining, and Basic resources industries. However an interesting factor to note when looking at the Gold mining industry (shown in appendix A) is that whilst the DCAPM was shown to be superior during the entire testing period, the explanatory power of all five models declined drastically from 2008 onwards. This result stands in stark contrast to the results of the other portfolios which comprised of mining companies.

**Figure 5-6. Graph of rolling adjusted  $R^2$  estimates for the Healthcare industry**



Whilst for all of the other industry groups, the DCAPM model was found to be the best model during the early years of the study, for healthcare it was found that the ICAPM<sup>EX</sup> model was superior from January 1995 up to mid 1997. Thereafter, whilst the DCAPM model's explanatory power increased from 1997 till the 2003, the ICAPM<sup>EX</sup> models were again found to be the best model from 2003 to February 2010. However, the single-factor ICAPM model displayed very low adjusted  $R^2$  values throughout the entire sample.



The results from the graphs paint a different picture from the overall results of the average  $R_{adj}^2$  values shown in table 5-3. Whilst the table showed that the DCAPM was the superior model over the entire sample period for all industry groups, the graphs produced show that even though the DCAPM was the best model for use during the earlier years of the study, the explanatory power of the ICAPM<sup>EX</sup> models have increased over time, and over recent years, this model is the best one for estimating asset returns in South Africa. This would therefore lead to the conclusion that the South African market is becoming increasingly integrated over time. However these results are not conclusive and it should be noted that the best model to be used changed over time and between industries. The results of the second pass will now be displayed in order to determine the significance and statistical rank of each of the models.

### **5.3.2. Second pass regression results**

The second pass results were evaluated in two ways. The first method looked at the alpha values obtained in order to determine whether each of the models is priced in the South African environment or not. Since these values were obtained by making use of panel data regressions, the preliminary panel data analyses is discussed before the actual results. The second method evaluated the information criteria in order to determine which model was superior according to each. A discussion of each of these two methods ensues.

#### **5.3.2.1. Preliminary panel data analyses**

The second pass of the FM method entailed a panel regression, as outlined in chapter 4 (section 4.6.1). Therefore, before any regression was estimated, it was necessary to carry out two tests in order to determine whether the data contains fixed or random effects, and whether these effects occur in the cross-sectional or time dimension. The first test conducted was therefore the Redundant Fixed Effects test, the results of which are as follows:

**Table 5-4. Results of Redundant Fixed Effects test**

<b>Test for cross-section and period fixed effects</b>			
<b>Effects test</b>	<b>Statistic</b>	<b>Degrees of Freedom</b>	<b>P-value</b>
Cross-section F	66.155	(19,3438)	0.0000
Cross-section Chi-Square	1134.2128		0.0000
Period F	26.3514	(181,3438)	0.0000

Period Chi-square	3167.4265		0.0000
Cross-Section/Period F	33.0256	(200,3438)	0.0000
Cross-section/Period Chi-square	3902.0743		0.0000

The preceding results show that for all three of the restrictions tested, the null hypothesis of redundant fixed effects was rejected due to the resulting p-values being less than the 5% level of significance. This therefore implies that the data contains fixed effects across both dimensions. The second test which was implemented is the Hausman test, which tests the RE model against that of FE to determine which is more suited by the data. The results produced are as follows:

**Table 5-5. Results of Hausman test**

<b>Test for cross-section and period random effects</b>			
<b>Test Summary</b>	<b>Chi-Square Statistic</b>	<b>Chi-Sq degrees of freedom</b>	<b>P-value</b>
Cross-section random	0.00000	1	1.000
Period random	0.00000	1	1.000
Cross-section and period random	0.00000	1	1.000
*Cross-section test variance is invalid. Hausman Statistic set to zero.			
*Period test variance is invalid. Hausman Statistic set to zero.			

Whilst the resultant p-values across all the restrictions are found to be greater than alpha, thus implying that the null hypothesis cannot be rejected, and the RE model is appropriate, the Eviews output also returns an error with the results, displayed in the last two rows of the above table. This phenomenon was discussed previously in section 4.6.1. Based on the previous discussion, since it was found that both cross-section and period dimensions have no variance, it can effectively be concluded that there are no random effects present in the data, and the fixed effects specification is appropriate.

The results produced here are similar to those of Brooks (2007: 506) in his simulation of the FM method using panel data methods, where he also finds that FE in both dimensions is appropriate or his

data. However Brooks (2007: 507) decides to eliminate the cross-sectional fixed effects from his analysis as the results for this model is “not qualitatively different from those of the initial pooled regression”, and he thus chooses to estimate his model with fixed period effects only. This study also finds similar results as the result of a regression in which both cross-section and period are fixed results in very similar coefficients and standard error estimates to that of the pooled regression. Therefore, the decision was taken that instead of estimating the model with fixed effects across both dimensions, one dimension would be chosen based on the theoretical evidence surrounding the subject.

Esterer and Shroder (2010: 13) argue that in the context of asset pricing tests, introducing an effect for each cross-sectional unit enables the model to capture other determinants of firm risk that might not be reflected by the other risk measures in the model, whilst the time effect captures the broad market valuation cycles that are not attributable to individual firms. Since the prime focus of this study is simply on evaluating whether the parameters included in the CAPM models are sufficient to capture the variation in returns, and not to determine if there are other risk factors applicable, the cross-sectional fixed effect is considered to be unnecessary. Furthermore, due to the large number of financial crises and which occur during the time period used in this study, it is considered more important to allow for the intercepts to vary across time than across cross-sections. This conclusion is confirmed by Petersen (2009: 435) who finds that the time effect is likely to be more prominent in equity returns. The panel data regression was therefore only estimated by making use of a fixed time effect, the results of which will now be displayed and interpreted.

### **5.3.2.2. Analysis of the cross-sectional regression coefficients**

In each CAPM model estimated, the  $\gamma_0$  value represents the intercept of the model. As stated in chapter 4, if this value is statistically significant, it implies that the model is insufficient for pricing assets as there are other factors which have an influence on returns that are not accounted for in the model. The market portfolios in all five models are the  $\gamma_1$  estimates, which should a statistically significant factor according to CAPM theory; whilst in the ICAPM<sup>EX</sup> models, the four exchange rates of the dollar, euro, pound and yen are denoted as:  $\gamma_2, \gamma_3, \gamma_4, \gamma_5$ .

For the variables  $\gamma_1$  to  $\gamma_5$ , the statistical significance of these were also evaluated. If a variable is statistically significant, this means that it is a relevant factor in the estimation of expected returns,

whereas if it is not statistically significant this implies that the factor can be eliminated. The results are shown in table 5-6:

**Table 5-6. Estimated gamma coefficients for the FM second pass regression.**

One asterisk (\*) denotes statistical significance at the 1% level, two asterisks (\*\*) denotes statistical significance at the 5% level, and three asterisks (\*\*\*) denote statistical significance at the 10% level

<b>Domestic CAPM</b>		
<b>Variable</b>	$\gamma_j$	<b>t-statistic</b>
<b>Intercept</b>	1.143	27.89*
<b>JSE ALSI risk premium</b>	-0.29	-4.09*
<b>International CAPM (MSCI World)</b>		
<b>Intercept</b>	0.99	49.38*
<b>MSCI World risk premium</b>	-0.000596	-0.08
<b>International CAPM (ACWI)</b>		
<b>Intercept</b>	0.98	46.96*
<b>ACWI risk premium</b>	0.000867	0.013
<b>ICAPM<sup>EX</sup> (MSCI World)</b>		
<b>Intercept</b>	1.12	38.04*
<b>MSCI World risk premium</b>	0.12	1.78**
<b>Dollar</b>	-0.32	-6.36*
<b>Euro</b>	-0.55	-8.76*
<b>Pound</b>	-0.28	-5.00*
<b>Yen</b>	-0.62	-7.77*
<b>ICAPM<sup>EX</sup> (ACWI)</b>		
<b>Intercept</b>	1.11	36.69*
<b>ACWI risk premium</b>	0.13	1.91**
<b>Dollar</b>	-0.32	-6.49*
<b>Euro</b>	-0.56	-8.92*
<b>Pound</b>	-0.29	-5.19*
<b>Yen</b>	-0.63	-7.97*

The intercept coefficients produced in each of the five estimated CAPM models were all found to be highly statistically significant at an alpha of 1%. This therefore may be an indication that there are risk factors other than the systematic risk of an asset which should be accounted for when estimating expected returns, in which case the CAPM model would be inadequate for this purpose. When looking at the DCAPM model, it can be seen that the estimate for the JSE ALSI risk premium is both negative and statistically significant. Whilst contrary to theoretical expectations, a result of this sort is not unusual as other studies such as Pettengill, Sundaram and Mathur (1995), Boudoukh, Richardson

and Smith (1993), Arnott and Ryan (2001), Arnott and Bernstein (2002), Van Rensburg and Robertson (2003) and McGill (2005) also found evidence of negative market risk premiums.

In McGill's (2005: 1) investigation of the historical South African equity premium from 1925 to 2004, she found negative risk premiums consistently over the latter twenty years of her analysis period. This result was also found in the Salomons and Grootveld (2003: 10) study of equity risk premiums in developed and emerging markets, as they discovered that over the period of 1994-2001, the average monthly risk premium for South Africa was -0.35%, a coefficient value which is close to the -0.29% estimate displayed in table 5-6. In their study of US asset data from 1936 to 1990, Pettengill *et al.* (1995: 103) found that a possible reason for the negative market risk premium produced is because the return on the risk free rate exceeded equity returns for 42% of the months in their sample period. When this approach was replicated in this study, a similar result was found, as from the 241 months included in the sample period, negative market risk premiums were found for 112 of these months, which amounts to a percentage of 46.5%.

The approach then taken by Pettengill *et al.* (1995: 107) was to estimate the cross-sectional regression with an additional dummy variable which allows for the effect of a negative market premium in particular months. Their approach was therefore adopted in this study in order to provide possible reasons for the results produced. A dummy variable ( $D$ ) which takes the value of 1 when the market risk premium is negative, and 0 when the market risk premium is positive, was therefore generated and included in a pooled regression of the DCAPM model, which takes the following form:

$$E(R_p) - R_f = \alpha_0 + \alpha_1\beta_p + \alpha_2D + \varepsilon$$

The results produced from the preceding regression are displayed below:

Variable	Coefficient	t-statistic
$D$	-0.21	-5.49

From the above results, it can be seen that the dummy variable is statistically significant, which therefore indicates that a possible reason for the negative JSE ALSI premium displayed in table 5-6 is due to the downturns in the South African market over the twenty year sample period.

When evaluating the world market risk premiums produced in the four ICAPM models estimated, it can be seen that in the single-factor models, both the MSCI World Index, as well as the ACWI are both statistically insignificant. However when these indices are estimated together with exchange

rates in the multifactor ICAPM<sup>EX</sup> models, the resultant premiums are both statistically significant, as well as positive, which conforms to the theory surrounding the models. Each of the exchange rate indices utilised are also found to be statistically significant, with all four of these variables exhibiting a negative correlation with expected returns.

This result echoes the negative correlations found in table 5-2, and suggests that asset returns in South Africa benefit when the rand strengthens against any of the four currencies being used in this study. Overall, the analysis of the coefficients produced from the second pass of the FM method indicates that of the five CAPM models estimated, both of the multifactor ICAPM<sup>EX</sup> models perform the best, as these models adhere to the theoretical assumptions underlying the models, viz. that the market risk premium is statistically significant and positive, and the exchange rate factors are all statistically significant in the explanation of expected returns.

### **5.3.2.2. Information criteria**

As discussed in chapter 4, there are five different information criteria which were utilised here. Whilst for  $R^2$  and adjusted  $R^2$ , the highest values indicate the best models, for the remaining three information criteria, the lowest values indicate the best models. The results are displayed in table 5-7:

**Table 5-7. Information criteria for the FM method**

	DCAPM	ICAPM (MSCI World)	ICAPM (ACWI)	ICAPM <sup>EX</sup> (MSCI World)	ICAPM <sup>EX</sup> (ACWI)
<b>R<sup>2</sup></b>	55.59%	55.38%	55.38%	56.73%	56.74%
<b>Adjusted R<sup>2</sup></b>	53.25%	53.03%	53.03%	54.40%	54.41%
<b>AIC</b>	2.438	2.443	2.443	2.415	2.414
<b>SBIC</b>	2.750	2.755	2.755	2.733	2.733
<b>HQIC</b>	2.549	2.554	2.554	2.528	2.528

The data presented in table 5-7 indicates that the ICAPM<sup>EX</sup> models perform the best out of the models tested, across all five of the information criteria, a result which differs from the first pass regression results, but concurs with the analysis of the coefficients from the second pass. This result holds true, not just for the AIC and  $R^2$  criteria, which are expected to bias towards the larger models being tested, but also for the SBIC which imposes stricter restrictions. An important observation is that there is no

visible difference between the resulting estimates for the ACWI and the MSCI World Index. This may be an indication that there is no difference between these two world indices and the use of either would be appropriate in the South African environment.

Upon analysis of the figures produced for the other models estimated, it can be seen that there are marginal differences between each of these models. For example, the difference in adjusted  $R^2$  value for the DCAPM and ICAPM<sup>EX</sup> (ACWI) model is a mere 1.16%, whilst the difference between the ICAPM (ACWI) and ICAPM<sup>EX</sup> (ACWI) is a similar value of 1.38%. This trend can be seen across all five of the information criteria employed. This observation may indicate that the use of the DCAPM model in the South African environment could be considered sufficient as the inclusion of global variables do not result in any significant increase in explanatory power. However, this possibility is not conclusive and the results from the other tests utilised should be examined as well. The next section therefore outlines the results produced from the forecasting analysis.

### **5.3.2.3. Forecasting**

A forecasting analysis was conducted from the second pass regression estimates, after which the MAE and RMSE estimates were collected and tabulated. The results are shown in table 5-8 below:

**Table 5-8. Forecasting statistics**

	<b>DCAPM</b>	<b>ICAPM (MSCI World)</b>	<b>ICAPM (ACWI)</b>	<b>ICAPM<sup>EX</sup> (MSCI World)</b>	<b>ICAPM<sup>EX</sup> (ACWI)</b>
<b>MAE</b>	0.752	0.731	0.730	0.763	0.767
<b>RMSE</b>	1.00	0.994	0.991	1.025	1.028

The results of the forecasting analysis stand in contrast to those produced from the other analyses, as these results show that the single factor ICAPM (ACWI) is the superior model, as this model produces the smallest RMSE and MAE values. However, the difference between the ACWI and MSCI World indices are again found to be marginal, for both the single-factor and multifactor models. The results shown in the above table show that, in contrast to the results previously outlined, the ICAPM<sup>EX</sup> models perform the worst under the forecasting analysis.

#### **5.3.2.4. Summary of Fama-Macbeth (1973) results**

The results of the first pass, second pass and forecasting analyses all indicated that different models were superior. These results are summarised in table 5-9:

**Table 5-9. Summary of FM model selection**

<b>Method of analysis</b>	<b>DCAPM</b>	<b>ICAPM (MSCI World)</b>	<b>ICAPM (ACWI)</b>	<b>ICAPM<sup>EX</sup> (MSCI World)</b>	<b>ICAPM<sup>EX</sup> (ACWI)</b>
<b>FM first pass</b>	X				
<b>FM second pass : Coefficients</b>				X	X
<b>Information criteria</b>					X
<b>Forecasting</b>			X		

The above table shows that thus far, the results are largely inconclusive as each of the different methods used have selected three different models as superior. Whilst the first pass results selected the DCAPM model as the best one for use, the second pass coefficient and information criteria results indicated that the ICAPM<sup>EX</sup> models performed the best, and the forecasting results concluded that the single-factor ICAPM (AWCI) model was superior to the other four models tested. Whilst the only common trend in the analysis thus far is that there is not much difference in the two world indices used, the pivotal question of whether exchange rates should be included in the study or not cannot be conclusively answered based on these results. Considering the volatility inherent in exchange rates, this question may therefore be answered when analysing the results of the conditional GARCH approach, which will now be discussed further.

#### **5.4. GARCH Estimation**

The second method of estimation which was used was the conditional GARCH model. The method followed a two-pass approach reminiscent of the Fama-Macbeth (1973) method already discussed. The results of the preliminary analysis will be reported first, after which results of the first and second pass will be discussed further.



### 5.4.1. Preliminary GARCH analysis

The preliminary analysis for the GARCH approach made use of calculated autocorrelation coefficients and Ljung-Box Q-statistics which indicate whether serial dependence is present in the data being tested. The results are shown in table 5-10.

**Table 5-10. Autocorrelation coefficients for each of the twenty industry portfolios being utilised in this study. The autocorrelations were tested up to 12 lags, with any value less than -0.126 or greater than 0.126 being considered statistically significant. All statistically significant coefficients are highlighted in blue. The Q-statistic for lag 12 is also reported. One asterisk (\*) denotes statistical significance at the 1% level, two asterisks (\*\*) denotes statistical significance at the 5% level, and three asterisks (\*\*\*) denote statistical significance at the 10% level, and all statistically significant Q-statistics are highlighted in pink**

Industry	Lag 1	Lag 2	Lag 3	Lag 12	Q(12)
<b>Industry Portfolios</b>					
Automobiles & Parts	0.314	0.162	0.115	0.126	(51.874)*
Banks & Financial Services	0.190	0.077	0.075	0.155	(29.122)*
Basic Resources	0.052	0.077	0.127	0.059	10.384
Building and Construction	0.414	0.190	0.106	-0.004	(71.958)*
Chemicals, Oils & Gas	-0.131	0.002	-0.089	-0.150	(31.567)*
Industrial Engineering	0.268	0.129	0.157	0.189	(48.903)*
Food and Beverage	0.171	0.059	0.014	0.046	14.901
General Mining	0.220	0.222	0.149	0.002	(37.422)*
Gold Mining	0.044	0.095	-0.064	0.026	10.548
Healthcare	0.056	0.108	0.011	0.046	10.350
Insurance	0.243	0.039	0.044	0.090	(20.657)***
Media	0.021	0.033	0.038	0.058	13.875
Other Industrial	0.245	0.103	0.075	0.142	(35.293)*
Personal & Household Goods	0.321	0.069	0.120	0.027	(41.494)*
Platinum, Diamonds, Coal and Precious Metals	0.268	0.170	0.166	0.041	(47.040)*
Property	0.192	0.009	-0.065	0.054	14.914
Retail	0.262	0.021	0.057	0.049	(24.287)**
Technology & Electrical	0.298	0.142	0.056	0.116	(53.257)*
Industrial Transport	0.071	0.029	0.021	0.085	16.244
Travel and Leisure	0.215	-0.014	0.067	0.121	(23.820)**

The preceding table shows that there exists significant serial dependence in a majority of the portfolios utilised in this study. Sixteen of the twenty portfolios used display significant autocorrelation coefficients in at least one lag of the series, with six portfolios still exhibiting statistically significant serial correlation at the maximum lag of 12. This result is reinforced when evaluating the Q-statistic values, as for thirteen of the portfolios; this statistic is significant at the maximum lag of twelve. The results of this table therefore indicate that the GARCH model may be an appropriate one for modelling the CAPM equations. This will therefore be analysed further, by first looking at the first pass regression results, after which the second pass results will be discussed.

#### **5.4.2. First pass GARCH estimation**

The first pass of the Fama-Macbeth (1973) model made use of rolling regressions to obtain the betas and  $R^2$  values. However, in the GARCH approach, the GARCH (1, 1)-M model was estimated over the full sample period of February 1990-February 2010. The resultant coefficients produced are showed in table 5-11 and table 5-12, together with their corresponding z-statistics.

When looking at the DCAPM model estimates shown in table 5-11, it can be seen that the JSE market portfolio is statistically significant at the 1% level for all twenty of the industry portfolios. According to the theory underlying the CAPM models, the intercept  $\theta_0$  should be statistically insignificant, and whilst this is the case for thirteen of the industry portfolios, the remaining seven portfolios (Automobiles and Parts, Banks and Financial Services, Food and Beverage, Insurance, Media, Platinum and Technology) all display statistically significant intercepts. This would imply that for these seven industry groups, there are other risk factors other than the JSE risk premium which have an effect on expected returns.

Standard CAPM theory also states that the  $\lambda$  coefficient (which is representative of market risk aversion) should be statistically significant and positive. However this variable is only found to be statistically significant for the two industries of Automobiles and Insurance, and the coefficient in both of these cases is negative. Whilst nine of the industry portfolios did display positive coefficient values, the only portfolio which is viable is that of Property, for which the coefficient is statistically significant at 11% level of significance. An interesting observation is that all the betas produced for the JSE market portfolio are found to be both statistically significant, as well as positive, a result which is conducive to the theory underlying the model.

**Table 5-11. The single-factor models (DCAPM, ICAPM (MSCI), ICAPM (ACWI)) GARCH (1, 1)-M model coefficient estimates for each of the industry portfolios.**

In the table below, z-statistics are displayed in parenthesis (), and one asterisk (\*) denotes statistical significance at the 1% level, two asterisks (\*\*) denotes statistical significance at the 5% level, and three asterisks (\*\*\*) denote statistical significance at the 10% level

Industry	DCAPM			ICAPM (MSCI)			ICAPM (ACWI)		
	$\theta_0$	JSE	$\lambda$	$\theta_0$	MSCI	$\lambda$	$\theta_0$	ACWI	$\lambda$
<b>Automobiles &amp; Parts</b>	1.61 (1.92)***	0.49 (9.57)*	-0.07 (-1.80)***	2.53 (2.37)**	0.19 (2.60)*	-0.07 (-2.10)**	2.57 (2.36)**	0.20 (2.75)*	-0.08 (-2.10)**
<b>Banks &amp; Financial Services</b>	4.70 (2.01)**	0.67 (7.69)*	-0.21 (-1.57)	2.64 (2.72)*	0.33 (2.59)*	-0.05 (-1.34)	2.69 (2.63)*	0.35 (2.76)*	-0.05 (-1.33)
<b>Basic Resources</b>	-4.19 (-0.87)	0.58 (7.25)*	0.15 (1.04)	-0.11 (-0.14)	0.28 (3.91)*	0.02 (0.90)	-0.03 (-0.04)	0.31 (4.29)*	0.02 (0.91)
<b>Building and Construction</b>	0.69 (1.17)	0.50 (8.08)*	-0.004 (-0.23)	0.77 (1.44)	0.13 (1.95)**	-0.003 (-0.24)	0.77 (1.43)	0.15 (2.03)**	-0.003 (-0.26)
<b>Chemicals, Oils &amp; Gas</b>	0.56 (1.05)	0.58 (12.44)*	0.003 (0.11)	0.54 (0.66)	0.27 (2.89)*	0.004 (0.19)	0.53 (0.65)	0.28 (3.08)*	0.004 (0.19)
<b>Industrial Engineering</b>	1.27 (1.06)	0.47 (8.59)*	0.005 (0.15)	-4.10 (-2.49)**	0.16 (1.81)***	0.12 (2.27)**	0.27 (0.37)	0.24 (3.31)*	0.13 (0.56)
<b>Food and Beverage</b>	0.91 (1.65)**	0.41 (10.68)*	-0.01 (-0.26)	-5.44 (-1.20)	0.18 (3.17)*	0.35 (1.29)	-5.18 (-1.19)	0.19 (3.42)*	0.34 (1.30)
<b>General Mining</b>	3.44 (1.17)	0.70 (8.55)*	-0.09 (-0.96)	37.42 (1.21)	0.28 (3.09)*	-0.77 (-1.05)	37.92 (1.15)	0.31 (3.42)*	-0.78 (-1.00)
<b>Gold Mining</b>	-27.01 (-0.81)	0.66 (5.39)*	0.29 (0.74)	-59.58 (-0.44)	0.09 (0.60)	0.54 (0.42)	-59.50 (-0.43)	0.12 (0.76)	0.54 (0.41)

Industry	DCAPM			ICAPM (MSCI)			ICAPM (ACWI)		
	$\theta_0$	JSE	$\lambda$	$\theta_0$	MSCI	$\lambda$	$\theta_0$	ACWI	$\lambda$
<b>Insurance</b>	3.54 (3.35)*	0.58 (7.75)*	-0.21 (-2.68)*	1.53 (4.05)*	0.28 (3.76)*	-0.027 (-1.72)***	1.53 (4.05)*	0.29 (3.95)*	-0.027 (-1.75)***
<b>Media</b>	0.98 (2.21)**	0.37 (5.35)*	0.009 (0.94)	0.99 (1.90)***	0.17 (1.90)***	0.006 (0.68)	0.97 (1.87)***	0.18 (2.05)**	0.006 (0.69)
<b>Other Industrial</b>	1.51 (1.40)	0.51 (13.89)*	-0.10 (-0.89)	2.43 (2.84)*	0.16 (2.26)**	-0.09 (-1.68)***	2.47 (2.74)*	0.17 (2.43)**	-0.09 (-1.66)***
<b>Personal &amp; Household Goods</b>	-1.21 (-1.21)	0.38 (6.19)*	0.06 (1.35)	-0.82 (-0.95)	0.13 (1.89)***	0.03 (0.98)	-0.84 (-0.97)	0.14 (2.06)**	0.04 (1.00)
<b>Platinum, Diamonds, Coal and Precious Metals</b>	1.67 (1.77)***	0.63 (8.81)*	-0.01 (-0.58)	4.64 (2.30)**	0.35 (4.27)*	-0.07 (-1.65)***	4.33 (2.23)**	0.38 (4.71)*	-0.07 (-1.57)
<b>Property</b>	-0.42 (-1.01)	0.26 (8.50)*	0.08 (1.61)	1.05 (1.92)***	0.065 (1.15)	-0.03 (-0.79)	1.04 (1.94)***	0.075 (1.32)	-0.03 (-0.79)
<b>Retail</b>	3.03 (1.36)	0.48 (8.28)*	-0.09 (-0.88)	3.80 (1.71)***	0.12 (1.56)	-0.08 (-1.10)	3.82 (1.70)***	0.14 (1.71)***	-0.08 (-1.10)
<b>Technology &amp; Electrical</b>	2.39 (1.83)***	0.67 (8.55)*	-0.05 (-0.86)	2.93 (4.10)*	0.33 (4.10)*	-0.04 (-1.88)***	2.83 (4.03)*	0.35 (4.37)*	-0.04 (-1.82)***
<b>Industrial Transport</b>	0.04 (0.02)	0.43 (6.66)*	0.03 (0.49)	1.01 (1.95)***	0.21 (1.98)**	-0.004 (-0.27)	0.93 (1.51)	0.21 (1.96)**	-0.002 (-0.14)
<b>Travel and Leisure</b>	0.47 (0.56)	0.53 (7.32)*	0.006 (0.28)	0.21 (0.24)	0.20 (2.09)**	0.01 (0.74)	0.19 (0.22)	0.22 (2.25)**	0.01 (0.75)

Table 5-12. The multifactor models (ICAPM<sup>EX</sup> (MSCI) and ICAPM<sup>EX</sup> (ACWI)) GARCH (1, 1)-M model coefficient estimates for each of the industry portfolios.

In the table below, z-statistics are displayed in parenthesis (), and one asterisk (\*) denotes statistical significance at the 1% level, two asterisks (\*\*) denotes statistical significance at the 5% level, and three asterisks (\*\*\*) denote statistical significance at the 10% level. In the table below, \$ denotes the US Dollar, € denotes the Euro, £ denotes the British Pound and ¥ denotes the Japanese Yen. The exchange rates which were found to be statistically significant under each model are highlighted below (Green for the \$, Yellow for the €, Pink for the £ and blue for the ¥)

Industry	ICAPM <sup>EX</sup> (MSCI)							ICAPM <sup>EX</sup> (ACWI)						
	$\lambda$	$\theta_0$	MSCI	\$	€	£	¥	$\lambda$	$\theta_0$	ACWI	\$	€	£	¥
Automobiles & Parts	-0.08 (-2.43)**	2.83 (3.23)*	0.39 (5.49)*	-0.16 (-1.19)	-0.07 (-0.41)	0.63 (3.51)*	0.001 (0.009)	-0.08 (-2.46)**	2.80 (3.26)*	0.39 (5.59)*	-0.17 (-1.22)	-0.07 (-0.41)	0.63 (3.53)*	-0.006 (-0.05)
Banks & Financial Services	0.38 (4.69)*	-7.10 (-7.38)*	0.68 (6.09)*	0.67 (5.21)**	0.14 (0.97)	0.17 (1.09)	-0.03 (-0.24)	0.33 (4.98)*	-6.60 (-6.95)*	0.74 (6.64)*	0.66 (5.14)**	0.10 (0.67)	0.19 (1.20)	-0.02 (-0.18)
Basic Resources	0.02 (0.85)	0.20 (0.25)	0.49 (6.30)*	0.30 (2.26)**	-0.13 (-0.83)	-0.03 (-0.24)	0.27 (2.14)*	0.02 (0.60)	0.39 (0.47)	0.49 (6.30)*	0.30 (2.30)**	-0.04 (-0.29)	-0.07 (-0.52)	0.21 (1.67)**
Building and Construction	0.003 (0.21)	0.55 (1.00)	0.33 (4.38)*	0.15 (1.20)	0.09 (0.51)	0.16 (1.02)	0.06 (0.58)	0.003 (0.22)	0.52 (0.95)	0.35 (4.70)*	0.15 (1.24)	0.09 (0.52)	0.16 (1.01)	0.06 (0.56)
Chemicals, Oils & Gas	0.003 (0.11)	0.82 (0.94)	0.44 (4.79)*	-0.04 (-0.25)	-0.05 (-0.32)	0.38 (1.96)**	0.12 (1.03)	0.005 (0.21)	0.67 (0.86)	0.45 (5.46)*	-0.06 (-0.40)	-0.07 (-0.52)	0.38 (2.4)**	0.15 (1.51)
Industrial Engineering	0.007 (0.34)	0.73 (1.13)	0.37 (4.65)*	0.10 (0.76)	0.38 (1.92)**	-0.04 (-0.18)	-0.05 (-0.51)	0.01 (0.52)	0.64 (1.05)	0.36 (4.76)*	0.09 (0.65)	0.41 (2.17)**	-0.06 (-0.32)	-0.06 (-0.60)
Food and Beverage	-0.04 (-0.52)	1.34 (1.43)	0.27 (4.41)*	-0.002 (-0.02)	-0.007 (-0.07)	0.17 (1.61)	0.13 (1.74)**	0.39 (0.82)	-5.22 (0.71)	0.34 (4.62)*	0.06 (0.59)	-0.008 (-0.07)	0.20 (1.65)**	0.09 (1.16)
General Mining	-1.18 (-1.17)	51.45 (1.34)	0.57 (5.81)*	0.33 (1.92)**	0.07 (0.44)	-0.13 (-0.76)	0.26 (1.91)**	-1.16 (-0.99)	50.13 (1.22)	0.58 (6.03)*	0.33 (1.92)**	0.07 (0.39)	-0.13 (-0.76)	0.26 (1.89)**
Gold Mining	-0.006 (-0.14)	1.31 (0.25)	0.19 (1.18)	0.25 (0.84)	-0.38 (-1.32)	0.17 (0.56)	0.11 (0.57)	0.60 (0.36)	-64.84 (-0.37)	0.20 (1.31)	0.34 (1.17)	-0.22 (-0.77)	0.04 (0.14)	0.02 (0.09)

Industry	ICAPM <sup>EX</sup> (MSCI)							ICAPM <sup>EX</sup> (ACWI)						
	$\lambda$	$\theta_0$	MSCI	\$	€	£	¥	$\lambda$	$\theta_0$	ACWI	\$	€	£	¥
<b>Insurance</b>	-0.03 (-1.20)	1.51 (3.20)*	0.51 (6.00)*	0.15 (1.32)	0.17 (1.40)	0.19 (1.44)	0.02 (0.26)	-0.03 (-1.20)	1.47 (3.15)*	0.51 (6.20)*	0.15 (1.32)	0.17 (1.42)	0.19 (1.44)	0.01 (0.11)
<b>Media</b>	0.009 (1.11)	0.93 (2.08)**	0.33 (4.07)*	0.05 (0.33)	-0.005 (-0.03)	0.17 (1.34)	0.12 (1.03)	0.01 (1.14)	0.91 (2.03)**	0.33 (4.09)*	0.05 (0.30)	-0.005 (-0.04)	0.17 (1.34)	0.11 (0.96)
<b>Other Industrial</b>	-0.02 (-0.48)	1.21 (1.64)	0.40 (6.37)*	0.11 (1.19)	-0.04 (-0.41)	0.28 (2.74)*	0.14 (1.84)**	-0.02 (-0.42)	1.15 (1.52)	0.40 (6.53)*	0.11 (1.17)	-0.04 (-0.38)	0.28 (2.76)*	0.13 (1.74)**
<b>Personal &amp; Household Goods</b>	0.03 (0.83)	-0.26 (-0.33)	0.29 (3.66)*	0.20 (1.57)	0.08 (0.56)	0.05 (0.36)	0.10 (0.99)	0.03 (0.85)	-0.28 (-0.36)	0.29 (3.76)*	0.20 (1.58)	0.08 (0.57)	0.05 (0.35)	0.10 (0.94)
<b>Platinum, Diamonds, Coal and Precious Metals</b>	-0.07 (-1.41)	4.35 (2.06)**	0.47 (4.67)*	0.14 (0.76)	-0.10 (-0.47)	-0.01 (-0.05)	0.17 (1.17)	-0.06 (-1.32)	3.88 (2.02)**	0.50 (5.06)*	0.15 (0.81)	-0.10 (-0.44)	-0.01 (-0.08)	0.17 (1.19)
<b>Property</b>	0.10 (1.35)	-0.56 (-0.80)	0.18 (3.88)*	0.04 (0.55)	0.003 (0.04)	0.22 (3.11)*	0.12 (2.10)**	0.09 (1.25)	-0.43 (-0.62)	0.18 (4.03)*	0.04 (0.58)	-0.01 (-0.14)	0.24 (3.44)*	0.10 (1.76)**
<b>Retail</b>	-0.07 (-1.35)	3.03 (2.57)*	0.42 (5.81)*	0.19 (1.42)	0.004 (0.027)	0.51 (3.51)*	-0.05 (-0.43)	-0.07 (-1.36)	3.06 (2.55)*	0.42 (5.90)*	0.19 (1.42)	0.004 (0.028)	0.51 (3.47)*	-0.06 (-0.51)
<b>Technology &amp; Electrical</b>	-0.004 (-0.15)	1.78 (2.30)**	0.63 (6.70)*	0.26 (1.83)**	0.07 (0.40)	0.25 (1.69)**	0.08 (0.66)	-0.003 (-0.11)	1.73 (2.22)**	0.63 (6.84)*	0.26 (1.81)**	0.07 (0.42)	0.25 (1.70)**	0.07 (0.55)
<b>Industrial Transport</b>	-0.06 (-1.28)	3.43 (2.02)**	0.48 (4.60)*	0.43 (2.31)**	-0.10 (-0.46)	0.19 (0.91)	-0.005 (-0.04)	-0.07 (-1.30)	3.47 (2.04)**	0.50 (4.63)*	0.43 (2.34)**	-0.10 (-0.48)	0.18 (0.87)	-0.01 (-0.12)
<b>Travel and Leisure</b>	0.003 (0.16)	0.87 (0.91)	0.40 (3.50)*	-0.12 (-0.61)	0.10 (0.53)	0.31 (1.58)	0.15 (1.04)	0.004 (0.19)	0.83 (0.88)	0.41 (3.62)*	-0.11 (-0.60)	0.10 (0.57)	0.30 (1.56)	0.14 (0.96)

When analysing the products of the ICAPM (MSCI) and ICAPM (ACWI), the results produced are very similar across a majority of the industries. However, the use of the ACWI as the market portfolio improves the statistical significance of the beta estimates for the four industries of: Personal and Household goods, Media, Industrial Engineering and Retail. In particular, for the Industrial Engineering portfolio, the ICAPM (ACWI) model conforms to theory as not only is the beta coefficient more statistically significant, but the intercept produced is statistically insignificant; a result which differs from the ICAPM (MSCI) as the intercept produced there was statistically significant at the 10% level.

Whilst for the DCAPM model, the JSE market portfolio was found to be statistically significant for all twenty portfolios, this does not hold true for the international single-factor CAPM models. For the ICAPM (MSCI) model, the beta is found to be statistically insignificant for the three industries of Gold Mining, Property and Retail; whilst for the ICAPM (ACWI) the two portfolios of Gold Mining and Retail again exhibited statistically insignificant betas. The intercept of the ICAPM (MSCI) was also found to be statistically significant for the ten of the industry portfolios, whereas for the ICAPM (ACWI) this value reduced marginally to nine portfolios. When looking at the  $\lambda$  coefficient, for the ICAPM (MSCI) only six of the industries produced statistically significant estimates, with only one of these six portfolios (Chemicals, Oils and Gas) producing a positive coefficient. For the ICAPM (ACWI), only four industries produced a statistically significant value, all of which had negative coefficients.

The results for the two multifactor ICAPM models (ICAPM<sup>EX</sup> (MSCI) and ICAPM<sup>EX</sup> (ACWI)) are displayed in table 5-12. Like with the single-factor ICAPM models, there are marginal differences when comparing the model containing the MSCI with the model containing the ACWI. For the ICAPM<sup>EX</sup> (MSCI) model, the coefficient of market risk aversion,  $\lambda$ , is only significant for two of the industry portfolios, with one exhibiting a positive coefficient and the other having a negative sign. This result is echoed for the ICAPM<sup>EX</sup> (ACWI) model.

The intercept  $\theta$  was found to be statistically significant for the same nine industries (Automobiles, Banks, Healthcare, Insurance, Media, Platinum, Property, Retail and Industrial Transport) in both of the ICAPM<sup>EX</sup> models. The MSCI and ACWI variables were also found to be statistically significant across all industries except the Gold industry. Whilst there were marginal differences between their respective coefficients, the statistical significance of the ACWI was consistently but marginally higher than that of the MSCI World Index.

When looking at the results produced for the exchange rate indices, the dollar was found to be statistically significant for 40% (5 industries) of the portfolios across both ICAPM<sup>EX</sup> models. The euro however was only found to be statistically significant for the Industrial Engineering portfolio (for both ICAPM<sup>EX</sup> models), whilst the Yen was found to be significant for five industries under the ICAPM<sup>EX</sup> (MSCI) and four under the ICAPM<sup>EX</sup> (ACWI). The pound was the exchange rate which was found to be statistically significant the most times, with seven industries in the ICAPM<sup>EX</sup> (MSCI) and eight industries in the ICAPM<sup>EX</sup> (ACWI) exhibiting statistical significance. Furthermore for the two industry portfolios of Food and Travel under the ICAPM<sup>EX</sup> (MSCI), the pound would be statistically significant if examined at a 12% level of significance. It was also found that all of the statistically significant exchange rate factors across both models had positive coefficients, which implies that exchange rates are positively correlated with changes in asset returns. This result however stands in contrast to the FM approach, where all the exchange rates were found to be negatively correlated with asset returns.

Whilst some of the industry portfolios exhibited significant exposures to only one of the four exchange rate factors, the Basic Resources and General Mining industries showed exposure to both the dollar and the yen, whilst the Other Industrial and Property industries showed significant exposure to both the pound and the yen. The Technology portfolio also exhibited significant exposure to both the dollar and the pound. Table 5-12 also shows that overall seven of the twenty industries do not exhibit any statistical significance to any of the exchange rates, including the gold and platinum mining portfolios, which one would consider to be highly sensitive to exchange rate changes due to these being global commodities. A possible reason for this however is that the exchange rates are jointly significant. This was therefore tested by means of Wald Coefficient tests. The results of these tests are displayed in table 5-13.

As outlined in chapter 4 (page 112), if the test statistics of either the chi-square or F-test produced is found to be greater than the critical values, this would lead to a rejection of the null hypothesis, which would imply that the four exchange rates used in this study jointly affect excess returns. An analysis of the results in table 5-13 shows that for eighteen of the twenty industries, all four exchange rates are found to be jointly significant. However, this result does not hold for the remaining two Gold and Platinum portfolios, contrary to what is expected. This issue will therefore be analysed further with reference to the other tests conducted.



Table 5-13. Wald coefficient test results

The null hypothesis for each test was that:  $\beta_{\$}$ ,  $\beta_{\epsilon}$ ,  $\beta_{\text{E}}$ ,  $\beta_{\text{Y}}$  are all jointly equal to zero. The F-stat and chi-squared test statistics produced by the Wald test are both displayed, with the chi-squared value in parenthesis (). The critical value for F (4, 231) is 3.32 at an alpha of 1% and 2.37 at an alpha of 5%. The critical value for  $\chi^2(4)$  is 13.277 at an alpha of 1% and 9.49 at an alpha of 5%. One asterisk (\*) denotes a rejection of the null hypothesis at the 1% level, two asterisks (\*\*) rejection at the 5% level.

$H_0: \beta_{\$} = 0, \beta_{\epsilon} = 0, \beta_{\text{E}} = 0, \beta_{\text{Y}} = 0$		
Industry	ICAPM <sup>EX</sup> (MSCI)	ICAPM <sup>EX</sup> (ACWI)
Automobiles & Parts	7.50* (30.02)*	7.57* (30.28)*
Banks & Financial Services	16.39* (65.55)*	16.30* (65.08)*
Basic Resources	5.33* (21.34)*	4.39* (17.58)*
Building and Construction	6.28* (25.10)*	6.64* (26.56)*
Chemicals, Oils & Gas	2.96** (11.86)**	4.80* (19.19)*
Industrial Engineering	4.90* (19.60)*	4.87* (19.46)*
Food and Beverage	4.13* (16.51)*	3.84* (15.34)*
General Mining	4.95* (19.78)*	5.01* (20.04)*
Gold Mining	0.93 (3.72)	0.71 (2.83)*
Healthcare	8.53* (33.04)*	8.38* (33.53)*
Insurance	13.50* (53.98)*	13.22* (52.90)*
Media	4.02* (16.08)*	3.77* (15.09)*
Other Industrial	14.09* (56.34)*	14.24* (56.96)*
Personal & Household Goods	6.50* (26.01)*	6.70* (26.80)*
Platinum, Diamonds, Coal and Precious Metals	0.67 (2.68)	0.76 (3.04)
Property	13.91* (55.65)*	14.71* (58.83)*
Retail	11.13* (44.51)*	11.12* (44.50)*
Technology & Electrical	10.82* (43.30)*	10.68* (42.73)*
Industrial Transport	4.73* (18.92)*	4.73* (18.91)*
Travel and Leisure	3.80* (15.18)*	3.82* (15.29)*

The  $R_{adj}^2$  values for the GARCH (1, 1) regressions were also collected and are displayed in table 5-14 below:

**Table 5-14. Adjusted  $R^2$  estimates for the first pass GARCH estimation**

	<b>DCAPM</b>	<b>ICAPM (MSCI World)</b>	<b>ICAPM (ACWI)</b>	<b>ICAPM<sup>EX</sup> (MSCI World)</b>	<b>ICAPM<sup>EX</sup> (ACWI)</b>
<b>Automobiles &amp; Parts</b>	30.55%	7.36%	7.87%	13.34%	13.61%
<b>Banks &amp; Financial Services</b>	47.56%	6.47%	7.63%	31.19%	32.03%
<b>Basic Resources</b>	25.48%	4.99%	5.91%	11.74%	12.62%
<b>Building and Construction</b>	27.45%	0.12%	0.65%	6.80%	7.72%
<b>Chemicals, Oils &amp; Gas</b>	29.14%	4.23%	4.93%	9.27%	10.24%
<b>Industrial Engineering</b>	19.44%	4.32%	2.40%	4.21%	5.03%
<b>Food and Beverage</b>	31.20%	4.04%	4.86%	9.56%	11.62%
<b>General Mining</b>	35.48%	9.99%	10.74%	16.15%	17.04%
<b>Gold Mining</b>	16.22%	2.81%	2.93%	-1.36%	2.22%
<b>Healthcare</b>	12.18%	1.56%	1.89%	11.35%	11.72%
<b>Insurance</b>	46.27%	5.69%	6.73%	24.07%	24.89%
<b>Media</b>	11.90%	0.66%	0.95%	5.75%	5.79%
<b>Other Industrial</b>	45.23%	3.53%	4.40%	18.01%	18.88%
<b>Personal &amp; Household Goods</b>	19.33%	-0.40%	-0.04%	6.96%	7.36%
<b>Platinum, Diamonds, Coal and Precious Metals</b>	28.68%	12.81%	13.53%	14.07%	14.95%
<b>Property</b>	18.90%	-0.07%	0.12%	12.59%	13.02%
<b>Retail</b>	32.65%	4.99%	5.47%	23.32%	23.80%
<b>Technology &amp; Electrical</b>	41.10%	8.04%	8.98%	19.85%	20.63%
<b>Industrial Transport</b>	24.49%	2.62%	3.07%	11.73%	11.83%
<b>Travel and Leisure</b>	23.84%	0.29%	0.68%	7.31%	7.70%
<b>Average</b>	28.35%	4.20%	4.69%	12.80%	13.64%

The results shown in table 5-14 largely echo those produced in the first pass estimation of the unconditional approach (as shown in table 5-3). The DCAPM still proves to be the superior model across all industries, with the explanatory power of the conditional model only

marginally greater than that of the unconditional model (1.53%). An interesting point to note is that whilst the conditional ICAPM<sup>EX</sup> estimates were less than the values produced under the unconditional models, the opposite is true for the single-factor ICAPM models. Whilst the explanatory power of the ICAPM (ACWI) increased by 1.5%, the values produced for the ICAPM (MSCI) increased by the highest margin of 1.6%. However the increase in explanatory power induced by the use of conditional models is still very small, and one might conclude that the simpler unconditional approach may be sufficient.

An observation of the ICAPM<sup>EX</sup> adjusted R<sup>2</sup> values indicates that the presence of exchange rates in the model increases the statistical significance of the international models, as the difference between the ICAPM and ICAPM<sup>EX</sup> models range from 2.63% for the Industrial Engineering portfolio, to 24.40% for the Banks and Financial services portfolio. Whilst this result holds true for most of the portfolios included in the analysis, a result which again proves contrary to expectations is that for the resource portfolios (Gold and Platinum), the difference is very small, with the statistical significance of the ICAPM model for the Gold portfolio proving to be higher than the associated value for the ICAPM<sup>EX</sup> model. This result coincides with the conclusions of the unconditional first pass regression output, which was discussed previously in section 5.3.1.

#### **5.4.2. Second pass GARCH estimation**

##### **5.4.2.1. Analysis of cross-sectional regression coefficients**

The results which were produced in the first pass were thereafter combined a second pass regression of the average returns of each industry against the conditional betas obtained over the full sample period.

**Table 5-15. Estimated gamma coefficients for the second pass GARCH estimation**

**One asterisk (\*) denotes statistical significance at the 1% level, two asterisks (\*\*) denotes statistical significance at the 5% level, and three asterisks (\*\*\*) denote statistical significance at the 10% level**

<b>Domestic CAPM</b>		
<b>Variable</b>	<b><math>\gamma_j</math></b>	<b>t-statistic</b>
<b>Intercept</b>	0.66	2.09**
<b>JSE ALSI risk premium</b>	0.18	0.31
<b>International CAPM (MSCI World)</b>		
<b>Intercept</b>	0.52	3.42*
<b>MSCI World risk premium</b>	1.14	1.90***
<b>International CAPM (ACWI)</b>		
<b>Intercept</b>	0.45	2.94*
<b>ACWI risk premium</b>	1.35	2.43*

ICAPM <sup>EX</sup> (MSCI World)		
Variable	$\gamma_j$	t-statistic
Intercept	0.57	1.99**
MSCI World risk premium	0.50	0.51
Dollar	-0.008	-0.009
Euro	0.55	0.59
Pound	-0.39	0.62
Yen	0.48	0.26
ICAPM <sup>EX</sup> (ACWI)		
Intercept	0.54	2.41**
ACWI risk premium	0.49	0.50
Dollar	0.03	0.03
Euro	0.70	0.71
Pound	-0.32	-0.46
Yen	<b>0.55</b>	<b>0.30</b>

The results displayed in the preceding table is that the conditional DCAPM model does not hold in the South African environment, as the intercept is statistically significant, whilst the JSE market risk premium is not. This result stands in contrast to the unconditional test, where the JSE market risk premium was found to be statistically significant and negative. Whilst the intercept coefficients were found to be statistically significant for all the models, under the two single-factor ICAPM models (ICAPM (MSCI) and ICAPM (ACWI)), these two market indices are also found to be statistically significant, with the ACWI risk premium significant at the 1% level, and the MSCI at the 5% level. However, in the ICAPM<sup>EX</sup> models, both these indices cease to be statistically significant, with all the exchange rate parameters also having low t-statistics. A possible reason for this is that the four exchange rates are jointly significant, as with the first pass results, which thus calls for Wald coefficient test to be conducted. The result of the Wald test for the ICAPM<sup>EX</sup> (MSCI) and ICAPM<sup>EX</sup> (ACWI) respectively are as follows:

Wald Test:			
Equation: ICAPMEX_MSCI_GARCH			
Test Statistic	Value	df	Probability
F-statistic	0.675699	(4, 14)	0.6199
Chi-square	2.702797	4	0.6087

Wald Test:			
Equation: ICAPMEX_ACWI_GARCH			
Test Statistic	Value	df	Probability
F-statistic	0.937390	(4, 14)	0.4708
Chi-square	3.749560	4	0.4410

An analysis of the results produced for both Wald tests show that the null hypothesis of all the exchange rate coefficients jointly equating to zero cannot be rejected. This therefore implies that the exchange rate factors are not significant factors in a conditional asset pricing model, which together with the insignificance of the market portfolios in each ICAPM<sup>EX</sup> model indicates that the conditional ICAPM<sup>EX</sup> model does not hold in the South African environment. This stands in stark contrast to the results of the unconditional models, where it was found that all the coefficients were highly statistically significant, as well as the results of the first pass GARCH estimation, where evidence was found of exchange rate significance. The results produced from the second pass of the GARCH estimation therefore indicates that the ICAPM (ACWI) model is superior to the other four models tested, with the ICAPM (MSCI World Index) also performing better than the DCAPM and multifactor ICAPM<sup>EX</sup> models. Further analysis is required by means of examining the information criteria produced for each conditional model, which follows in the next section.

#### **5.4.2.2. Information criteria**

The information criteria from the second pass results of the GARCH estimation was collected and is displayed in table 5-16 below:

**Table 5-16. Information criteria for the GARCH method.**

	DCAPM	ICAPM (MSCI World)	ICAPM (ACWI)	ICAPM <sup>EX</sup> (MSCI World)	ICAPM <sup>EX</sup> (ACWI)
<b>R<sup>2</sup></b>	0.39%	7.61%	11.16%	20.14%	21.33%
<b>Adjusted R<sup>2</sup></b>	-5.14%	2.48%	6.22%	-8.39%	-6.76%
<b>AIC</b>	0.83	0.76	0.72	1.01	1.00
<b>SBIC</b>	0.93	0.86	0.82	1.31	1.30
<b>HQIC</b>	0.85	0.78	0.74	1.07	1.06

The model selected under each criterion is highlighted in green in the preceding table. The results produced are again in stark contrast to the results of the unconditional models, as displayed in table 5-7. Whereas for the unconditional approach, the ICAPM<sup>EX</sup> (ACWI) model was found to be the one which performed the best, as it produced the highest  $R^2$  and adjusted  $R^2$  values, as well as the lowest AIC, SBIC and HQIC values; this result does not hold true for this analysis as both ICAPM<sup>EX</sup> models are consistently selected as the worst models, across all five information criteria. Instead, the ICAPM (ACWI) model is found to be the best performing, with the ICAPM (MSCI) ranked second best.

It can also be seen that even though the ICAPM<sup>EX</sup> models produce the highest  $R^2$  values, this is only due to the large number of parameters being estimated in their models, as their adjusted  $R^2$  values become negative. The results from the information criteria do however coincide with the conclusion from the analysis of the coefficients produced, as displayed in table 5-15, which also indicated that the ICAPM (ACWI) was the best performing conditional model.

#### **5.4.2.3. Summary of GARCH results**

The results of the first pass and second pass and again indicated that different models were superior, similar to the unconditional approach. The results are summarised in table 5-17:

**Table 5-17. Summary of model selection under the GARCH approach**

Method used	DCAPM	ICAPM (MSCI World)	ICAPM (ACWI)	ICAPM <sup>EX</sup> (MSCI World)	ICAPM <sup>EX</sup> (ACWI)
GARCH first pass	X				
GARCH second pass			X		
Information criteria			X		

The results of the above table show that the even though the DCAPM is again found to be superior when evaluating the first pass results, the ICAPM (ACWI) model is found to be the superior model under both second pass GARCH analyses, a result which concurs with the forecasting results of the unconditional FM approach. However, it should also be noted that, thus far, the models which contain the MSCI World Index have produced very similar results to those of the ACWI. Therefore in the choice between these two world indices, it could be inferred that the use of either would be sufficient.

## 5.5. Cost of equity approach

A summary of all the tests conducted under the cost of equity approach is contained in table 4-5 (page 136). Each of these tests were therefore conducted first by assuming that the beta values remain constant throughout the period of analysis, similar to the assumption made by Koedijk *et al* (2002). The results of each of these will now be displayed and discussed separately.

### 5.5.1. Tests conducted assuming betas remain constant over time

#### 5.5.1.1. Tests of the DCAPM against the ICAPM and ICAPM<sup>EX</sup> models

The first two tests under this assumption were conducted to determine the pricing error between the DCAPM model and each of the ICAPM models. When evaluating the difference between the DCAPM and ICAPM models, the regressions were conducted twice, once for the MSCI World portfolio, and the second time for the ACWI portfolio. This approach was replicated when evaluating the difference between the DCAPM and multifactor ICAPM<sup>EX</sup> models. The results of these tests are therefore shown in table 5-18.

**Table 5-18. Estimates of pricing error ( $\delta_i$ )**

In the table below, t-statistics are displayed in parenthesis (), and one asterisk (\*) denotes statistical significance at the 1% level, two asterisks (\*\*) denotes statistical significance at the 5% level, and three asterisks (\*\*\*) denote statistical significance at the 10% level. All statistically significant factors for the single-factor ICAPM models are highlighted in yellow, while the statistically significant factors for the multifactor ICAPM<sup>EX</sup> models are highlighted in blue.

	Difference between DCAPM and ICAPM models		Difference between DCAPM and ICAPM <sup>EX</sup> models	
	ICAPM (MSCI)	ICAPM (ACWI)	ICAPM <sup>EX</sup> (MSCI)	ICAPM <sup>EX</sup> (ACWI)
<b>Automobiles &amp; Parts</b>	0.003 (0.04)	-0.003 (-0.03)	0.22 (0.77)	0.22 (0.77)
<b>Banks &amp; Financial Services</b>	-0.07 (-1.06)	-0.066 (-1.02)	1.09 (4.60)*	1.11 (4.60)*
<b>Basic Resources</b>	0.015 (0.18)	0.028 (0.33)	0.21 (0.64)	0.21 (0.64)
<b>Building and Construction</b>	-0.22 (-2.66)*	-0.21 (-2.54)**	0.72 (2.26)**	0.73 (2.26)**

	Difference between DCAPM and ICAPM models		Difference between DCAPM and ICAPM <sup>EX</sup> models	
	ICAPM (MSCI)	ICAPM (ACWI)	ICAPM <sup>EX</sup> (MSCI)	ICAPM <sup>EX</sup> (ACWI)
<b>Chemicals, Oils &amp; Gas</b>	-0.33 (-0.41)	-0.033 (-0.41)	-0.03 (-0.09)	-0.03 (-0.09)
<b>Industrial Engineering</b>	-0.08 (-0.95)	-0.08 (-0.93)	0.14 (0.42)	0.14 (0.42)
<b>Food and Beverage</b>	-0.07 (-1.25)	-0.06 (-1.18)	0.21 (1.01)	0.21 (1.01)
<b>General Mining</b>	-0.087 (-1.02)	-0.08 (-0.92)	0.28 (0.85)	0.29 (0.85)
<b>Gold Mining</b>	-0.32 (-2.27)**	-0.32 (-2.28)**	0.07 (0.13)	0.07 (0.12)
<b>Healthcare</b>	-0.05 (-0.53)	-0.05 (-0.47)	0.63 (1.62)	0.63 (1.62)
<b>Insurance</b>	-0.05 (-0.79)	-0.05 (-0.77)	0.65 (2.79)*	0.66 (2.79)*
<b>Media</b>	-0.007 (-0.06)	-0.007 (-0.06)	0.71 (1.68)***	0.72 (1.68)***
<b>Other Industrial</b>	-0.13 (-2.78)*	-0.13 (-2.77)*	0.56 (3.06)*	0.57 (3.06)*
<b>Personal &amp; Household Goods</b>	-0.12 (-1.65)***	-0.12 (-1.63)***	0.67 (2.44)**	0.68 (2.44)**
<b>Platinum, Diamonds, Coal and Precious Metals</b>	0.10 (1.12)	0.11 (1.25)	-0.24 (-0.67)	-0.24 (-0.67)
<b>Property</b>	-0.15 (-3.16)*	-0.15 (-3.12)*	0.72 (4.08)*	0.74 (4.08)*
<b>Retail</b>	-0.18 (-2.64)*	-0.19 (-2.67)*	1.11 (4.15)*	1.13 (4.15)*
<b>Technology &amp; Electrical</b>	-0.03 (-0.49)	-0.03 (-0.46)	0.62 (2.17)*	0.63 (2.17)*
<b>Industrial Transport</b>	-0.09 (-1.08)	-0.09 (-1.11)	0.69 (2.16)**	0.70 (2.16)**
<b>Travel and Leisure</b>	-0.15 (-1.75)***	-0.16 (-1.78)***	0.36 (1.04)	0.37 (1.04)



If the  $\delta_i$  estimates produced under the single-factor ICAPM models are statistically significant, this implies that the use of the DCAPM model to estimate cost of equity is inappropriate and the ICAPM model with relevant market portfolio should be utilised instead. Similarly, if the  $\delta_i$  estimates for the ICAPM<sup>EX</sup> models are statistically significant, this implies that the ICAPM<sup>EX</sup> model should be used instead of the DCAPM. The results shown in the preceding table show that for the five industry portfolios of Building and Construction, Other Industrials, Personal and Household Goods, Property and Retail, use of the DCAPM would be inappropriate as the pricing error is found to be statistically significant for both the single-factor and multi-factor ICAPM models.

In addition, for the Gold Mining portfolio, the results show that the single-factor ICAPM model should be utilised instead of the DCAPM as the domestic market portfolio does not capture all of the risks relevant to this sector of the market. The use of the world market portfolio and exchange rate exposures in the ICAPM<sup>EX</sup> models were also found to be statistically significant for the five portfolios of Banks and Financial Services, Insurance, Media, Technology and Electrical and Industrial Transport. This therefore leaves eight portfolios out of the total of twenty in the analysis for which the DCAPM was found to be sufficient over both the single- and multifactor ICAPM models. It should also be noted that the results produced for the MSCI are echoed for the ACWI, which indicates that these two portfolios cannot be distinguished from each other under this analysis. These results are largely in conjunction with those produced in the previous two analyses, as there is some support found for all five of the models used.

For the ten portfolios under which the pricing error of the ICAPM<sup>EX</sup> model was found to be statistically significant, only five of these could be due to the statistical significance of the world market index (as these portfolios also had significant pricing errors for the single-factor ICAPM models, as discussed previously). This may indicate that the significant pricing errors in the remaining five portfolios can be attributed to the presence of the exchange rate factors. This issue is therefore one which will be investigated further by specifically testing for exchange rate exposures.

#### **5.5.1.2. Tests of exchange rate exposure**

The “exchange rate exposure” and “total exposure” tests are represented by the last two rows of table 4-5 (page 136). Whilst there is only one result for the exchange rate exposure due to the domestic market portfolio being used, the “total exposure” tests will have two results for each

industry, one with the MSCI World portfolio, and one with the ACWI. The results of each of these tests are displayed in table 5-19 below:

**Table 5-19. Exchange rate exposure tests**

In the table below, t-statistics are displayed in parenthesis (), and one asterisk (\*) denotes statistical significance at the 1% level, two asterisks (\*\*) denotes statistical significance at the 5% level, and three asterisks (\*\*\*) denote statistical significance at the 10% level. All statistically significant coefficients for the exchange rate exposure test are highlighted in yellow, while the statistically significant coefficients for the total exposure test are highlighted in blue.

	Exchange rate exposure	Total Exposure	
		MSCI	ACWI
<b>Automobiles &amp; Parts</b>	-0.97 (-0.78)	-2.03 (-1.62)	-2.04 (-1.62)
<b>Banks &amp; Financial Services</b>	-4.80 (-4.61)*	-6.09 (-5.92)*	-6.09 (-5.92)*
<b>Basic Resources</b>	-0.93 (-0.64)	-2.08 (-1.45)	-2.08 (1.45)
<b>Building and Construction</b>	-3.18 (-2.26)**	-4.38 (-3.14)*	-4.38 (-3.14)*
<b>Chemicals, Oils &amp; Gas</b>	0.13 (0.09)	-1.10 (-0.80)	-1.10 (-0.80)
<b>Industrial Engineering</b>	-0.61 (-0.42)	-1.57 (-1.09)	-1.57 (-1.09)
<b>Food and Beverage</b>	-0.91 (-1.01)	-1.74 (-1.94)**	-1.74 (-1.94)**
<b>General Mining</b>	-1.25 (-0.85)	-2.72 (-1.86)**	-2.72 (-1.86)**
<b>Gold Mining</b>	-0.31 (-0.13)	-1.70 (-0.71)	-1.70 (-0.71)
<b>Healthcare</b>	-2.74 (-1.62)	-3.57 (-2.12)**	-3.57 (-2.12)**
<b>Insurance</b>	-2.86 (-2.79)*	-4.07 (-4.00)*	-4.07 (-3.99)*
<b>Media</b>	-3.12 (-1.68)**	-4.19 (-2.25)**	-4.15 (-2.25)**
<b>Other Industrial</b>	-2.47 (-3.06)*	-3.46 (-4.31)*	-3.46 (-4.31)*

	Exchange rate exposure	Total Exposure	
		MSCI	ACWI
<b>Personal &amp; Household Goods</b>	-2.96 (2.44)**	-3.74 (-3.09)*	-3.74 (-3.09)*
<b>Platinum, Diamonds, Coal and Precious Metals</b>	1.04 (0.67)	-0.32 (-0.21)	-0.32 (-0.21)
<b>Property</b>	-3.18 (-4.08)*	-3.68 (-4.74)*	-3.68 (-4.74)*
<b>Retail</b>	-4.87 (-4.15)*	-5.97 (-5.10)*	-5.97 (-5.10)*
<b>Technology &amp; Electrical</b>	-2.73 (-2.17)**	-4.41 (-3.31)*	-4.14 (-3.11)*
<b>Industrial Transport</b>	-3.04 (-2.16)**	-4.24 (-3.01)*	-4.24 (-3.02)*
<b>Travel and Leisure</b>	-1.58 (-1.04)	-2.75 (-1.81)***	-2.75 (-1.81)***

The results of the exposure test shown in column 2 of table 5-19 show that for a nine of the twenty portfolios, the coefficient produced is statistically significant, which therefore implies that the presence of exchange rates is a significant factor in estimating the cost of equity, and that the firms in these industries have exposures which cannot be accounted for by the domestic market portfolio. For the remaining industries (which include the three mining portfolios – General mining, Platinum and Gold), the coefficients produced are statistically insignificant, which implies that the DCAPM will be appropriate for use. However when looking at the “total exposure” test results shown in column 3 and 4, it can be seen that the General Mining sector now exhibits statistically significant coefficients (at an alpha of 10%) when both world market portfolios are utilised.

The results of the total exposure also indicates that for a majority of the portfolios in the sample (fourteen), the coefficient produced was found to be statistically significant, which indicates that exchange rate factors do exhibit a significant influence on the returns of assets, even after removing for any effect already captured by the domestic and global portfolios. This result indicates that inclusion of simply the domestic or world market portfolios in the single-factor ICAPM models may not be sufficient for capturing the variation in asset returns, in which case a multifactor ICAPM model would be considered more appropriate. This evidence in favour of

the inclusion of exchange rates concurs with those produced in similar studies of the South African environment, like Barr and Kantor (2005), and Barr, Kantor and Holdsworth (2007).

### **5.6. Summary**

This chapter contained the results and discussion of each of the three analytical methods used in this study to test the different CAPM models. Although there were some common trends observed, the results of the different tests sometimes differed in their selection of appropriate models. These tests and their respective conclusions will therefore be summarised in the discussion below.

- *Unconditional FM Estimation*

The adjusted  $R^2$  values collected from the first pass regressions of this approach indicated that, whilst the DCAPM model produced the highest explanatory power across all twenty portfolios over the entire sample period, when this value was allowed to vary over time, the results varied across different time periods. In particular, evidence of international integration was observed over the latter years of the sample as the explanatory power of the ICAPM models was found to have increased over recent years. This was confirmed by the selection of the ICAPM<sup>EX</sup> models over the DCAPM according to the information criteria reviewed, and when the single-factor ICAPM models were found to be superior in the forecasting analysis. The presence of exchange rate risk was also found to be important as these factors were found to be statistically significant when included in both ICAPM<sup>EX</sup> models.

- *Conditional GARCH (1,1)–M model*

The analysis of the first pass GARCH estimation results were in accordance with those of the FM method, where the DCAPM model was found to produce higher adjusted  $R^2$  values, however, evidence was also found in favour of the inclusion of exchange rates in asset pricing models, with all four exchange rates being found to be jointly significant for a majority of the portfolios in the study. However, the second pass results indicated that the single-factor ICAPM models would be preferred over the other two models, a result which was consistent across both an analysis of the cross-sectional regression coefficients, as well as for the information criteria.

- *Cost of Equity Approach*

When the difference between the cost of equity estimates of each of the models was tested, evidence was found in favour of all three models. When the DCAPM was evaluated against the single-factor ICAPM model, it was found that the difference in cost of equity estimates between the two models was only significant for seven of the portfolios. The difference in estimates between estimates of the DCAPM and ICAPM<sup>EX</sup> models was tested next, and it was found that 50% of the portfolios produced significantly different results. This evidence in favour of exchange rate risk was strengthened when tests focused exclusively on exchange rate exposure produced similar results.

The results from all three analyses therefore imply that whilst the JSE market portfolio may be able to capture some of the variation experienced in returns, the presence of international factors such as the world market portfolios, as well as exchange rate risk factors, are also important in the context of asset pricing.

## CHAPTER 6 : CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Review of Research Objectives

The cost of equity calculation is an essential one for both companies as well as investors. Since its inception in 1965, the CAPM has provided an invaluable means of attaining this variable, with many studies showing that this model is used extensively by both financial managers of corporations, as well as individual investors who wish to calculate their required return. The popularity of this model is largely dependent on its simple and intuitive appeal, with the risk inherent in an asset incorporated by measuring the covariance of an assets return with the return on the market. Whilst in previous years, when markets were considered to be largely segmented from the global economy, the investor's domestic market portfolio was considered to be sufficient to incorporate all of the risks experienced by the assets, in recent years this has changed.

One of the most notable changes in global financial markets in recent years has been the growing degree of integration as the constraints to capital mobility have been gradually relaxed. This resultant increase in transactions across borders has meant that investors are now exposed to many more risk factors, which may not be sufficiently captured by the domestic market portfolio. This issue has therefore led to the development of two extensions of the traditional CAPM model, viz. the ICAPM of Grauer, Litzenberger and Stehle (1976) and the ICAPM<sup>EX</sup> developed by Solnik (1974). Both these models incorporate the use of a global market portfolio instead of a domestic portfolio, whilst Solnik's (1974) model incorporates the presence of exchange rate risk as well.

The primary objective of this study was therefore to investigate these two international models against the domestic model in order to determine which model is the most appropriate for use in the South African economy. The secondary objectives of this analysis were as follows:

- To determine which global market proxy – the Morgan Stanley Capital International (MSCI) World Index or the MCSI All Country World Index (ACWI) is superior in capturing the risks inherent in South African assets.
- To determine which specific exchange rate factors exert a significant influence on the returns of JSE-listed assets.

- To investigate the industry-specific characteristics and the responsiveness of different industries to different risk factors, in order to determine if their performances are consistent with theory.

There were three different methodological approaches adopted in order to provide answers to the questions already posed, the results of which were displayed and discussed in the previous chapter. The next sections therefore outline the main results obtained which aim to address each of the research objectives outlined above.

## **6.2. Summary of results obtained**

### **6.2.1. Primary Objective – Which of the three models studied is superior**

The results produced for each of the three analyses are summarised and displayed in the table below:

**Table 6-1. Summary of results**

<b>Method of analysis</b>	<b>DCAPM</b>	<b>ICAPM (MSCI World)</b>	<b>ICAPM (ACWI)</b>	<b>ICAPM<sup>EX</sup> (MSCI World)</b>	<b>ICAPM<sup>EX</sup> (ACWI)</b>
<b>FM first pass</b>	X				
<b>FM second pass : Coefficients</b>				X	X
<b>FM: Information criteria</b>					X
<b>FM: Forecasting</b>			X		
<b>GARCH first pass</b>	X				
<b>GARCH second pass: Coefficients</b>			X		
<b>GARCH: Information criteria</b>			X		

The preceding table shows that the conclusion about which model is superior in the estimation of expected returns, varied across the different methods used. Whilst both the conditional and unconditional first pass methods selected the DCAPM model as being appropriate, this evidence in favour of the DCAPM can be considered weak based on the rolling  $R^2$  regression graphs displayed in figures 5-3 up to 5-6, as well as those under appendix A. These graphs indicate that

whilst the DCAPM model was considered appropriate over certain periods, its superiority has fluctuated over time, with recent years advocating the inclusion of international parameters into the CAPM model, in order to incorporate for/ increasing global integration. This conclusion is confirmed when observing the results of the analyses conducted on the second pass regressions, as all five of these methods select the ICAPM models as apt.

When estimating the FM method, it was found that the incorporation of a fixed-time effect in panel data is important in the estimation of asset pricing models, as it allows for the intercept to vary across observations over time, thus allowing for the incorporation of any changes in business cycles or any financial crises experienced during the sample period. When this effect was therefore incorporated into the FM second pass regression, it was found that the JSE ALSI was both statistically significant, as well as negative. However when the associated value was analysed under the GARCH estimation, the JSE ALSI became positive but ceased to be statistically significant.

A similar effect occurred on the other four CAPM models estimated, as variables which were found to be statistically significant under the unconditional FM method, ceased to be significant under the GARCH approach, and vice versa. A result which was common among the two tests, however, is that all of the intercepts in the models were found to be statistically significant. Whilst it could be inferred that this is because there are other risk factors which affect expected returns and therefore need to also be included in asset pricing models; another possibility for this result is due to the misspecification of any of the proxies utilised for variables such as the risk-free rate or the market portfolios.

Whilst the results displayed in table 6-1 indicate that in the choice between the two international market portfolios, the ACWI exhibits superior performance, it should be noted that the difference between the two portfolios were consistently marginal, in which case either could be used in the international CAPM model, and the results yielded would be similar. This issue will be discussed again in section 6.2.2.1.

The results of the cost of equity approach largely echoed those of the other two approaches, as evidence was found in favour of the international CAPM models over the domestic model. Furthermore, many of the industry portfolios were found to display statistically significant



exchange rate exposure coefficients (table 5-19, page 174). Therefore based on this method of analysis, there is sufficient evidence to conclude that in the choice between the two ICAPM models, the ICAPM<sup>EX</sup> would be preferred as it allows for the inclusion of exchange rate risk factors into the model.

The results produced therefore are mixed regarding which model is the best for use in the South African environment. Therefore whilst it could be sufficient to utilise a single-factor ICAPM model, the inclusion of exchange rate risk as additional factors should not be ignored completely, as their presence has been found to exert a significant influence on the returns of South African financial assets.

## **6.2.2. Secondary objectives**

### **6.2.2.1. Which global market proxy is superior for use?**

The two proxies for the global market portfolio used in this study were the MSCI World Index, made up of developed countries, and the MSCI ACWI, which is made up of developed as well as emerging markets. The hypothesis formed at the beginning of the analysis was that the ACWI would be better suited to the South African environment, as it incorporates the risks relevant to emerging markets (including South Africa) in the compilation of the index returns. When looking at the  $R^2$  values produced in a regression of the JSE ALSI against each of these two indices (page 142), it was found that the ACWI displayed marginal superiority over the MSCI World Index in the years of 1990-2008, after which the gap between the two indices widened further, with the ACWI now displaying much greater explanatory power than the MSCI World Index.

This marginal superiority of the ACWI against the MSCI was consistent across the analysis of the first pass regressions under both the unconditional and conditional approaches. The same holds true for the cost of equity approach, since if there were any differences in coefficients or t-statistics for portfolios, the difference was very small and did not change the overall result. From this analysis, it can therefore be seen that whilst one would expect the ACWI to be the more suitable index for the South African environment, its use as a proxy in the ICAPM does not result in output that is very different from that produced by the MSCI World Index. Therefore it can be concluded that the use of either of these proxies will be appropriate in the estimation of expected returns.

### **6.2.2.2. Which exchange rate factors have the greatest significance?**

The four exchange rate factors chosen for this study were those of the US Dollar, Euro, Japanese Yen and British Pound, as these regions constitute the largest part of the world indices, and display important trading relationships with South Africa as well. Therefore it was hypothesised that movements in these variables would have a significant influence on returns experienced by South African assets. Whilst under the unconditional approach, all exchange rate factors were found to be highly statistically significant (table 5-7, page 152), the results of the second pass of the conditional approach showed that none of these factors were significant.

When specific exchange rate factors were analysed under the first pass GARCH approach, it was found that for seven of the industrial portfolios, there was no statistically significant exchange rates found. However for the remaining thirteen portfolios, it was found that the pound was the exchange rate which was found to be statistically significant the most times, which was followed by the dollar, and then the yen. The euro however was only found to be statistically significant for one of the industry portfolios. Therefore it can be concluded that, if exchange rate factors are to be included in an asset pricing model, the Euro can be excluded from the analysis whilst it would be advantageous to include the remaining three exchange rate factors.

### **6.2.2.3. Industry specific analysis**

As predicted, the JSE ALSI had a noteworthy influence on each of the twenty portfolios used in the analysis. However, it was also found that for a majority of these portfolios, the use of the ICAPM<sup>EX</sup> models provided higher explanatory power in the later two years of this analysis. This result was confirmed when evaluating the results of the cost of equity approach, as it was found that many of the industries tested are vulnerable to significant exchange rate exposure. An interesting observation however, is that for the portfolios which were made up of companies that trade in resources such as gold and platinum, whilst one would expect that the returns of these companies would be largely based on what occurs in a global context, results to the contrary were found. These portfolio returns were instead largely explained by returns on the domestic market index, and did not display any statistically significant responses to changes in any of the four exchange rates used in the analysis.

### **6.3. Opportunities for further research**

The results produced in this study, whilst compelling and intuitive in some places, are also found to be counterintuitive to theory, with fluctuating results produced over different analytical methods as well. The following opportunities have therefore been identified, in which future researchers may enhance their studies of the ICAPM models within the South African context.

- The use of proxies for each of the inputs into the CAPM models can be changed. The debate on which appropriate asset should be used to proxy for the risk-free rate is ongoing, and the use of the correct/incorrect model can have a significant influence on the results produced. The same holds true for the use of a proxy for the market portfolio. Due to the segmentation effect inherent on the JSE (Van Rensburg, 1997), the use of a financial and industrial index in place of the JSE ALSI may be more appropriate. Furthermore, there are wide arrays of available proxies for the global market portfolio, which may be found to be more apt for use in the South African financial environment.

Similarly, there are many different exchange rates which can be used in the ICAPM<sup>EX</sup> models, to which South African assets may be more sensitive.

- The methodological approaches utilised in this study, whilst advantageous in many ways, are not devoid of any criticism, in which case techniques which are more sophisticated in their implementation may be able to capture risk characteristics which could not be discovered in this study.
- There are a wide array of other asset pricing models, such as the APT, and the Fama and French (1993) three-factor model, which take into account different factors and can also be extended to accommodate for increasing integration. The nature of the parameters included in these studies may therefore be able to capture the variation in returns on assets much better than the beta parameter is able to.

#### **6.4. Conclusion**

The primary objective of this study was to evaluate the usage of the International CAPM models in South Africa in order to provide valuable advice to the majority of practitioners who choose to estimate their cost of equity by using the CAPM model. Whilst the results produced were largely varying, a significant amount of evidence was found in favour of an International model instead of a domestic one. This is probably due to the decreasing barriers to investment in South Africa, which have occurred in the years post-apartheid, and has resulted in a higher level of financial integration with the financial world than in previous times. Therefore whilst the DCAPM model may have been appropriate for use in previous years, the current financial environment advocates the use of an international alternative.

In the choice between the two international models, there was evidence produced in favour of both the single-factor and multifactor models. Therefore if a practitioner is in search of a simpler model with less parameters to estimate, the single-factor ICAPM model would be considered sufficient for the purpose. However, since evidence has been found in favour of the inclusion of exchange rate risk in an asset pricing model, the multifactor ICAPM<sup>EX</sup> model would be considered the most efficient and effective CAPM model for use in the South African financial environment.

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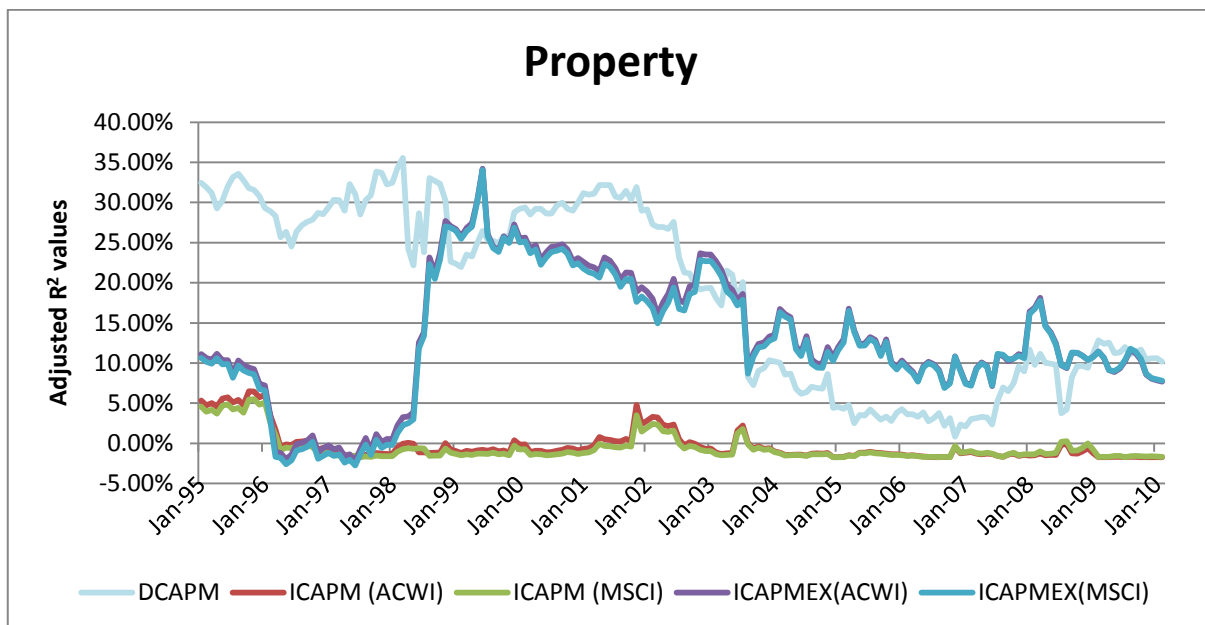
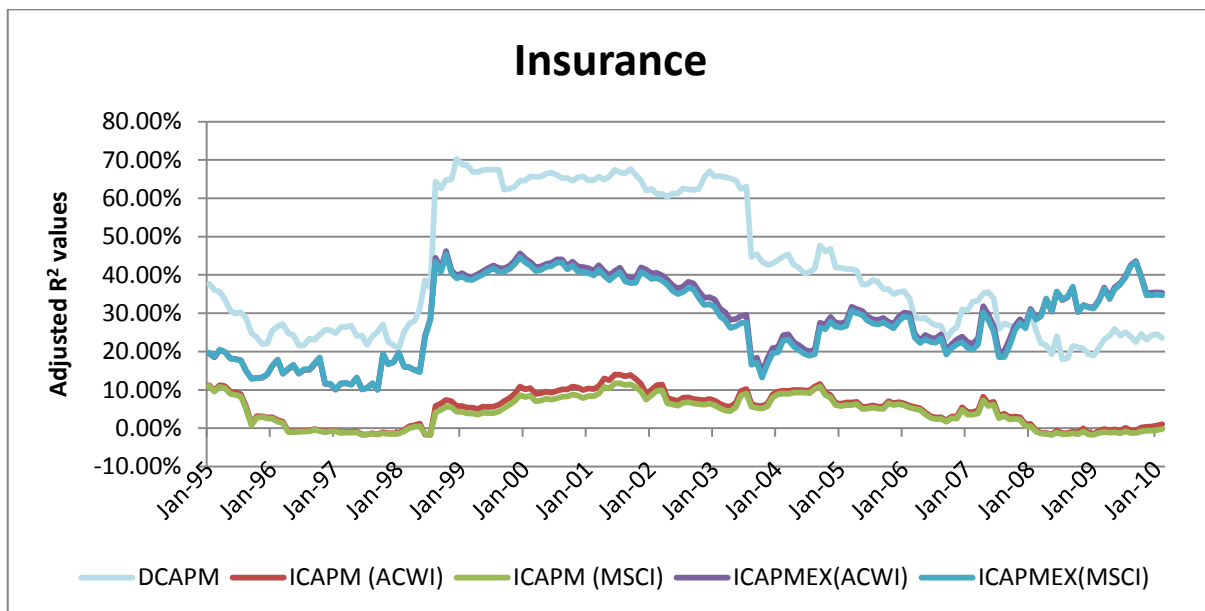
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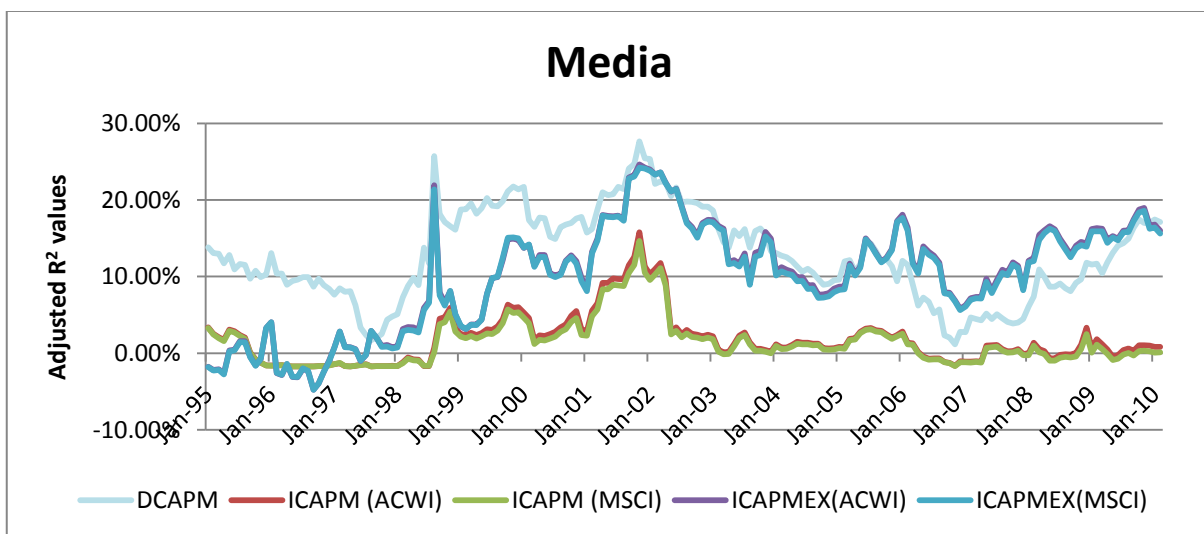
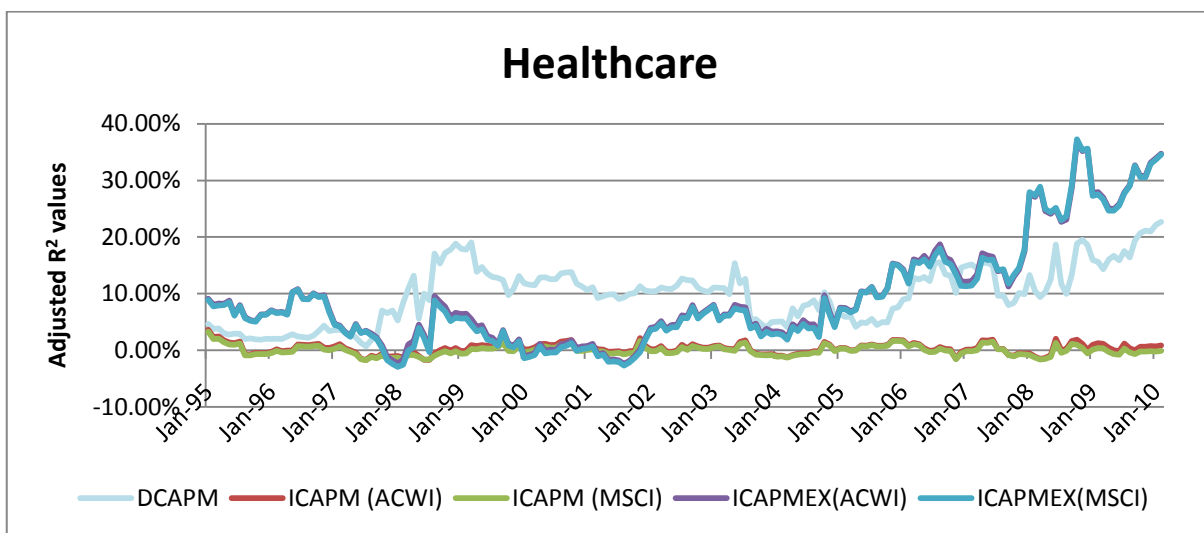
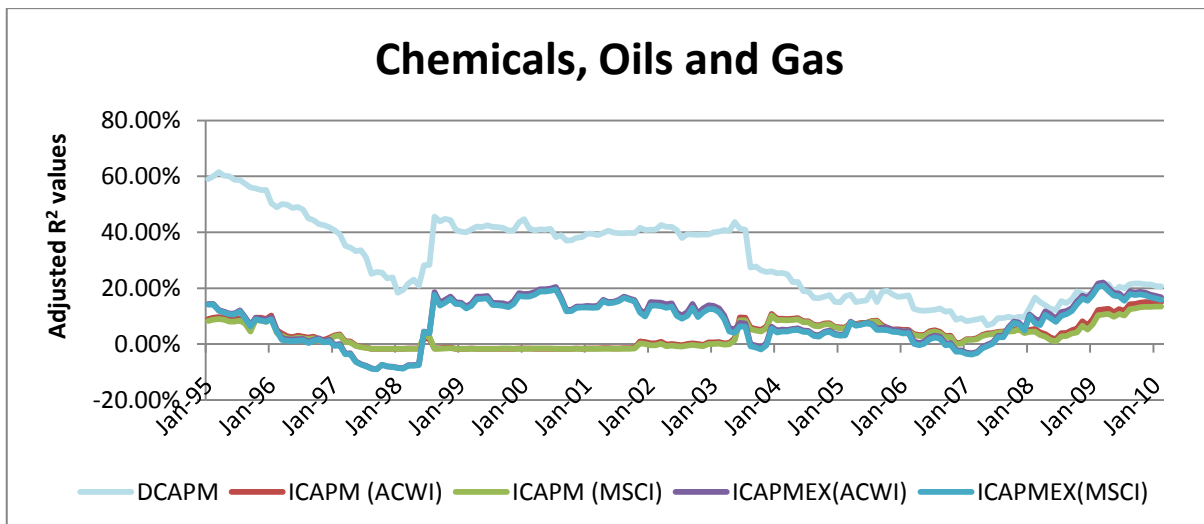
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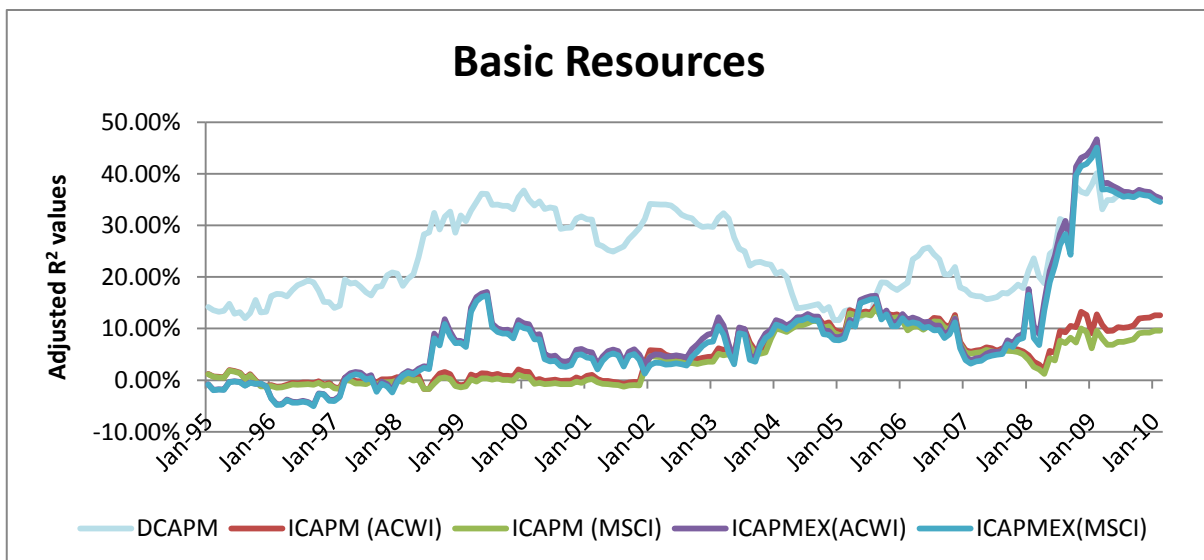
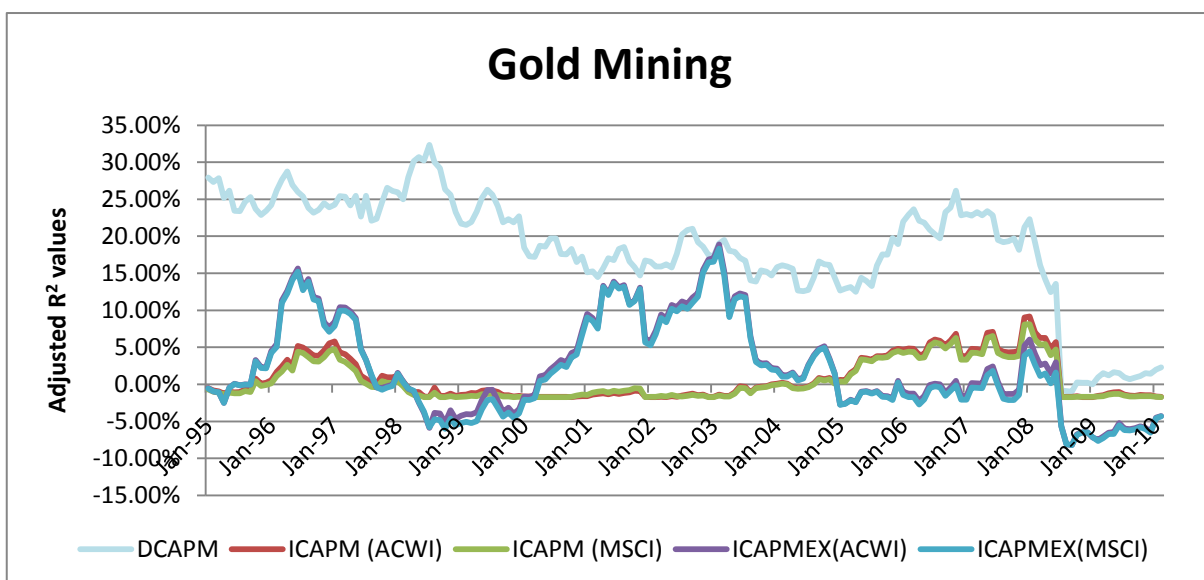
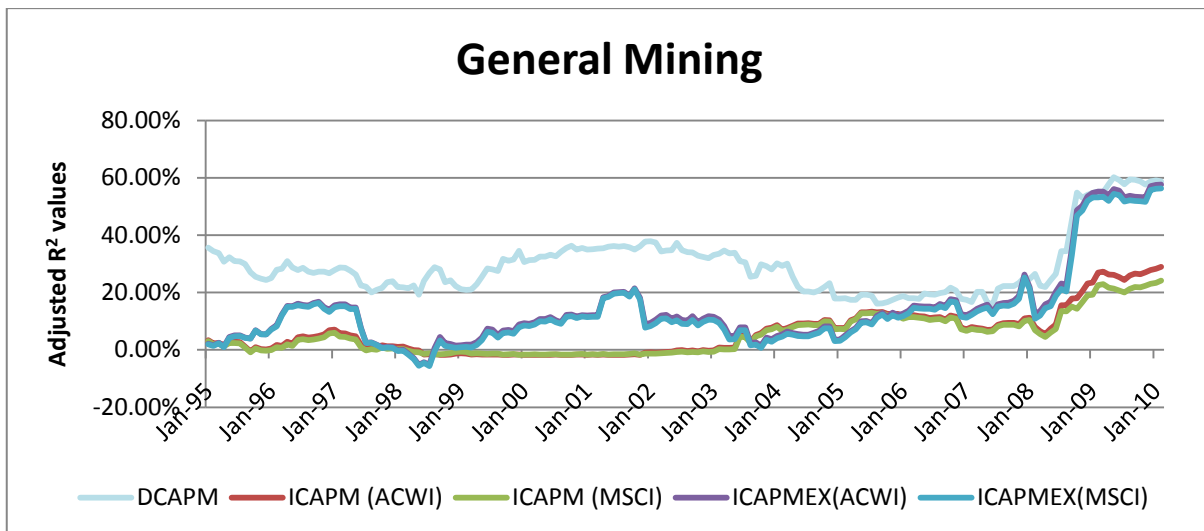
## Appendix

Adjusted R<sup>2</sup> values

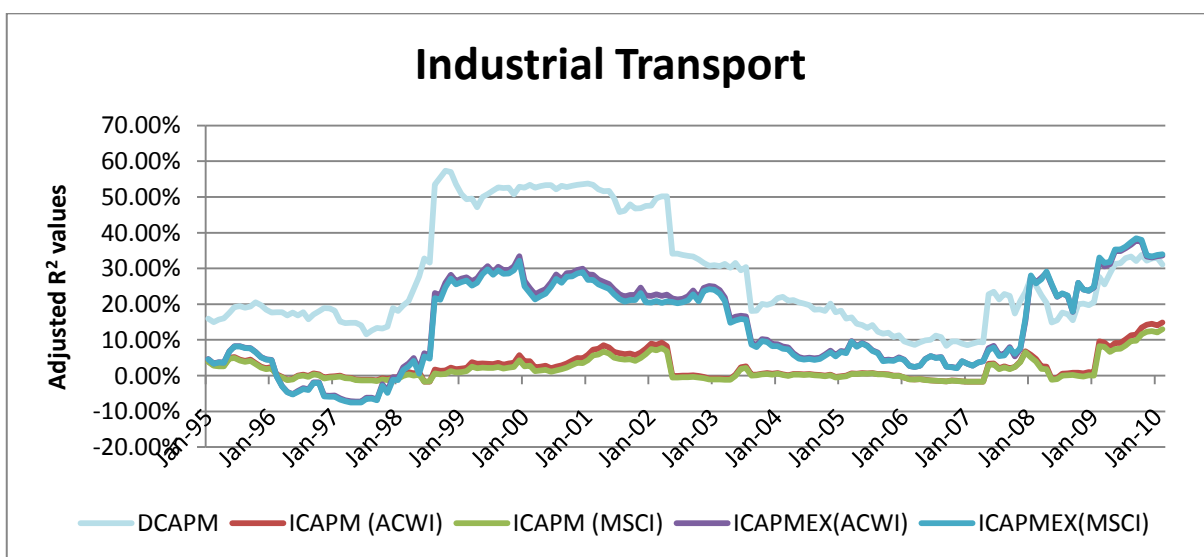
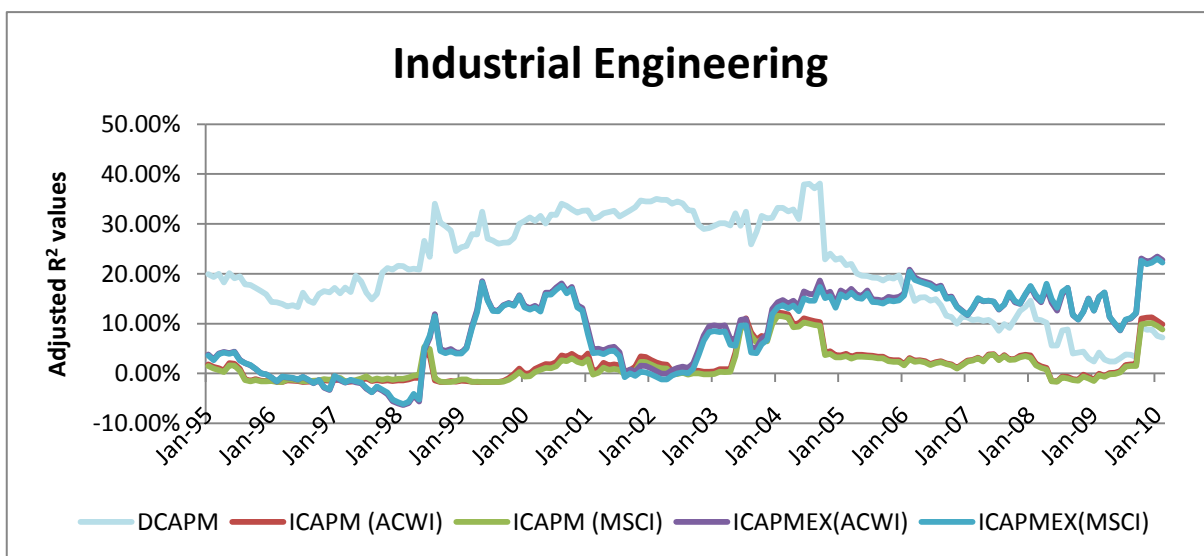
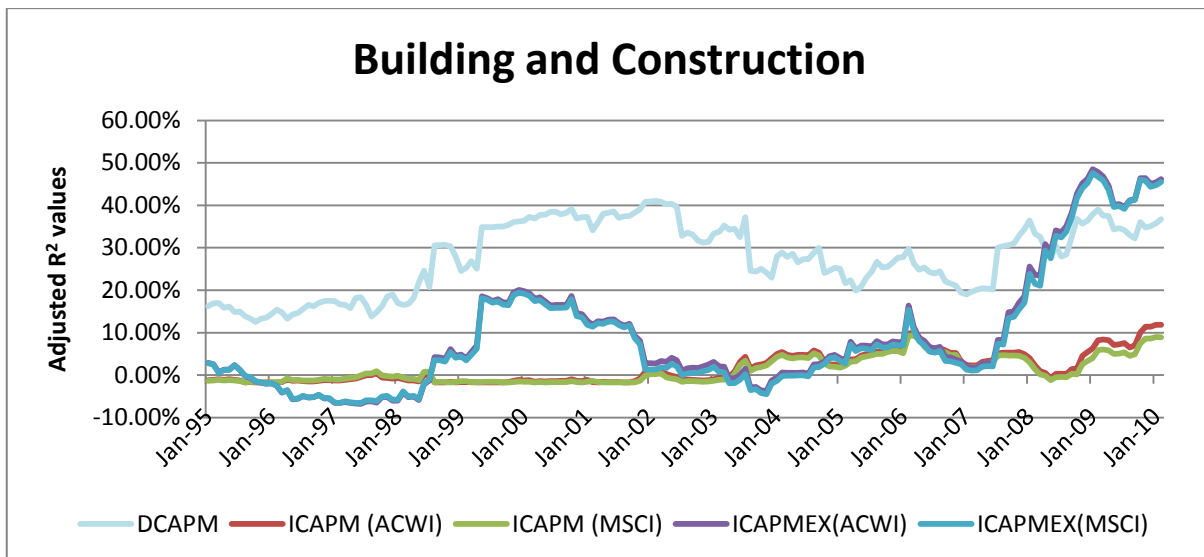
### A. Graphs of Rolling adjusted R<sup>2</sup> values from the first pass of the FM approach

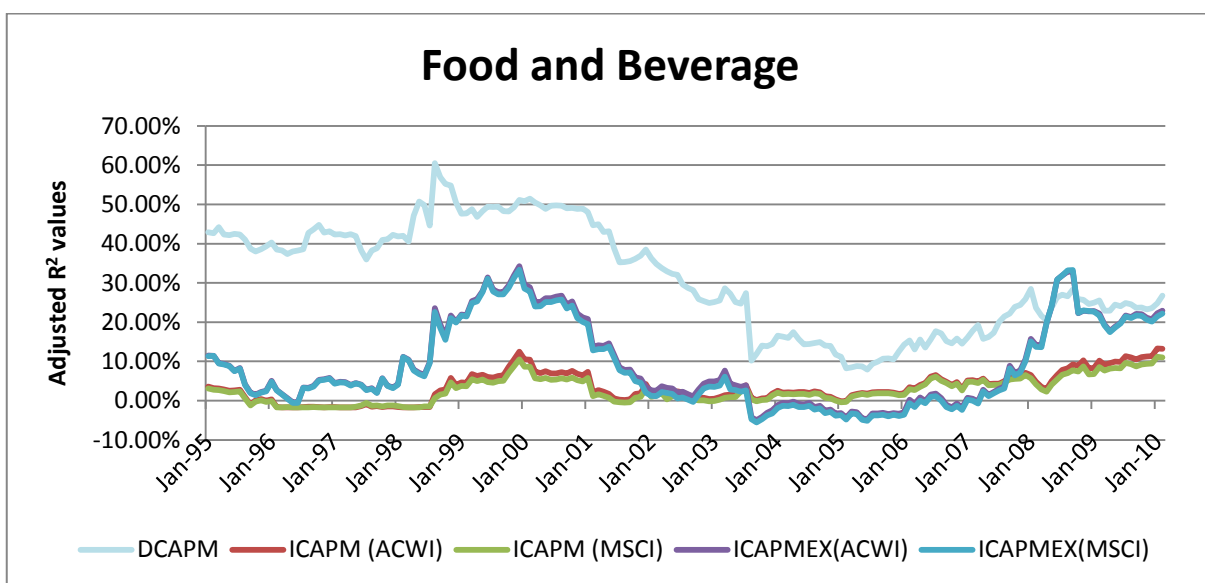
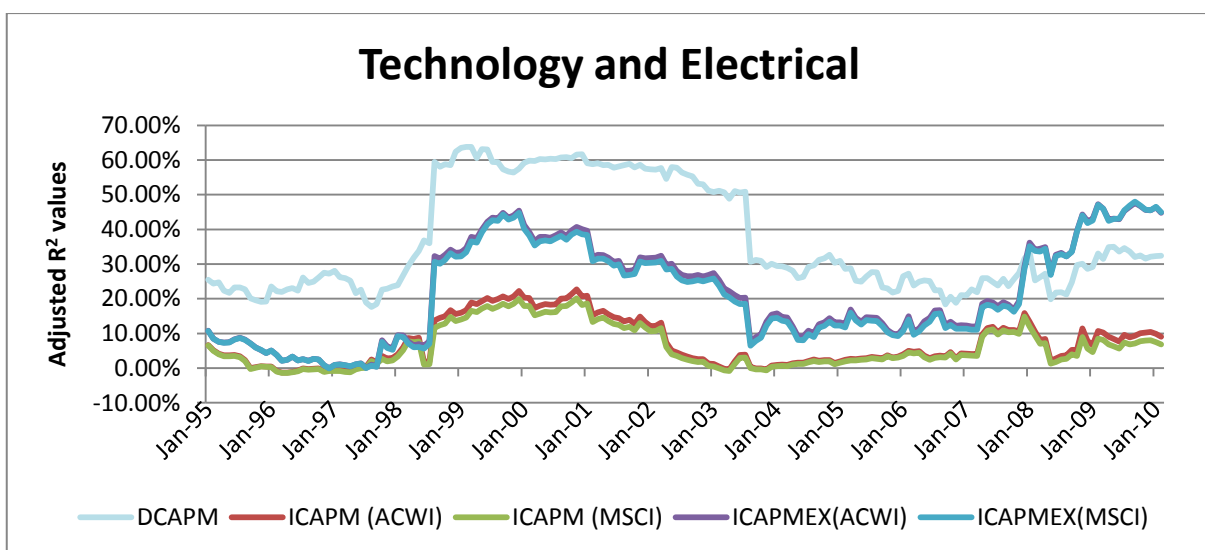
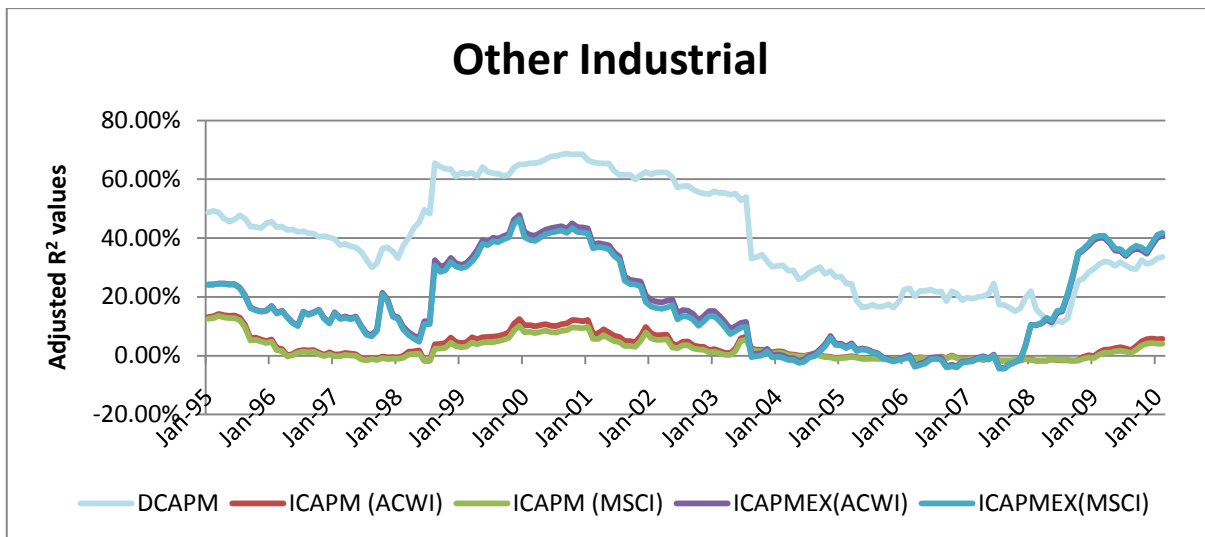


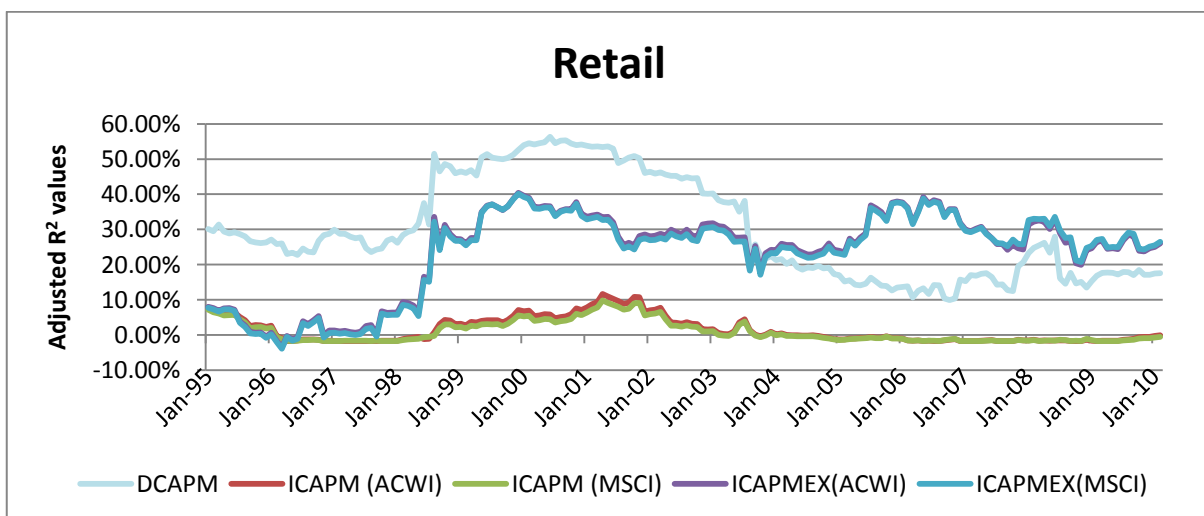
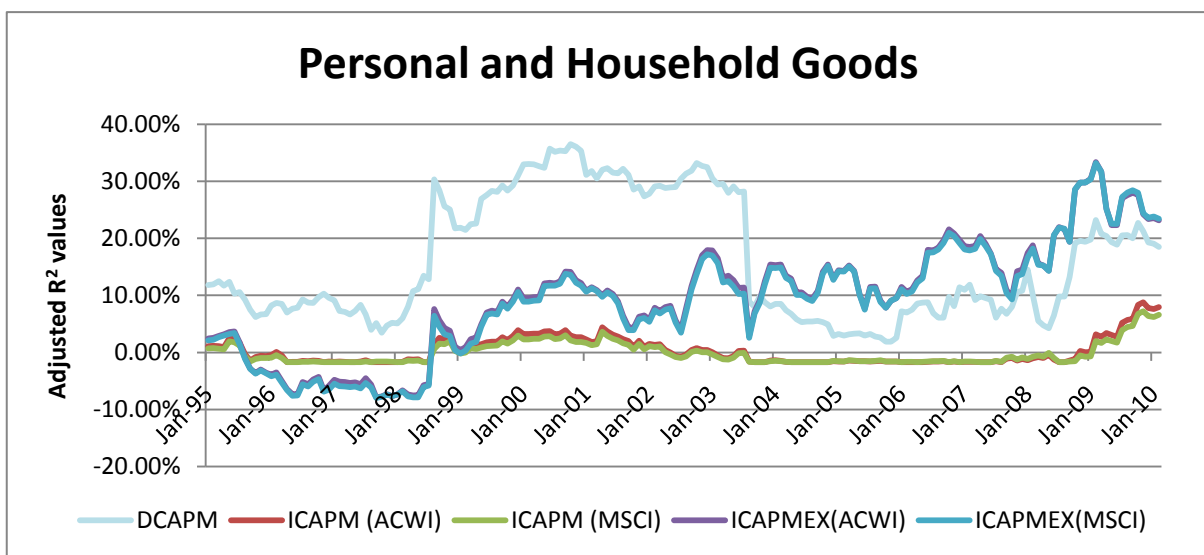
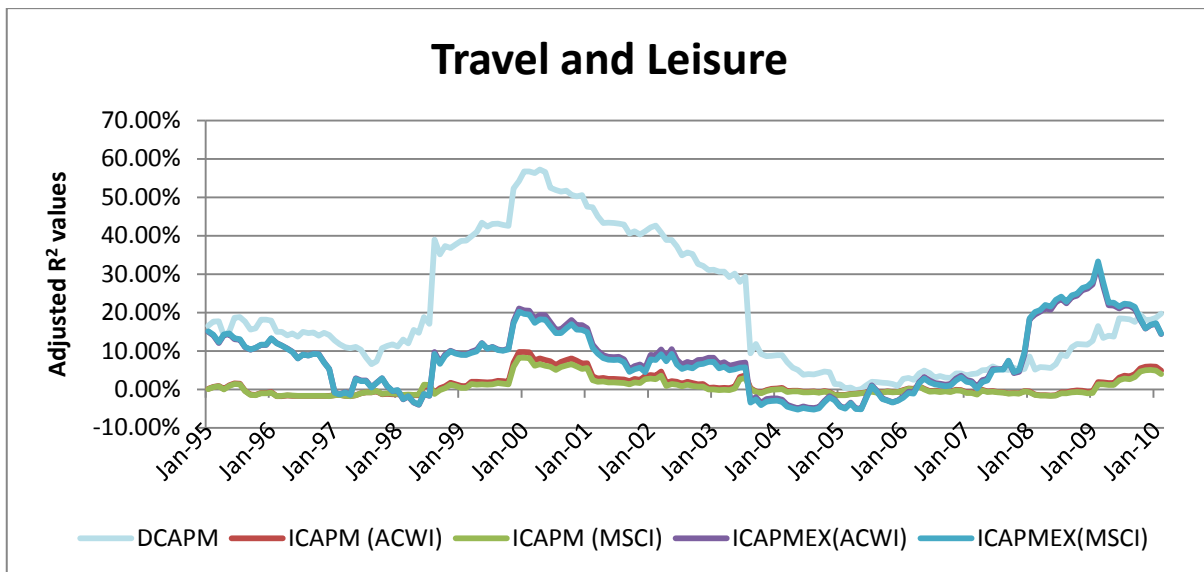












**B. Ethical Clearance**