VOLATILITY AND THE RISK-RETURN RELATIONSHIP ON THE SOUTH AFRICAN EQUITY MARKET

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DECLARATION

Except for references specifically indicated in the text, and such help as has been acknowledged, this thesis is wholly my own work and has not been submitted to any other University, Technikon or College for degree purposes.

ABSTRACT

The volatility of stock markets has important implications for investment decision making, financial stability and overall macroeconomic stability. This study examines the risk-return relationship as well as the behaviour of volatility of the South African equity markets using both aggregate, industrial level and sector level data. The study is divided into three parts. The first part investigates the behaviour of volatility in each of the industries, sectors and the benchmark series focussing on whether volatility is symmetric or asymmetric. Subsequently we investigate which, among the GARCH family of models appropriately captured the risk-return relationship under which distributional assumption. The second part examines the risk-return relationship on the SA stock market. The third part examines the long term trend of volatility and whether volatility significantly increases during financial crises and during major global shocks.

The GARCH-M, EGARCH-M and TARCH-M models under the Gaussian, Student –*t* and the GED are used. The findings this study makes are as follows: firstly, there is no clear relationship between risk and return. Secondly, volatility is asymmetrical, implying that bad news has a greater effect on volatility than good news in the South African equity market. Thirdly, the TARCH-M model under the GED was found to be the most appropriate model. Fourthly, volatility increases during financial crises and major global shocks. Overall, volatility is generally not priced on the South African equity markets. Thus, both local and international investors need to consider other factors that influence returns such as skewness. The general increase in volatility during financial crises and major global shocks poses a major concern for policy makers as this may cause financial instability. Thus policy makers need to be mindful of the behaviour of volatility in the South African equity market in response to external shocks.

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Opinions expressed and conclusions derived are those of the author and are not necessarily to be attributed to Rhodes University.

LIST OF ACRONYMS

ADF	Augmented Dickey Fuller
AIC	Akaike Information Criterion
ALSI	All Share Index
APT	Arbitrage Pricing Theory
AR	Autoregressive
ARCH	Autoregressive Conditional Heteroskedasticity
ARCH LM	Autoregressive Conditional Heteroskedasticity Lagrange Multiplier
ARCH-M	Autoregressive Conditional Heteroskedasticity- in-mean
ARIMA	Autoregressive Integrated-Moving Average
B-G	Breusch-Godfrey Serial Correlation LM test
CAPM	Capital Asset Pricing Model
COV	Covariance
CSD	Central Securities Depository
DW	Durbin Watson
EGARCH	Exponential GARCH
EGARCH-M	Exponential GARCH- in Mean
FSB	Financial Services Board
FTSE	Financial Times-Stock Exchange
FTSE 100	Financial Times-Stock Exchange 100 Share Index
GARCH	Generalized Autoregressive Conditional Heteroskedasticity
GARCH-M	Generalized Autoregressive Conditional Heteroskedasticity- in Mean
GCS	Global Classification System
GDP	Gross Domestic Product
GED	Generalized Error Distribution
GJR-M	Glosten-Jagannathan-Runkle – in Mean
GMM	General Method of Moments

HIV/AIDS	Acquired Immune Deficiency Syndrome / Human Immunodeficiency Virus
ICAPM	Intetemporal Capital Asset Pricing Model
ICB	Industry Classification Benchmark
IMF	International Monetary Fund
IT	Information Technology
JET	Johannesburg Equities Trading
JSE	Johannesburg Stock Exchange
J-B	Jacque-Bera
KPSS	Kwiatkowski-Phillips-Schmidt-Shin
LB	Ljung-Box
LM	Lagrange Multiplier
LMIL	London Market Information Link
LSE	London Stock Exchange
KSE	Karachi Stock Exchange
MBI	Macedonian Blue Chip Index
MENA	Middle Eastern and North African
MGARCH-M	Multivariate GARCH-M
MSE	Macedonian Stock Exchange
NBER	National Bureau of Economic Research
OECD	Organisation for Economic Co-operation and Development
OTC	Over-The-Counter
SA	South Africa
SAIFM	South African Institute of Financial Markets
SAP	Systems Application Protocol
SETS	Securities Electronic Trading System
SIC	Schwartz Information Criteria
SSA	Securities Services Act 2004

STRATE	Share Trading Totally Electronic
SWIFT	Society for Worldwide Interbank Financial Telecommunication
S&P	Standard & Poor
TARCH	Threshold Autoregressive Conditional Heteroskedasticity
US	United States

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CHAPTER ONE
INTRODUCTION

1.1 CONTEXT OF RESEARCH

Modelling and forecasting stock market volatility has been the subject of vast theoretical and empirical inquiry. Many of the applications of volatility require the estimation or forecast of a volatility parameter (Brooks, 2002: 441). Various measures of risk are often considered when making investment decisions, and there are two commonly used measures of risk. Firstly, standard deviation measures the variability of returns above and below the mean return: this measure of risk is often used as a measure of volatility. Secondly, the Beta measures the percentage of an investment's movement that are attributable to movements in its benchmark index. Each of these risk measures must be used to compare and evaluate potential investments. Ideally an investor should compare the same risk measures to each different potential investment to get a relative performance.

In finance there is a hypothesis which some authors have dubbed "the first fundamental law in finance" (Ghysels et al., 2005), which states that the greater the risk the greater the return. Essentially investors are expected only to accept higher risk in their portfolio if this risk is adequately matched by a commensurate return. It therefore follows that the pricing of an asset is primarily determined by the level of risk associated with that asset. It becomes imperative that the risk or volatility parameter in such an asset is accurately modelled in order to definitively determine if investors are adequately compensated for assuming greater risk.

This relationship between risk and return is of particular importance in asset management, specifically in the area of portfolio diversification. Prior to selecting any investment for a portfolio, investors should decide upon the proportion of different assets to be held. Diversification requires that asset managers select assets that are negatively or lowly correlated. This selection of assets has no simple formula that can find the right asset allocation for an individual investor: such allocations are usually subject to the investor's unique characteristics pertaining to risk appetite, age and investment horizon (Nuttall et al., 2000:17). On account of this, it is imperative that the relationship between risk and return be accurately modelled in order to aid the investment decisions of investors and portfolio managers (Nuttall et al., 2000: 17)

The past two decades have seen widespread deregulation and liberalization of financial markets in Africa through the International Monetary Fund (IMF) sponsored structural adjustment programme. This trend towards greater liberalization has been hailed as it assists investors to rapidly adjust their investment portfolios in response to shocks, leading to less impact on prices and thus volatility or risk (see Montiel and Reinhart, 1999). However, there is a body of empirical literature that has examined the behaviour of liberalized stock markets and found that liberalization has led to increased market volatility (see Borensztein and Gelos, 2000, Froot et al., 2001 and Kaminsky et al., 2000). Because of these differing conclusions there is a lack of consensus on the impact of liberalization on volatility which subsequently affects portfolio diversification.

Apart from the risk which is specific to an individual market such as equity markets, it is prudent to fully understand risk that affects all markets (systemic risk), specifically in the areas of banking and insurance for the purposes of risk management. This is necessary for financial regulation as governments seek to impose risk-based capital adequacy requirements that are commensurate with the amount of risk taken by financial institutions (Christoffersen et al., 1998).

The derivatives market operates around the central notion of accurately priced financial derivative assets such as options. In the calculation of such traded options, a volatility component enters directly into the Black-Scholes formula for deriving prices of traded options (SAIFM, 2009: 142). Some authors have argued that volatility is the single most important input into the option pricing model, and as such various measures of volatility exist (see Sircar and Papanicolaou, 1998, and Yin and Ye 2006). Firstly, historic volatility entails using historic price data for share price movements. In application this measure of volatility is considered flawed as it assumes that the past volatility will reflect the future volatility. Secondly, implied volatility is a measure of volatility that is implied in the price of that traded option. Since this is unknown, to derive this measure involves algebraic manipulation (Sircar and Papanicolaou, 1998: 50). Volatility is therefore a component that directly affects asset pricing that needs to be understood.

These developments in literature have led to a growing interest in studying volatility for the purpose assessing its impact on the equity markets. This study shall investigate the nature of volatility as well as the existence of an equity premium on the South African equity market. The results of such a research can offer insights into asset and risk management practices as well as financial regulation.

1.2 OBJECTIVES OF THE STUDY

The main objective of the study is to analyse whether investors are compensated for assuming greater risk on the South African equity market, and to analyse the behaviour and long-term trend of volatility using aggregate, industrial and sectorial data. In addressing these objectives the following three sub-objectives will also be addressed:

- To investigate if volatility is asymmetric or symmetric in each of the industries, sectors and the benchmark series studied;
- To investigate which among the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) family of models appropriately captures the risk-return relationship and under which error distributional assumption; and
- To investigate the long term trend in volatility and whether volatility increases during financial crises and during major global shocks.
- To articulate policy implications of the findings.

1.3 MOTIVATION FOR THE STUDY

Much of the research on the existence of risk premium on the stock markets has centred primarily on European and Asian markets with a distinct lack of research on African equity markets, most notably South Africa. The latest empirical work done on this subject in South Africa was conducted by Mangani (2008) who explored the structure of volatility on the JSE by employing ARCH-type models. The main conclusion of the study was that the effects of volatility are symmetric and volatility is not a commonly priced factor.

Like Mangani's (2008) study, this study looks at volatility and the risk-return relationship on the South African equity market. However, this research addresses some of the deficiencies of Mangani (2008) as well as using a more recent data set. One of the main conclusions of Mangani (2008) was that the volatility effects are symmetrical. This is in contrast to voluminous empirical evidence that has shown that negative shocks are likely to cause volatility to rise more than a positive shock of the same magnitude i.e. leverage effects (see Karmakar, 2007, and Leon et al., 2005). In the case of equity returns, leverage effects occur when a fall in the value of a firm's stock price causes the firm's debt to equity ratio to rise. This leads to shareholders who bear residual risk of the firm perceiving their future cash flow stream as being relatively more risky (Brooks, 2002: 469).

In fact, a more recent work by Chinzara and Aziakpono (2009) established that the impact of volatility on the JSE (using the All Share Index) was asymmetrical. A possible explanation of the difference in conclusions pertaining to the symmetry of volatility could be due to the fact that Chinzara and Aziakpono (2009) used a more recent data set than Mangani (2008). Mangani's (2008) study focused on the period from 1973 to 2002, while Chinzara and Aziakpono (2009) focused on the period from 1994 to 2006. This discrepancy necessitates the need for a more recent study to make inferences into the symmetry of volatility using components of both studies.

Financial data is often observed at high frequencies such as daily, hourly or minute-by-minute. The reasoning for this is that financial markets such as the stock market adopt market information and incorporate it into asset prices very quickly (Brooks, 2002: 3). It thus seems appropriate when modelling financial data to use higher frequency data such as daily observations. Mangani (2008), however, used weekly data in his estimation, which might have been inappropriate given that the JSE has been found to be informationally efficient (see Gilbertson and Roux, 1977). Therefore this study uses daily data.

In estimating the ARCH models Mangani (2008) assumed that the error term was normally distributed, which seems to be a departure from vast empirical work on the distributional properties of financial returns (see Affleck-Graves and McDonald, 1989; Dufour et al., 2003; Jondeau and Rockinger, 2006; Szego, 2002; Tokat et al., 2003). The unanimous conclusion of these studies is that financial returns are not normally distributed as the returns tend to exhibit excess peakedness and fatter tails at the mean. Based on this, this study will test the risk premium hypothesis using Autoregressive Conditional Heteroskedasticity (ARCH) type models assuming three different distributional assumptions – Gaussian, Student –*t*, Generalized Error distribution (GED) – and establish which of these distributions would be appropriate in modelling the volatility of the South African equity market.

The JSE moved onto the London Stock Exchange's new equity system, TradElect, on 2 April 2007 (SAIFM 2008: 16). TradeElect has increased the level of efficiency and performance of the JSE which has seen liquidity increase by more than 50% since its inception and significant reduction in trading costs (SAIFM, 2008: 16). The increase in liquidity and reduction in trading costs could have had an impact on volatility of the JSE due to the fact that trading in shares and other securities is now a cheap and viable option. The increased liquidity has had an impact on price discovery of shares and subsequently volatility of shares (Business Report, 2007). This development further necessitates for an updated study on the risk-return relationship.

The results obtained from this research will be beneficial to investors, locally and abroad, because the knowledge of whether assuming more risk will lead to more returns is the fundamental reason in making investment decisions.

1.4 METHODS OF STUDY

In order to lay a foundation for our empirical analysis we will firstly carry out an in-depth review of the relevant theoretical and empirical literature. For our empirical analysis we will use daily stock market returns for the period 1995:06–2009:07, although it should be noted that not all the series cover this period. For details concerning the time period for each of the estimated returns see Table 1. Before applying formal econometric methodology, we will perform several descriptive statistical tests which include reporting on the mean, variance, standard deviation, skewness, kurtosis and the Jacque-Bera test for normality. The purpose of this is to check the distributional properties of the returns before applying formal econometric tests. In order to tackle the first sub-objective we use three different univariate GARCH models assuming three different error distributions. These are the GARCH, Exponential GARCH (EGARCH) and the Threshold ARCH (TARCH) under the Gaussian distribution, Student –*t* Distribution and the GED. In order to tackle the second sub-objective the risk-return parameter will be analysed to assess whether a relationship exists between risk and return, and if such a relationship does exist whether it conforms to the predictions of the CAPM and APT models. The last sub-objective will be investigated by generating conditional variance series of each of the series and regress them against a constant and a time variable. This will be analysed by making use of dummy variables which will be added into the volatility trend equation.

1.5 ORGANIZATION OF THE STUDY

The study is organized as follows: The next chapter reviews both theoretical and empirical literature regarding the risk-return relationship. This chapter is divided into two main sections: the theoretical framework which informs on the *a priori* expectation of the risk-return relationship, specifically the Capital Asset Pricing Model (CAPM) and the Arbitrage Pricing theory (APT), and the empirical literature. Chapter 3 gives an overview of the South African Equity market and the industries, sectors and benchmark indices therein. Chapter 4 sets out the methodology used in this study. The results of this study are presented and analysed in Chapter 5. Conclusions, policy recommendations and areas of further research are highlighted in Chapter 6.

CHAPTER TWO

THEORETICAL MODELS AND LITERATURE REVIEW

2.1 INTRODUCTION

This chapter sets the theoretical framework as well as reviewing some of the relevant empirical literature on the risk-return relationship. The first part of the chapter looks at the theoretical literature. Here we review the finance models that outline the theoretical link between risk and return. The second part of the chapter focuses on the empirical literature on the risk-return relationship.

2.2 THEORETICAL FRAMEWORK

The link between risk and return stems from portfolio theory which evolved from the works of Markowitz (1959). The theory shows how a risk-averse-income maximising investor can construct a portfolio that will maximise the return per unit of risk or lower risk per unit of return.

Risk is usually defined as the statistical probability that the actual return will differ from the expected return. From this definition, risk is viewed as symmetrical, implying that risk embraces both the possibility of actual returns being greater or less than the expected return. However, the attitude towards risk is asymmetrical, as investors are more concerned with the actual return being less than the expected return (Howells and Bain, 2005: 170).

Within the portfolio theory, actual risk is measured as the degree of variation in the return over a period. This essentially means that the greater the dispersion of actual returns around the mean or expected returns, the greater the risk. At the same time the lesser the dispersion of actual returns around the mean (or expected return), the lower the risk (Howells and Bain, 2005: 177).

Two categories of risk are suggested by portfolio theory: systematic and unsystematic risk. Systematic risk is the risk that affects all assets across the market but the effects differ both among assets and asset classes. Turbulent political events, recessions and wars are examples of systematic risk that cannot be diversified away, while unsystematic risk is peculiar to a single asset or a small group of assets. An announcement of an oil strike will primarily affect that company and perhaps a few others. The latter category of risk can be diversified away (Patterson, 1995: 35).

Returns of financial assets most commonly comprise dividends earned (in the case of equities, for example) and capital gains (profits arising from an increases in price) (Firer et al., 2004: 351). Financial asset returns tend to exhibit certain characteristics, the first of which is leptokurtosis. This is the tendency of the distribution of returns to exhibit excess peakedness and fat tails at the mean. Secondly, returns also tend to exhibit volatility clustering, which is the tendency of volatility to appear in bunches. Thus, large returns are expected to follow large returns, and small returns to follow small returns. Lastly, financial market returns tend to exhibit leverage effects, which is the tendency of volatility to rise more following negative news as compared to positive news of the same magnitude (Brooks, 2002: 438).

Apart from knowing the risk-return profile of individual assets, investors require knowledge on the degree of correlation of assets in a portfolio for the purposes of diversification. This is intuitively appealing as an investor would want to hold assets in a portfolio that are not affected by the same events. In other words, a fully diversified or granular portfolio will only have systematic risk as the unsystematic risk would have been eliminated by holding assets that are negatively correlated. This notion can be demonstrated by considering a hypothetical portfolio consisting only of two assets which are individually volatile. If the return of one asset went up while the return on the other went down, the aggregate return of the two assets would be constant as the variations of the two assets would cancel each other out (Howells and Bain, 2005: 169).

Three possible implications can be drawn from the above analysis. Firstly, no rational investor will incur unsystematic risk since it is not necessary. Secondly, the risk premium is only compensation for systematic risk. Thirdly, standard deviation overstates the relevant level of risk faced by an investor who behaves rationally (Howells and Bain, 2005: 177). The next section focuses on reviewing the two most influential models that seek to establish a link between risk and return.

2.2.1 Capital Asset Pricing Model

Modern portfolio theory has formed the basis of the Sharpe-Lintner Capital Asset Pricing Model (CAPM), and many of its extensions, in an attempt to measure the price of risk. The central idea of CAPM is that the rate of return on an asset will be equal to the risk free rate plus a risk premium. Here risk premium is compensation for undiversifiable risk. This model is used to determine theoretically the required rate of return given a level of risk, which is normally referred to as beta coefficient.

The CAPM makes several key assumptions. Firstly it assumes that all investors have homogenous expectations of returns, which can be defined as their best predictions of future returns within a specified time period and which are based on all the available information at the time. Secondly, the CAPM model assumes that when buying and selling securities there are no taxes or transactions costs involved. In reality, most investments are subject to capital gain or loss taxes, as well as transaction costs. Thirdly, CAPM assumes that investors have a single period investment horizon. Essentially, the model in this regard is static, meaning that it assumes investors are only concerned with investments in the current period. The fourth assumption is that when evaluating investments, the capital markets are in equilibrium and all investments are properly priced in line with their risk levels. This means there are no arbitrage opportunities for investors (i.e. opportunities for an investor to obtain different prices for one asset in two or more markets, thus profiting from the asset's pricing imbalance in different markets). Lastly, the model assumes the existence of a risk-free rate, that all investors have access to the risk-free rate, and that there is no limit to the amount that may be borrowed or lent at the risk free rate, although these assumptions are often relaxed with more complicated versions of the model (Howells and Bain, 2005: 170).

The CAPM is formally shown by the following formula:

$$R_{it} = R_{ft} + \beta_i (R_{mt} - R_{ft}) + \varepsilon_{it} \qquad [2.1]$$

where R_{it} is the expected return on the capital asset, R_{ft} is the risk-free rate of return, R_{mt} is the expected return of the market and β_i is the beta coefficient which measures the sensitivity of the asset returns to market returns. Equation 2.1 states that the return on an asset is equal to the risk-free rate plus the assets's beta multiplied by the actual excess return on the market plus a random shock that reflects the risk attributable to a specific asset.

To better understand the concept of risk in this model let us consider the following equation which allows for the estimation of the stock's beta coefficient:

$$R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + \varepsilon_{it} \qquad [2.2]$$

Alpha (α_i) in Equation 2.2 is a risk-adjusted measure of a return on an investment. It is the return in excess of the compensation for the risk borne (Howells and Bain 2005: 172).

In an efficient market the expected value of α equals the return of the risk-free asset, therefore implying the following:

$$E(\alpha_i) = r_f \qquad [2.3]$$

If $\alpha_i < rf$ then either the investment has earned too little for its risk or it is too risky for the return. If $\alpha_i > rf$ then the investment earned a return in excess of the reward for the assumed risk. If $\alpha_i = rf$ then the investment has earned a return adequate to the risk taken.

The ε_{it} error term in the equation reflects the diversifiable or idiosyncratic risk of the asset. Given diversified holdings of assets, each individual investor's exposure to idiosyncratic risk associated with any particular asset is small and uncorrelated with the rest of their portfolio. It follows that $E(\varepsilon_{it}) = 0$, which means that in an appropriately diversified portfolio, idiosyncratic risk is zero. Hence, the contribution of idiosyncratic risk to the risk of the portfolio as a whole is negligible. Therefore only systematic risk needs to be taken into account when pricing assets (Javed, 2000: 5).

The β in the equation describes how the expected return of a stock is correlated with the return to the market portfolio. By definition, the market itself has an underlying beta of 1, and individual stocks are ranked according to how much they deviate from the market. An asset with a beta of 0 essentially implies that the stock is not correlated with the market. A positive beta means that the asset generally follows the market. For instance, if the stock's beta is 2, this means that a partcular stock follows the market but does so by a factor of 2; meaning that if the market overall declines by 3% the stock itself will decline by 6%. A negative beta shows that the asset moves inversely with the market. Therefore, if a stock has a beta of -2, a decline in the overall market by 3% would mean that the stock would increase in value by 6%. However, it is also possible that a negative beta might occur even when both the market index and the stock under consideration have positive returns. For instance it is possible that lower positive returns of the index coincide with higher positive returns of the stock, or vice versa, thus resulting in a negative beta coefficient. A higher beta suggests that the stock has greater volatility and is therefore considered to have greater risk (Levinson, 2002: 142).

Therefore, the beta coefficient is a key parameter in this model as it measures the part of the asset's risk that cannot be diversified away. This coefficient can be calculated as follows:

$$\beta_{it} = \frac{COV(R_{it}, R_{mt})}{VAR\ (R_{mt})} \qquad [2.4]$$

where $COV(R_{it}, R_{mt})$ measures the covariance of an individual asset to the market and $VAR\ (R_{mt})$ is the variance of the whole market (Fama and French, 2004: 28).

From the review of the CAPM we find that the risk on an asset essentially comprises two elements. The first is systematic risk which is what an investor is rewarded for holding in their portfolio (returns), and idiosyncratic risk which can be diversified away, thus the market does not reward an investor for holding this form of risk. Thus the risk-return relationship being studied here is the relationship between systematic risk and return

2.2.2 The Arbitrage Pricing Theory (APT)

The APT is an appealing alternative to the CAPM because it harnesses the intuition behind the CAPM, but uses fewer assumptions. The APT is based on a linear generating process and relies essentially on the following assumptions: firstly, capital markets are perfect; secondly, the number of assets is close to infinity; thirdly, investors have homogeneous expectations (the same as CAPM); and lastly, the returns are generated according to a linear factor model (Gilles and LeRoy, 1991: 214).

Moreover, the APT is not restricted to the single period case and thus will hold in both the multi-period and single period cases. Although consistent with every conceivable prescription for portfolio diversification, no particular portfolio plays a role in the APT. Unlike the CAPM, there is no requirement that the market portfolio be mean-variance efficient (Patterson, 1995: 145).

There are two major differences between the APT and the CAPM. Firstly, the APT allows for more than just one generating factor. Secondly, the APT demonstrates that since any market equilibrium must be consistent with no arbitrage profits, every equilibrium will be characterized by a linear relationship between each asset's expected return and its returns loadings on the common factors (Roll and Ross, 1980: 1074).

The APT begins with the traditional neoclassical assumptions of perfectly competitive and frictionless asset markets. Just as the CAPM is derived from the assumption that random asset returns follow a multivariate normal distribution, the APT also begins with an assumption on the return generating process. Individuals are assumed to believe (homogeneously) that the random returns on the set of assets being considered are governed by *k*- factor generating model of the form:

$$\bar{r}_i = E_i + b_{i1}\bar{\delta}_1 + \dots b_{ik}\bar{\delta}_k + \bar{\epsilon}_i, \qquad [2.5]$$

$$i = 1, \dots, n$$

The first term in Equation 2.5, $E_{i,}$, is the expected return on the i^{th} asset. The coefficients b_{i1} to b_{ik} quantify the sensitivity of asset *i*'s returns to the movements in the common factors $\bar{\delta}_1$ to δ_k. The common factors capture the systematic components of risk in the model. Chen, Roll and Ross (1986) indentify the following macroeconomic and financial variables as systemic components of risk: the return on an equity index, the spread of short and long-term interest rates, a measure of the private sector's default premium, the inflation rate, the growth rates of industrial production, and the aggregate consumption. According to the authors these factors are the main determinants of cross-sectional variations in estimated expected returns.

The final term, $\bar{\epsilon}_i$, is a noise term, which represents an unsystematic risk component, idiosyncratic to the i^{th} asset. It is assumed to reflect the random influence of information that is unrelated to other assets. From Equation 2.5 it is assumed that:

$$E[\bar{\epsilon}_i] = 0 \quad [2.5.1]$$

$$E[\bar{\epsilon}_i \bar{\epsilon}_j] = 0 \quad [2.5.2]$$

$$E[\bar{\delta}_k] = 0 \quad [2.5.3]$$

$$E[\bar{\epsilon} i \bar{\delta}_k] = 0 \quad [2.5.4]$$

$$E\,[\bar{\delta}_k \, \bar{\delta}_m] = 0 \quad [2.5.5]$$

Equation 2.5.1 simply states that the idiosyncratic or unsystematic risk is zero on average, implying that a fully diversified portfolio will not include idiosyncratic risk and thus investors will not get rewarded for having this type of risk in their portfolio. Equation 2.5.2 states that the idiosyncratic risk is uncorrelated across different assets, Equation 2.5.3 states that the factor is zero on average ($\bar{\delta}_1$ $\bar{\delta}_2$ ... $\bar{\delta}_k$ and $\bar{\epsilon}_i$ have zero means), Equation 2.5.4 states that the idiosyncratic risk is uncorrelated with the common factors that affect the portfolio, and Equation 2.5.5 states that different factors are uncorrelated. Finally it is assumed that for the number of assets in the portfolio, *n* is much greater than the number of factors, *k*.

The APT itself is derived from the return generating process derived from Equation 2.5. Consider an individual who is currently holding a portfolio and is considering an alteration of his / her portfolio: any new portfolio will differ from the old portfolio by investment proportions x_i (i = 1, ..., m), which is the dollar amount purchased or sold of asset *i* as a fraction of total invested wealth. The sum of x_i proportions,

$$\sum_i x_i = 0$$

since the new portfolio and the old portfolio contribute an equal amount of wealth into the *n* assets. In other words, additional purchases of assets must be financed by sales of others. Assets that are financed through selling other assets with a view to making profits are called arbitrage portfolios.

Because idiosyncratic risk can be diversified away $\bar{\epsilon}_i$, can be omitted, and Equation 2.5 would say that each asset *i* has returns r_i, that are an exact linear combination of the returns on a riskless asset (with identical return in each state) and the returns on *k* other factors or assets or column vectors, $\bar{\delta}_1$ ..., $\bar{\delta}_k$. In such a setting, the riskless return and each of the *k* factors can be expressed as a linear combination of *k* + 1 asset's returns. Thus, portfolios of the first *k* + 1 assets are perfect substitutes for all other assets in the market. Since perfect substitutes must be priced equally, there must be restrictions on the individual returns generated by the model. This is the core of the APT: there are only a few systematic components of risk existing in nature. As a consequence, many portfolios are close substitutes and, as such, they must have the same value (Roll and Ross, 1980: 1077).

In algebraic terms the APT reduces to the following:

$$E_i = \lambda_0 + \lambda_1 b_{i1} + ... + \lambda_k b_{ik,} \text{ for all } i. \quad [2.6]$$

where E_i is the expected return, λ_0 is the return to *i* if all factors equal zero, λ_k is the sensitivity of asset *i* to factor *k* (also known as the factor loading), and $b_{ik,}$is the realized value of the factor at time *t*.

One of the immediate consequences of using the linear equation function [Equation 2.6] above is that it supports Markowitz and the CAPM reasoning of diversification. Statistically, the greater the number of observations/assets in a portfolio, the lower the value of the residual. As the residual falls, the level of uncertainty surrounding the return of a portfolio falls and the risk is consequently lower. Thus the arbitrage pricing theory arrives at the conclusion that diversification helps to reduce the amount of risk an investor exposes themselves to (Ingersoll, 1984: 1028).

If there is a riskless asset with the return, E_0 , then b_{0j} = 0 and

$$E_0 = \lambda_{0,} \quad [2.6.1]$$

hence:

$$E_i - E_0 = \lambda_1 b_{i1} + ... + \lambda_k b_{ik} \qquad [2.7]$$

where that E_0 is the riskless rate of return and is the common return on all “zero-beta” assets, i.e., assets with $b_{ij} = 0$, for all j. This implies that it is possible to create a portfolio that has no residual variance (i.e. no unsystematic risk) (Roll and Ross, 1980: 1078).

In this model it is important to understand the interpretation of the risk premium λ which is the same for all assets (independent of i,j). By forming portfolios with a unit systematic risk on each factor and no risk on other factors, each λ_j can be calculated as follows:

$$\lambda_j = E^j - E_o \qquad [2.8]$$

$E^j - E_o$ is the excess return or market risk premium on portfolios with only systematic factor j. Given this then Equation 2.7 can be written as

$$E_i - E_0 = (E^1 - E_0)\, b_{i1} + ... + (E^k - E_0)\, b_{ik} \qquad [2.9]$$

This excess return on asset i is equal to b_i, which shows the sensitivity of returns on i to factor risk, thus b_{ik} shows the sensitivity to factor risk for asset k. The expected return on security i weights these security-specific betas by a weight λ_j that is the same for all the securities. Hence λ_j may be interpreted as the extra expected return required because of the securities sensitivity to the j^{th} factor (Roll and Ross, 1980: 1079).

When assets are undervalued there exists an opportunity for arbitrage, as people profit from exploiting the opportunity to receive higher returns for the same risk exposure. As long as one linear relationship exists between risk and return, no arbitrage opportunity exists. If there is any deviation from the linear relationship, then arbitrage will set in to restore equilibrium in the market (Farrell, 1997: 52).

The APT and the CAPM are two of the most influential theories on asset pricing. The APT differs from the CAPM in that it is less restrictive in its assumptions, and it allows for an explanatory rather than a statistical model of asset returns. The APT assumes that each investor will hold a unique portfolio with its own set of betas, whereas the CAPM assumes that all investors hold the market portfolio. In some ways the CAPM can be considered a special case of the APT because when there is only one factor in the APT, it essentially reduces to the CAPM.

Additionally, the APT is considered a “supply-side” model, since its beta coefficients reflect the sensitivity of the underlying asset to economic factors. On the other hand the CAPM is considered a “demand-side” model. Its results, although similar to those of the APT, arise from a maximisation problem of each investor’s utility function, and from the resulting market equilibrium (investors are considered to be the consumers of the assets).

2.2.3 Attitudes towards risk

The theory of utility maximisation categorises investors into three groups depending on their risk preference. Firstly, risk-averse investors are those who, if given a choice between two assets that have the same return but different levels of risk, would opt for the asset with a lower risk. With this group of investors the expected return increases at an increasing rate as the risk increases. Secondly, risk-neutral investors have a linear utility function exhibiting constant marginal utility of wealth. This implies that an investor is indifferent between investing in risk-free assets and risky assets if they all provide the same return. The expected return increases at a constant rate as risk increases. The last category is that of risk-loving investors who exhibit a convex utility function. If such investors are faced with the choice between two assets with the same return but different risk, such an investor will pick the stock with the greater level of risk. In this case, the expected return increases at a decreasing rate as the level of risk increases (Stracca, 2004: 385).

An important application of the ARCH class of volatility models is in modelling the trade-off between the expected risk and return of an asset. It is generally assumed that the average investor is risk-averse, at least toward significant portfolio management decisions. However, the increase in the expected return required for an increase in risk varies across asset holders depending on their attitudes towards risk. For a variety of institutional and regulatory reasons, different types of market participants have a different tolerance of risk. For example, pension funds are typically more conservative investors that put high priority on capital preservation. In contrast, hedge funds are more aggressive in their pursuit of high returns (Tarashev et al., 2003: 59). The relationship between risk and return as generated by various models needs to be interpreted with the understanding that risk preference (which has a tendency of varying over time) plays a significant role in asset pricing.

The next section focuses on the empirical literature in order to investigate the existence and nature of the risk and return relationship.

2.3 EMPIRICAL STUDIES ON THE RISK-RETURN RELATIONSHIP

2.3.1 Developed stock markets

An extensive body of literature exists for developed stock markets when testing the basic hypothesis of the CAPM of Sharpe (1964), Lintner (1965), Mossin (1966) and Merton (1973) which hypothesises a positive risk-return relationship. In order to test this hypothesis the ARCH-in-mean (ARCH-M) model developed by Engle et al. (1987) provides a natural tool for the estimation of this relationship. The current state of literature on the existence and nature of the relationship between risk and return is quite illusive. Backus and Gregory (1993) note that the relationship between risk and return may be increasing, decreasing, flat, or nonmonotonic or increasing, as is the case in most of the ARCH-M literature.

One strand of literature focuses on testing the risk-return relationship using the ARCH family of models. French et al. (1987) used two methods to investigate this relationship. Using daily returns they first computed estimates of monthly volatility on a univariate Autoregressive Integrated-Moving Average (ARIMA) model. The authors also used daily returns from the S&P composite portfolio to estimate ex ante measure of volatility using a GARCH-M model. The results from these two models showed evidence that the expected market risk premium (the expected return on a stock portfolio minus the Treasury bill yield) was positively related to the predictable volatility of stock returns. The authors also found evidence that unexpected stock market returns were negatively related to the unexpected change in the volatility of stock returns.

Chou (1988) supported French et al.'s (1987) finding of a positive relation between the predictable components of stock returns and volatility in the United States. Chou's (1988) study used weekly data for the period July 1962 to December 1985 and used a GARCH-M specification. However, Baillie and DeGennaro (1990) used the GARCH-M model and a similar data set to that of French et al. (1987) and Chou (1988), and found that there is no evidence of a positive relationship between risk and return (as measured by mean and variance). They established that the mean-variance optimization of Markowitz is inappropriate under the assumption of the conditional Student –*t* density.

Using a monthly data set spanning from 1851 to 1989 for the US, Glosten et al. (1993) used a modified GARCH-M model. This model was modified in three ways: firstly the model allowed for seasonal patterns in volatility (by imposing dummy variables in the GARCH-M model); secondly, the model allowed for asymmetries in the conditional variance equation; and lastly, the model allowed for nominal interest rates to predict conditional volatility. Inconsistent with the results of French et al. (1987) and Chou (1988), Glosten et al. found a negative relationship between expected stock market return and volatility.

Theodossiou and Lee (1995) studied the nature of stock market volatility and its relation to expected returns for ten industrialized countries (Australia, Belgium, Canada, France, Italy, Japan, Switzerland, the United Kingdom, the United States, and (West) Germany). They used the GARCH-M specification and tested three different specifications for the conditional variance and expected market returns relationship, which are the linear, square root and log-linear specifications. Moreover, no restrictions on the lag structure were imposed as opposed to the single-lag specification imposed by Chou (1988). The results of this study supported the findings of the preceding studies that did not find a significant relationship between conditional volatility and expected returns.

Lanne and Saikkonen (2004) used a modified GARCH-M model in order to cater for skewness and kurtosis. The study used monthly US stock returns for the period from 1946 to 2002. The authors motivated this modification by arguing that the modified model was capable of modelling moderate skewness and kurtosis typically encountered in financial return series. The results of this study showed that there was a positive and significant relationship between risk and return.

Further extensions of the GARCH-M specifications have been used in literature to investigate the nature and existence of the time-varying risk premium. For instance, using a bivariate GARCH-M model, Chan et al. (1992) tested the International CAPM and found a statistically significant positive relationship between the conditional expected excess returns and the covariance. The authors used the S&P 500 index to compute the conditional covariance and the Nikei 225 index and Japan's Morgan Stanley index as a proxy to international excess returns. Bae (1995) used the bivariate GARCH-M model to test the Korean Composite Stock Price Index and the Morgan Stanley Capital International world index for the period 1980 to 1990. The results of the study indicated a positive relationship between risk and return.

Jochum (1999) used a bivariate GARCH(1,1)-M methodology to estimate the price of variance and covariance risk of the Swiss Market Index daily returns with regard to the major equity markets of Tokyo, Frankfurt, London and New York. Using a weighting procedure that allowed risk to be weighted in proportion to market capitalisation, the study found significant evidence that the covariance risk was significant and positive for all the markets except Frankfurt.

A further extension of the GARCH-M model that has been used in the literature is the Multivariate GARCH-M (MGARCH-M) model used by Hansson and Hordahl (1998) to investigate the relationship between risk and expected return on the Swedish stock market based on the CAPM. This model was tested against six alternative hypotheses: (1) the zero-beta version of the CAPM; (2) the market price of risk varies across portfolios; (3) expected excess returns can be explained by asset-specific constants in addition to market risk; (4) the variance of individual portfolios is priced; (5) the covariance with the world market portfolio return is priced; and (6) the covariance with changes in consumption is priced. The investigation was done using beta-ranked, size-ranked, and industry-sorted portfolios. The estimates for the null hypothesis showed that the price of risk is positive and significant for all portfolio groupings. Tai (2003) also used the same MGARCH-M to test Merton's (1973) Intertemporal CAPM. Using four risk factors (market portfolio, size portfolio, book-to-market portfolio and momentum portfolio) and data for the US from 1953-2000, the study established that these risk factors are not only significantly priced but are also time-varying in nature.

Another body of empirical literature uses an alternative to the GARCH-M framework and focuses on using the Instrumental Variables technique[1] for the specification of conditional moments. Using monthly US data from 1959-1979, Campbell (1985) tested the ICAPM using the instrumental variables technique and found a positive relationship between conditional mean and conditional variance. However, using the same approach Harvey (1991) found a negative relationship between the conditional mean and conditional variance. This result was obtained by testing the conditional CAPM using a similar method of instrumental variables with data spanning a period of 20 years for 16 OECD countries and Hong Kong. However, Turner et al. (1989) used a two stage Markov model on the US stock market and found that the relationship between expected stock returns and volatility ranged from positive to negative.

Non-parametric models also form the basis of another strand of literature that seeks to test the risk-return tradeoff. Koop (1994: 176) noted that using a model that assumes the underlying white noise disturbances to be normally distributed (such as traditional ARCH models) faces the risk of misspecification by assuming a specific functional form. This problem can be addressed by considering more general densities for the underlying white noise errors or by using non- or semi-parametric estimation techniques. Thomas and Wickens (1989) provided non-parametric estimates for the foreign exchange and equity risk premia for West Germany, Japan, the United Kingdom and United States for 1973–1988. The results in this study indicated that evidence in support of a positive risk-return relationship was lacking.

In line with preceding authors, Pagan and Hong (1991) analysed US monthly stock volatility from 1834–1925 using a non-parametric model. The results indicated that there was a weak negative relationship between risk and return during this period. However, Harrison and Zhang (1999) found that the relationship was significantly positive at longer horizons. For a specification that facilitates regime-switching, Whitelaw (2000) documented a negative unconditional link between the mean and variance of the market portfolio.

In an attempt to analyse the risk premium in the Italian stock market, Bottazzi and Corradi (1991) compared the ARCH-M models to the non-parametric models. The results of the

[1] The instrumental variables technique is an estimation procedure applicable to situations in which the independent variable is not independent of the disturbance. If an appropriate instrumental variable can be found for each endogenous variable that appears as a regressor in a simultaneous equation, the instrumental variable technique provides consistent estimates regressor in a simultaneous equation, the instrumental variable technique provides consistent estimates (Kennedy, 2003:174)

estimation of the ARCH-M model confirmed the existence of the ARCH process in the conditional variance and showed evidence of a time varying risk premium. This result remained true when a non-parametric specification was adopted. The two models concluded that the Italian equity market exhibited a positive and significant relation between risk and expected return.

As can be noted, many of the studies that have been conducted focused solely on testing the CAPM and its extensions based on mean-variance. Adesi et al. (2004) noted that there were a number of empirical irregularities that were not consistent with the standard version of the CAPM. The authors argued that these irregularities are still subject to much debate, both on a theoretical and empirical level, however, the evidence suggests that the CAPM is not a satisfactory model of asset returns.

Adesi et al. (2004) noted that it is important for asset returns to fully consider coskweness in the role of asset pricing. The authors further argued that an asset with positive (negative) coskewness reduces (increases) the risk of the portfolio to large absolute market returns, and should command a lower (higher) expected return in equilibrium. Extending this idea to behaviours in financial markets, one can argue that a risk averter will be reluctant to undertake any investment that presents a (very) small possibility of a large loss, compensated by a limited gain. Moreover, investors will accept a lower expected return from an investment with a higher positive skewness in returns and the same variance. Other things being equal, investors will prefer portfolios with a larger probability of very large payoffs.

The first study to implement this intuition was conducted by Kraus and Litzenberger (1976), who augmented the standard two-moment CAPM by introducing a measure of systematic coskewness risk and used the model to explain the risk-return trade-off. The three-moment model asserts that investors are willing to pay premiums for the assets with positive co-skewness with the market portfolio. The authors established that the three-moment CAPM corrects for the apparent mispricing of high- and low-risk stocks encountered in the standard two-moment CAPM.

Friend and Westerfield (1980) used the Kraus and Litzenberger (1976) version of the CAPM to investigate the existence of positive-skewness preference on the US security markets. Although they were unable to substantiate Kraus and Litzenberger's (1976) conclusions there was some inconclusive evidence that an investor may pay a premium for positive skewness of portfolio returns. They also found that the results were sensitive to the market conditions. Sentana (1998) investigated the existence of such a preference on the Spanish stock market using a multivariate factor model and did not find any evidence to support investors' positive-skewness preference. Similarly Lim (1989) investigated this hypothesis but used the Generalized Method of Moments (GMM) and found skewness to be priced on the US securities market.

Compared with earlier studies on skewness preference, only a few studies examined the impact of kurtosis on stock returns. Scott and Horath (1980) suggested that investors have positive preference for the third and higher odd moments and negative preference for the second and higher even moments of return distributions. Extending the three-moment CAPM, Fang and Lai (1997) argued that investors will not only forgo the expected excess returns in exchange for taking the benefit of increasing the systematic skewness, but they are also compensated by higher expected returns for bearing the systematic covariance and the kurtosis risk.

2.3.2 Emerging markets

Various authors[2] have documented that emerging markets have different characteristics in the equity markets that are distinct from developed markets. The four main distinguishing characteristics are: average returns are higher, low correlations with developed markets, easier predictability of returns (meaning the markets are inefficient), and higher volatility. Harvey (1995) attributed the high volatility of returns to three factors: firstly, a lack of diversification in the country index; secondly, high risk exposures to volatile economic factors; and thirdly, time-variation in the risk exposures and/or incomplete integration into world capital markets. Although there is some evidence to suggest that many emerging markets are becoming more integrated into global capital markets overall, these markets still differ from developed markets in high liquidity risk and limited availability of high quality, large capitalization shares.

[2] For example, see Salomons and Grootveld (2003), Appiah-Kusi and Menyah (2003), Harvey et al. (2000), Kawakatsu and Morey (1999), Bekaert et al. (1998), Bekaert and Harvey (1997), De Santis and Imrohoroglu (1997), Bekaert et al. (1997), and Schaller and Van Norden (1997).

The above-mentioned distinguishing characteristics of emerging markets have attracted much research in the modelling of time-varying nature of volatility as well as attempting to establish the risk-return relationship. Much of the literature that has been put forward to investigate this relationship has been conducted using the GARCH family of models.

Using a GARCH-M model Poshakwale and Murinde (2001) investigated stock market volatility in the East European emerging markets of Hungary and Poland. The study covered a period from 1994 to 1996 using daily data from the Bulgarian and Warsaw stock markets. Contrary to the predictions of the CAPM, the results indicated that conditional volatility was not priced on both markets.

A similar result was obtained by Yu and Hassan (2008) using an extension to the GARCH model, the EGARCH model. The main aim of this study was to investigate regional and international integration of the Middle Eastern and North African (MENA) stock markets. Daily data was used to cover the period 1999–2005. The results indicated that there was a significant positive risk-return relationship in Bahrain, Oman and Saudi Arabia, while in Egypt, Jordan, Morocco and Turkey volatility was not priced. Using the same model Karmakar (2007) found evidence in support of a negative risk-return relationship on the Indian stock market using the S&P CNX Nifty for the period 1990–2004. Similarly, using the EGARCH-M model Saleem (2007) found that positive returns were matched with higher volatility on Pakistan's stock exchange (Karachi stock exchange). This study covered the period from 1997 to 2004 using the daily closing prices of the KSE-100 index.

Battilossi and Houpt (2006) investigated the relationship between risk, return and volume on the Bilbao stock exchange (1916–1936) using the augmented GARCH-M model that was modified to account for volume traded. The authors found that there was little evidence of a significantly positive risk-return trade-off. This result contradicts the CAPM and intuitively one would expect that since emerging markets are generally considered to be risky then there should be an adequate compensation for assuming more risk. However, Salomons and Grootveld (2003) found a significant relationship between risk and return in 20 emerging markets. They further stated that the existence of such a relationship is highly dependent on the sample period used. Interestingly the authors concluded that the difference between emerging and developed equity premiums follows a cyclical pattern that resembles the global business cycle.

Using the GARCH, EGARCH, TARCH and PGARCH models, Kovačić (2008) found a weak relationship between risk and return in the Macedonian Stock Exchange (MSE). The author used the MBI-10 index, which is the capitalization-weighted index consisting of up to 10 shares listed on the official market of the MSE, covering a period from 2005 to 2007. Kovačić (2008) tested the result assuming three different distributions – Gaussian, Student –*t* and GED – and found that the TARCH model with a Student –*t* distribution was the best model to accurately model the data. Leon (2008) used a similar approach by using GARCH models with a Student –*t* and a Gaussian distributional assumption in investigating the risk-return relationship in the West African Economic and Monetary Union, using weekly returns for the period 1999–2005. The study revealed that expected stock return has a positive but statistically insignificant relationship with expected volatility. He also found that volatility is higher during market booms than when the market declines.

2.3.3 South Africa

As noted earlier, there is very limited research on emerging markets, specifically Africa, of which the JSE is the oldest, largest and most liquid market. The few studies that have attempted to study the risk-return relationship on the JSE have predominantly focused on incomparable non-econometric techniques such as the Sharpe ratio. One of the earliest econometric studies of conditional returns to conditional risk using GARCH-M models that is comparable to the studies reviewed above was conducted by Samouilhan (2007). The author investigated the JSE's risk-return behaviour by focusing on the intertemporal relationship between the conditional domestic equity market premium, its conditional variance and its conditional covariance with the international equity market. The daily JSE/Actuaries All Share Top 40 Companies and the Financial Times-Stock Exchange 100 Share Index (FTSE 100) acted as proxies for domestic and international market portfolio, respectively, as well as the 90-day Treasury Bill rate as a proxy for the risk-free rate. The research found evidence of a positive relationship between foreign returns and domestic returns and also a positive relationship between foreign and domestic volatility, a result which is in line with the Intetemporal CAPM. The study also found that movements in the international equity market had two effects on the local market: increasing the risk of the domestic market by reducing the international diversification benefits, and explaining some of the volatility of domestic equities.

In modelling the volatility on the JSE employing ARCH-type models, Mangani (2008) found that volatility was symmetric and was not a commonly priced factor. This result was obtained by considering two portfolios (with data from 1973–2002): the All Share Index (ALSI) and a portfolio with 42 stocks. The portfolio of 42 stocks was used because the ALSI is dominated by resource stocks and thus it was necessary to have a portfolio that was not unduly influenced by the dynamics of the resource stocks. This result was echoed by Chinzara and Aziakpono (2009), who primarily studied returns and volatility linkages between SA and the world major equity markets. Using a GARCH-M methodology to test the risk-premum hypothesis the authors, like Mangani (2008), found that volatility is not a commonly priced factor and found that volatility is asymmetric, as opposed to symmetrical as found by Mangani (2008).

2.4 CONCLUSION

This chapter explored diverse issues regarding risk and return. In order to lay a foundation for the empirical analysis, the relevant theory that informed the risk-return relationship was reviewed. The CAPM and the APT were reviewed as these are the two prominent asset pricing models. The empirical evidence on the risk-return relationship was also reviewed.

The literature was grouped into three sections: developed markets, emerging markets and the South African equity market. The literature essentially showed that there is a lack of a consensus relating to the existence of an equity premium. However, much of the studies on this subject have been done on the developed countries such as the USA, Europe and Australia. There is a distinct lack of literature on emerging markets, especially South Africa. However, the scant research done reveals the same conclusion: a lack of a consensus with regard to the existence of a risk-return relationship.

The next chapter looks at the structure of the South African equity market with a view to establishing whether there are indicators pointing towards the nature of volatility or the existence of an equity premium.

CHAPTER THREE
OVERVIEW OF THE SOUTH AFRICAN EQUITY MARKET

3.1 INTRODUCTION

Having reviewed the theoretical and empirical literature on volatility and the risk-return relationship, we now explore some of the institutional and technical issues of concern in analysing the relationship between risk and return on the South African equity market. This chapter is divided into three sections which focus on the South African equity market. Section 3.2 looks at the background of the JSE Limited. The speed of trading, settlement and clearing has an impact on the efficiency of the market which in turn has implications on return and risk (Mabhunu, 2004: 15). Of equal importance in understanding the risk-return relationship is understanding the regulatory framework governing the equity markets. The strength of regulation of a stock market affects the timely availability of information, insider trading and transparency, all of which have an effect on asset prices, thus affecting return and volatility of the market. Section 3.3 looks at the composition and categorisation of some of the industries and sectors. This review is important as it lays a foundation for the empirical analysis which will be carried out mainly at an industrial and sectorial level.

3.2 THE SOUTH AFRICAN EQUITY MARKET

The equity markets in most countries are formalised as opposed to being over-the-counter (OTC) markets and this is because risk management, clearing and settlement are better performed by such a vehicle (Faure, 2005: 12). The formal equity market plays a significant role in the financial system and the economy in terms of providing a facility for the issue of equity (shares) by companies (primary market), thereby channelling savings into productive (in most cases) investment, as well as for the trading of these instruments (secondary market). The latter market has many benefits, including the facilitation of the primary market, the signalling to companies of the perception of professional investors in respect of the listed companies, indicating the receptiveness of the market for, and the pricing of, new issues (Faure, 2005: 7).

The formal exchange for equities in South Africa is JSE Limited (JSE) (Equities Division), which is licensed annually in terms of the Securities Services Act 2004 (SSA). The Financial Services Board (FSB) administers the Act, and the Registrar of Securities Services is the Chief Executive Officer of the FSB (Faure, 2005: 8).

Historically, there have been several stock exchanges that have facilitated the trading of listed shares in South Africa. The first recorded share dealing was in Cape Town in 1838, followed by the Kimberley Royal Stock Exchange, and in 1887 the Johannesburg Stock Exchange was established. In 2000 the name was changed to JSE Securities Exchange South Africa, and the name was changed to JSE Limited in 2005 after it demutualised. Although the JSE is the only stock exchange currently operating in South Africa, there is statutory provision for the operation of more than one stock exchange. Since its formation in 1887 the JSE has gone through vast changes, including, among other things, numerous changes in trading systems, management, and modification of rules.

3.2.1 Trading, settlement and clearing

On 7 June 1996 the open outcry trading floor was replaced by an automated trading system known as the Johannesburg Equities Trading (JET) system. The introduction of this system meant that the trading structure was now a continuous order-driven system with dual capacity trading, complemented by member firms voluntarily acting as market makers. The JET system was replaced by the London Stock Exchange Securities Electronic Trading System (SETS) in May 2002. This represented an upgrade to a superior trading platform that has the added advantage that equity prices and other information from the JSE are disseminated by the LSE to the main financial centres around the world. This system was mainly adopted in order to encourage more international interest in the JSE. The JSE also introduces the LSE’s London Market Information Link (LMIL) system, known in South Africa as InfoWiz, to provide a world-class information dissemination system and substantially improve the distribution of real-time equities market information. The introduction of JSE SETS also represented a strategic alliance with the LSE and improved the international visibility of the JSE. Moreover, the JSE adopted a new classification system for shares to bring the JSE in line with international best practice, and replaced its indices with new indices, called the FTSE/JSE Africa Index Series (Faure, 2005: 143; JSE, 2009).

In 1999 the JSE introduced an electronic clearing and settlement system, called Share Trading Totally Electronic (STRATE). STRATE is the approved Central Securities Depository (CSD) and the electronic settlement system for equities in South Africa[3]. The first phase of STRATE was implemented at the end of September 1999. Between then and the end of March 2002, every JSE listed equity was migrated for settlement through STRATE. The technology allowed trades to be settled from any country in the world as STRATE is connected to the Society for Worldwide Interbank Financial Telecommunication (SWIFT), an international network that supplies secure messaging services and interface software to wholesale financial entities. Under the STRATE system there was greater efficiency because the system achieved secure, electronic settlement of share transactions on the JSE including off-market trades. STRATE ushered in a new era of clearing and settlement, which not only boosted the JSE's competitiveness in the international financial markets, but also improved South Africa's standing in terms of settlement and operational risk. With the reduction of operational and settlement risk the overall risk (systemic) that is eventually priced in equity securities reduces. In accordance with the CAPM and the APT, the required return should reduce as the systematic risk reduces.

3.2.2 Regulation

It is imperative that any stock exchange is properly regulated for the purposes of protecting the various types of investors through the use of various regulatory tools. A proper regulatory framework that is adhered to by all market participants, and is enforced by the appropriate regulatory authorities, brings about systemic stability.

Since its inception, the JSE's regulatory framework has been based on self-regulation. Legislation relating to the JSE, as embodied in the Security Services Act 2004, seeks to protect the interests of the general public in buying and selling shares without unduly infringing upon self-regulation (SAIFM, 2008: 48)

In the interest of self-regulation the Act requires the exchange to draft its own rulebook, which must be approved by the FSB. The JSE executive has the authority and discretion to alter the trading period, close, suspend or halt trading, or take any such steps necessary to

[3] Electronic settlement involves rolling, clearing and settlement within 5 working days of dealing (T + 5). Thus, settlement takes place every business day of the week, and not later than 5 working days after the deal takes place.

maintain an orderly market. The rules also detail the security procedures, reporting procedures and resources required by members to ensure the efficiency and integrity of the equities market, as well as the proper functioning of the JSE trading system. The effective implementation of these rules and regulations through compliance requirements and reporting requirements will ensure that all market participants deal and trade at fair prices as well as reducing systemic risk. As regulatory standards improve risks such as fraud will be significantly lowered thus lowering systemic risk. According to the predictions of the CAPM and the APT, as systemic risk is lowered so should the required rate of return.

3.3 STRUCTURE OF THE SOUTH AFRICAN EQUITY MARKET

The companies that are listed on the main board of the JSE are classified under various groups according to industry, supersectors, sectors and subsectors as shown in Table 3.1[4]. According to the Industry Classification Benchmark (ICB) created in 2004 by index companies FTSE and Dow Jones, and also adopted by many exchanges including the JSE, there are 10 industries, 18 supersectors, 39 sectors and 104 subsectors (see Table 3.1). Prior to the introduction of the ICB, all listed companies were classified according to the FTSE Global Classification System (GCS), which was one of a number of global classification systems. The ICB was announced on the backdrop of increased pressure by investors for a unified classification system. The introduction of this system impacted the sector which a company listed on as well as the calculation of the FTSE/JSE Africa Indices. Under the old FTSE Global Classification System, there were three tiers of classifications (10 economic groups, 36 industry sectors and 102 subsectors). Although South Africa has all the industries and supersectors (with the exception of utilities), as well as the majority of the sectors, it does not have the full range of subsectors. A full complement of the 104 subsectors is found on markets of well developed countries.

Some of the key drivers of the South African economy are Oil and Gas, Financials, Telecommunications, Technology, Basic Resources and Health Care. The Oil and Gas industry comprise coal, crude oil, natural gas, hydro-electric power, nuclear power and renewals, of which coal mining by far exceeds the others, accounting for 77% of South Africa's power requirements. This figure is bound to increase in the future owing to the lack

[4] Table 3.1 also shows the indices that were used for estimation in this study. In addition to these, the All Share index, Small Cap and Mid Cap indices were also included.

of a suitable alternative and an abundance of coal deposits; as a result large coal mining houses have developed. The industry is highly concentrated with 85% of the coal production done by five companies, namely Anglo Coal, BHP Billiton, Sasol Mining, Exxaro, Kumba Coal and Xstrata. Collectively these companies produce and export 28% of South Africa's production internationally, and thus they are fourth largest coal exporter in the world. Due to its high export orientation, this industry is highly susceptible to international energy demand, thus the expectation is that the volatility experienced in this industry largely stems from international pressure (Mining Weekly, 2009).

The South African Financials industry mainly comprises banking, insurance and real estate. The insurance industry boasts the largest insurance penetration in the world of 14% in comparison to 3.9% of other emerging markets[5]. The banking system, on the other hand, has one of the most efficient banking systems in comparison to most developing nations. The extensive banking facilities comprise a network of branches and ATMs throughout the country as well as a wide array of financial services including commercial, merchant and retail banking, mortgage lending, insurance and investment. The banking subsector is the largest component of South Africa's Financial industry. This industry has 36 registered banks, of which 14 are South African controlled, 6 are foreign controlled, 14 are local branches of international banks and 2 are mutual banks. Of these, ABSA, Nedcor, Standard Bank and Investec account for 80% of the total banking assets. Their pattern of evolution has largely centred on consolidation through mergers and acquisitions of smaller firms providing financial services (IMF, 2009). The banking sector in South Africa has so far not required any state bailouts in response to the global market collapse, mainly due to strict exchange control legislation limiting the banks' offshore exposure, sound management policies (e.g. strict adherence to Basel II principles) and self-regulation following the collapse of Saambou and Regal. Such adherence to regulation could be part of the reason why volatility in this industry has not been as high as other emerging markets.

One of the key industries that have aided growth in South Africa is the Telecommunications industry. This industry is one of the fastest growing industries in South Africa, mainly driven by the rapid growth in mobile telephony. Together with transport and storage, this industry accounts for 10% of GDP. The licensing of Neotel ended Telkom's (with the government

[5] Insurance penetration is the insurance premium as a percentage of GDP.

being the largest shareholder) fixed line monopoly. With respect to mobile communications, South Africa is the fourth fastest growing mobile communications market in the world. This growth is primarily driven by the operation of Vodacom, MTN and Cell-C in the South African market, as well as a regional and international presence in the Middle East[6]. However, the costs of bandwidth are still prohibitively high although the government has made concerted efforts to lower such costs through the formation of Infraco, a new state-owned company that will provide bandwidth through fibre-optic cables in a bid to lower costs. Much like the Banking sector, one would expect volatility and returns in the Telecommunications industry to be largely linked to external shocks and pressures (Department of Communications, 2009).

South Africa is ranked as the 20th largest consumer of Information Technology (IT) products and services. This industry is characterised by technology leadership in Africa specifically in the area of electronic banking systems such as pre-payment, revenue management and fraud prevention systems. Several international corporates recognised as world leaders operate subsidiaries from South Africa, including IBM, Unisys, Microsoft, Intel, Systems Application Protocol (SAP), Dell, Novel and Compaq. This industry is set to continue showing strong growth in the future as regulatory and conditions improve. Such improvements have seen SA-based companies and SA subsidiaries of international companies supply most of the new wireless and fixed telecommunication networks not only in South Africa but in Africa at large (GCIS, 2009). Due to the increasing presence of international IT companies in the South African market, we would expect volatility and returns to be largely influenced by global sentiment and external shocks.

Much of South Africa's wealth has been built on the country's vast resource base. The country is the leading producer of gold and platinum and is currently the fourth largest producer of diamonds. Although SA is the largest gold producer in the world, the relative importance of gold as a key earner of foreign exchange reserves has diminished over time. In the 1970s and 1980s gold contributed 14% of the country's GDP and it is currently contributing 5.8% of GDP. This industry still proves to be of vital importance to the domestic and international economy as precious metals contribute 65% of the country's mineral exports. Furthermore, 80% of the world's platinum is supplied from South Africa. Two of the

[6] Virgin Mobile operates in South Africa as a virtual network in partnership with Cell-C.

world's biggest mining companies originate from South Africa, namely BHP Billiton and Anglo American Plc[7]. Currently Rio Tinto has invested US$ 2.7 billion in building an aluminium smelter, while De Beers is building two new mines and Indian steel company Tata Steel has invested R650 million into the industry (Department of Minerals and Energy, 2009). The Basic Materials industry includes the Chemical sector, which is the largest of its kind in Africa. Exports of chemicals have been growing at an annual average of 19% since 1999 due to new trade agreements and improved competitiveness due to cost-effective access to water and steam. Due to the increasing presence of South African companies in the global market, we would expect volatility and returns to be largely influenced by global sentiment and external shocks

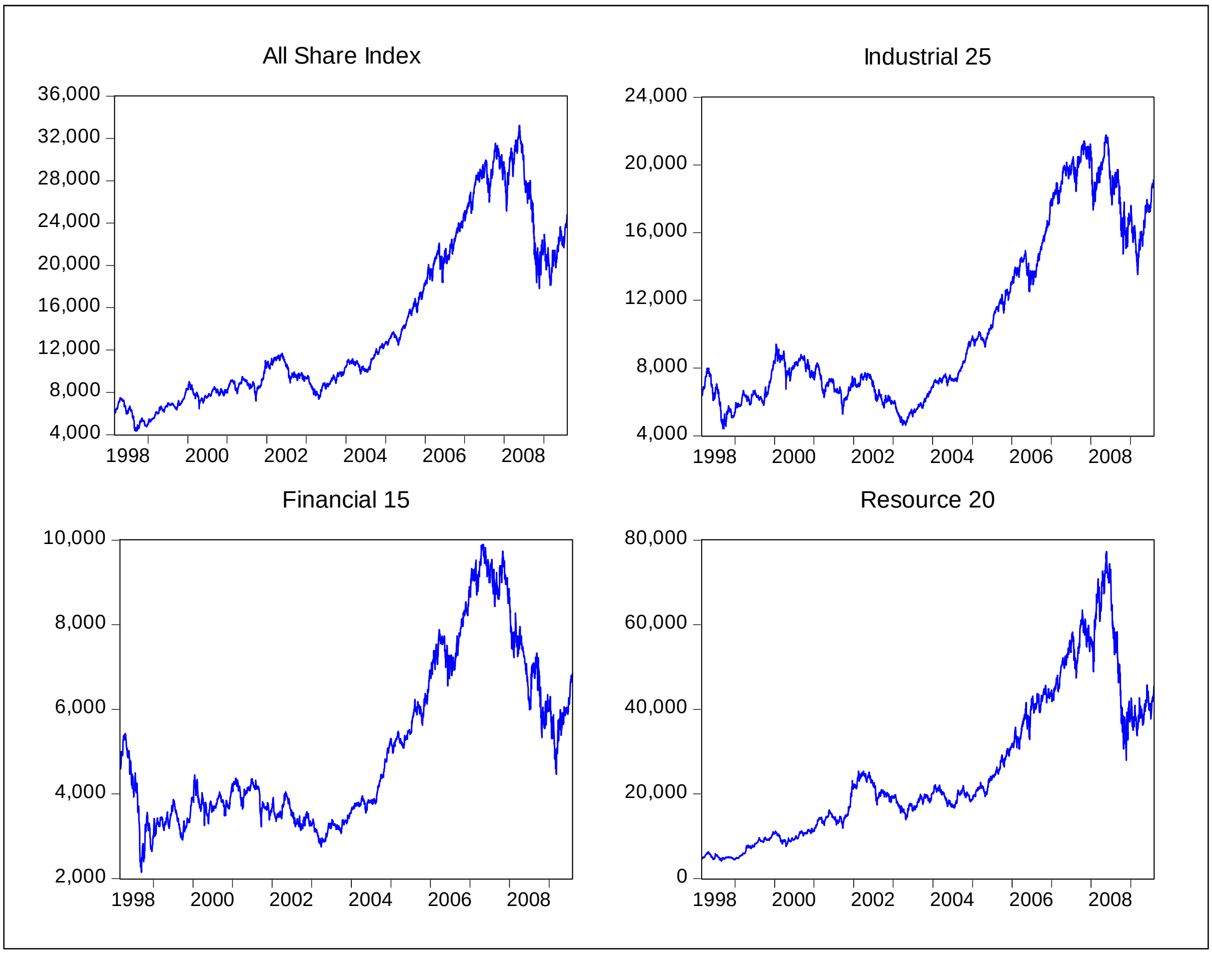
The South African Health Care industry consists of a large public sector and a smaller but fast-growing private sector. Health Care in South Africa ranges from the most basic primary health care offered by the government to the highly sophisticated health care offered by the private sector. The public sector is generally under-resourced while the fast growing private sector is well funded mainly through commercial lines. A significant majority of all private hospitals are owned by three large private hospital groups, namely Netcare, Medi-Care and Life Health Care. It is estimated that the private sector spends R66 billion to service 7 million people, while the rest of the economy (38 million people) depend on R59 billion. South Africa's public health budget is 3.05% of GDP in comparison to 7.8% in the United Kingdom (Department of Health, 2009). The global financial crisis has led to most donor countries such as the US restricting the amount of foreign aid aimed at combating HIV/AIDS in South Africa (Science in Africa, 2009). As a result we would expect volatility to increase as uncertainty about the amount of funding continues to persist.

The trends of these industries are discussed below.

[7] Anglo American has its primary listing in London and its secondary listing in South Africa.

3.4 TRENDS IN SELECTED INDICES[8]

FIGURE 3: STOCK MARKET INDICES



Each industry has various indices that are used as a customized basket of securities that track a particular market or segment. Each index has its own calculation methodology and its own specific process in order to select particular securities. Share indices essentially provide an image of the performance of the equity market. An index may also be defined as a tool that "describes" the share market at a point in time in terms of price levels, dividend yield and earnings yield. Portfolio trackers also use indices as benchmarks against which their portfolio performance is measured. A holder of an index security is entitled to sell the index for cash

[8] The FTSE/JSE Industrial 25 Index consists of the 25 largest companies in the Industrials industry, FTSE/JSE Financial 15 consists of the top 15 companies in the Financials industry and the FTSE/JSE Resources 20 consists of the top 20 companies in the Resources industry. The All Share Index is a market capitalisation weighted index for all the traded stocks.

on any stock exchange on which that index is listed at the current market price. The index may be adjusted from time to time because of mergers, amalgamations, reorganisations, changes in liquidity, market capitalisation etc. involving the constituent companies. These adjustments may require removing the company from the index and substituting it with a new constituent company, or a change in the weighting of the shares in the constituent companies (SATRIX, 2007).

As evident from Figure 3, there seems to be comovement of indices on the JSE. As can be deduced from the graphs, these markets are exhibiting considerable volatility. This level of volatility can be attributed to local market factors such as inflation concerns as well as international factors such as the US sub-prime mortgage crisis that has led to considerable losses in equity investment values.

As can be seen from Figure 3 the indices seem to have reacted to the 1998 Asian crisis and the September 2001 US attacks. From 2002 to the middle of 2008, the South African equity market experienced the longest period of positive returns or bull runs. All previous bull runs had been followed by dismal results. This was true for the South African equity market, as is seen in the drop in values from 2008 to the current period, illustrating the extent of short term volatility[9]. Furthermore, most economic bull runs listed remained significantly below the previous peak as much as a year later (Old Mutual, 2008: 3).

The financial crisis has impacted the JSE negatively, as can be seen from the steep decline in equity prices from late 2008 onwards. While the JSE offers investors lucrative potential gains, it is still seen as a very risky developing market by many large international investors. When world markets experienced a shock (like the sub-prime loan defaults), foreign investors were quick to move their investments away from riskier markets, and the resulting sell-off placed downward pressure on local share prices.

There are some general issues and questions that can be raised from the graphical analysis above. What does the volatility of the markets mean for the passive investor (through investing in equity Exchange Traded Funds, for example) and the active investor (through

[9] Asset prices are starting to rise as the global economy recovers from the recession.

individual stock selection) in terms of return? Such a question cannot be answered by the graphical plots of the indices but require empirical examination.

3.5 CONCLUSION

This chapter outlined the institutional and technical issues pertaining to the South African market. Section 3.2 looked at developments that have taken place on the local equity market such as trading, settlement and clearing, as well as the regulatory environment. It was noted that these factors are key areas that can significantly reduce systemic risk, thereby reducing the return required as compensation for holding risk. Section 3.3 highlighted the structure and classification of sectors into their various industries. It was observed that the volatility on the South African equity market seems susceptible to international and local trends. Finally section 3.4 looked at the recent trends on some of the selected indices on the JSE. It was observed that the South African equity market reacted to the 1998 Asian crisis and the September 11 attacks as well as the recent global financial crisis. Together with Chapter 2, this review laid down the foundation for the empirical analysis which follows in Chapter 4.

CHAPTER FOUR
METHODOLOGY AND ANALYTICAL FRAMEWORK

4.1 INTRODUCTION

This chapter sets out the analytical framework that is used to provide answers to the objectives set out in Chapter 1. Following other empirical studies (see for example Karmakar, 2007; Mangani, 2008; Chinzara and Aziakpono (2009), we use GARCH-M models in our analysis. Following Kovačić (2008) the GARCH models will be estimated assuming three different distributions i.e. Gaussian, Student $-t$ and GED in order to identify the distribution that performs best. In this study 48 series were estimated using three models assuming three different distributions. As a result 432 models were estimated in total.

The chapter is organised as follows: Section 4.2 discuses the analytical framework of the GARCH-M models, 4.3 discusses the distributional assumptions to be used, 4.4 discusses the long term nature of volatility, 4.5 discusses the proxies and the data used as well as issues surrounding the data and 4.5 has the conclusion and the summary.

4.2 ANALYSIS OF VOLATILITY AND THE RISK-RETURN RELATIONSHIP

Financial data is characterised by leptokurtosis, volatility clustering and leverage effects. These properties cannot be adequately captured by the use of linear structural models, thus non-linear models have been found to be useful for modelling financial data. Most typical structural models are assumed to have a constant variance. However, if the variance of the errors are not constant the implication would be standard error estimates that are faulty. It is unlikely in the context of financial time series that the variance of the errors will be constant, thus using non-linear models will prove to be prudent. The ARCH model of Engle (1982) and the GARCH of Bollerslev (1986), and different extensions to these models have been extensively used in recent empirical studies (Appiah-Kusi and Menyah 2003; Chinzara and Aziakpono 2009). The application of the ARCH methodology on a single return series involves modelling the variance in the return series with its lags as well as past errors that are derived from the regression of the mean return series on lagged versions of itself. However, there are a number of problems with the symmetric ARCH and GARCH models. Firstly, the number of lags to be included in the variance equation is unspecified by the model and thus as successive lags are added the model becomes impractical for application purposes. Secondly, it also follows that as successive lags are added it becomes probable that one or more of the lags included will be negative which violates the non-negativity constraint. Thirdly, the model fails to allow any direct feedback between the mean and conditional variance (Brooks, 2002: 469). Lastly, the ARCH model does not account for leverage effects, thereby reflecting biased results when modelling negative and positive shocks.

In order to address the objective regarding the nature of the risk-return relationship we analyse the volatility of each of the industries and sectors using the GARCH-M, EGARCH-M and the TARCH-M models assuming three different distributions for the error term i.e. Gausian, Student –*t* and the GED. We then analyse the parameter for risk premium and if that parameter is statistically significant, then the increase in risk, given by an increase in the conditional variance, leads to a rise in the mean return.

Below is a discussion of the models and the procedures that will be used in analysing volatility and to determine the relationship between risk and return.

4.2.1 The mean equation

The first step in modelling volatility is to specify an appropriate mean equation. The equation can take the form of a standard structural model, an autoregressive (AR) model, or a combination of the two. The mean equation selected should be 'white noise', meaning it should have a constant mean and variance, zero autocovariance, except at lag zero. Partly following Takaendesa et al. (2006) and Chinzara and Aziakpono (2009)[10], this study employs the following mean equations[11]:

$$y_t = \mu + \varepsilon_t \quad [4.1a]$$

$$y_t = \mu + y_{t-1} + \varepsilon_t \quad [4.1b]$$

where y_t returns are for each of the industries and sectors and μ is a constant. The estimated model will then be tested for autocorrelation using the Breush-Godfrey Serial Correlation LM test and the Durbin Watson (DW) test. Should there be evidence of autocorrelation, lagged

[10] These studies employed a mean equation that regressed the depended variable on a constant.

[11] As will be seen in Chapter 5, the mean equation with an AR(1) component (Equation 4.1b) was found to be the most appropriate.

values of the dependent variable will be added to the right hand side of Equation 4.1a until serial correlation is eliminated. The appropriate mean equation will further be tested to ascertain if ARCH effects were captured prior to estimating volatility models.

4.2.2 Testing for ARCH effects

The observation that the magnitude of current residuals for many financial time series tends to be non-linearly related to the magnitude of their past residuals forms the reasoning behind the ARCH test. Although the presence of heteroskedasticity/ARCH effects in the data does not invalidate standard inference, ignoring it may result in a loss of efficiency (Eviews, 2007). There are two tests: ARCH LM and the White Heteroskedasticity tests[12]. In this study we utilise the ARCH LM test as it is the most widely used method to test for ARCH effects in empirical studies (see for example Brooks and Ragunathan, 2003; Chinzara and Aziakpono, 2009; Magnus and Fosu, 2006). The test procedure involves regressing the squared residuals on a constant and the lagged squared residuals up to lag q are estimated. The null hypothesis is of no ARCH effects in the data and two test statistics are reported, the F statistic and the Observed R-squared (which follows a $\chi 2$ distribution). If the test statistic is significant then there is evidence of ARCH effects in the data.

4.2.3 Univariate GARCH-M

The central hypothesis of this study that has proved to be of paramount importance in financial markets is that risky assets attract greater returns in comparison to less risky assets (see Brooks, 2002). Engle, Lilien and Robins (1987) proposed the use of the ARCH-M specification where the conditional variance of asset returns enters into the conditional mean equation, thus letting the return of the security be partly determined by its risk. Since GARCH models are considerably more popular than ARCH models (as is evident in the literature review), it is more common to estimate a GARCH-M model. An example of a GARCH-M model is given by the following specification:

$$y_t = \mu + \delta\sigma_{t-1} + u_t , \qquad u_t \sim N(0,\sigma_t^2) \qquad [4.2]$$

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta\sigma_{t-1}^2 \qquad [4.3]$$

[12] The test regression is run by regressing each cross product of the residuals on the cross products of the regressors and testing the joint significance of the regression (Eviews 7 II: 353)

The above equation is a GARCH (1,1)-M where α_1 is the coefficient of lagged squared residuals, u_{t-1}^2 is the lagged squared residual from the mean equation and β is the coefficient for the lagged GARCH component which is the lagged conditional variance. It is important to note that $\alpha + \beta < 1$ if the stationarity condition is to be satisfied as there is no theoretical justification for models whose summation of the lagged residual term and the lagged conditional variance is more than one.

δ is the coefficient of the standard deviation, which essentially is the risk premium. The GARCH-M model relaxes the assumption made by the basic GARCH model of constant average risk premium over the sample period. The GARCH-M specification relaxes this assumption by allowing volatility feedback effect to become operational (Brooks, 2002: 480). If δ is positive (negative) and statistically significant, then increased risk, given by an increase in conditional variance, leads to a rise (fall) in the mean return, thus δ can be interpreted as a time-varying risk premium. The implication of a statistically positive relationship would mean that an investor on the South African equity market is being compensated for assuming greater risk. If however, such a relationship is negative this could imply that during times of great volatility or uncertainty investors react to a factor other than the standard deviation of stocks from their historical mean, possibly skewness.

The GARCH-M will be tested for ARCH effects, and if the ARCH LM test suggests that there is still evidence of ARCH effects, the EGARCH-M will be explored. EGARCH-M is an asymmetric model that was developed as a result of the limitations of the GARCH-M model such as the possibility of the violation of the non-negativity constraint. Brooks (2002: 469) argues that equity returns exhibit asymmetric responses of volatility to positive and negative shocks which are attributed to leverage effects. Leverage effects occur when a fall in the value of a firm's stock causes the firm's debt to equity ratio to rise, which leads ordinary shareholders to perceive their future cash flow stream as being relatively more risky. The EGARCH-M model takes Equation [4.1b] as its mean equation and the following conditional variance equation:

$$\ln(\sigma_t^2) = \omega + \beta\ln(\sigma_{t-1}^2) + \gamma\frac{u_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha\left[\frac{|u_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}}\right] \qquad [4.4]$$

$\alpha + \beta < 1$, $\gamma < 0$, if volatility is asymmetric where α and β are still interpreted as they are in the GARCH (1, 1)- M model, γ is the asymmetry coefficient and ω is the intercept term. The left-hand side is the log of the conditional variance. It should be noted that in the original specification of the model, Nelson (1991) assumed a GED for the errors. Changing the distributional assumption of the errors from the original Nelson (1991) GED will leave the estimates the same except for the intercept term ω, which varies as distributional assumptions change. If $\gamma < 0$ and statistically significant, then negative shocks imply a higher next period conditional variance than positive shocks of the same magnitude (i.e. asymmetric impacts (Eviews, 2007: 597).

The EGARCH-M model has a number of advantages over the pure GARCH-M. Firstly, since the $\ln(\sigma_t^2)$ is modelled, even if the parameters are negative, σ_t^2 will be positive, thus there is no need to artificially impose non-negativity constraints on the parameters. The modelling of $\ln(\sigma_t^2)$ implies that the leverage effect is exponential rather than quadratic, meaning that the conditional variance is guaranteed to be non-negative. Secondly, asymmetries are allowed for, since if the relationship between volatility and returns is negative, δ will be negative (Brooks, 2002: 469).

The GJR GARCH-M (TARCH-M) will also be explored in the event that the EGARCH-M does not fully eliminate the ARCH effects. Like the EGARCH-M model, the TARCH-M is an asymmetric model. However, the specification and interpretation differs from the EGARCH-M. The TARCH-M was proposed by Zakoian (1993) and Glosten, Jaganathan and Runkle (1993). Taking equation [4.1b] as the mean equation, this model is simply a re-specification of the GARCH (1, 1)-M model with an additional term to account for asymmetry as follows:

$$\sigma_t^2 = \alpha_0 + \alpha_1 u_{t-1}^2 + \beta\sigma_{t-1}^2 + \gamma u_{t-1}^2 I_{t-1} \quad [4.5]$$

where $I_{t-1} = 1$ if $u_{t-1}^2 < 0$

= 0 otherwise

I is the asymmetry component and γ is the asymmetry coefficient. The presence of leverage effects will mean that the coefficient of asymmetry will be positive and significant (i.e. $\gamma > 0$).

The reasoning behind this is similar to that of the EGARCH model, where negative news will have a greater impact on volatility than good news of the same magnitude. While good news will have an impact on α_1 , bad news will have an impact on $\alpha_1 + \gamma$. Thus, if γ is significantly different from zero, then clearly the impact of good news is different from the impact of bad news on current volatility. If $\gamma > 0$ leverage effects exists in stock markets, and if $\gamma \neq 0$ [13] then the impact of news is asymmetric (Eviews, 2007: 587).

4.3 DISTRIBUTIONAL ASSUMPTIONS

In order to complete the specification of the GARCH models it is necessary to make a choice on the distributional assumption of the conditional distribution of the error term. Partly following Kovačić (2008) we assume three distributional assumptions: Gaussian distribution, Student –*t* distribution and the GED. This was done in order to take into account fat tails that are common in most financial data. Given a distributional assumption, ARCH models are typically estimated using the maximum likelihood method. A GARCH model with conditionally normal errors, the contribution to the log-likelihood for observation *t*, is:

$$l_t = -\frac{1}{2} log(2\pi) - \frac{1}{2} log\sigma_t^2 - \frac{1}{2}(y_t - X_t^{'}\theta)^2/\sigma_t^2, \qquad [4.6]$$

A common feature of financial data is that it is characterized by fat tails. In order to account for this, some authors argue for distributions such as the Student –*t* and the GED.

For the Student –*t* distribution, the contribution to the log-likelihood for observation *t* is:

$$l_t = -\frac{1}{2} log\left(\frac{\pi(\nu-2)\Gamma(\nu/2)^2}{\Gamma((\nu+1)/2)^2}\right) - \frac{1}{2} log\sigma_t^2 - \frac{(\nu + 1)}{2}\log\left(1 + \frac{(y_t - X_t^{'}\theta)^2}{\sigma_t^2(\nu-2)}\right) \qquad [4.7]$$

given $\Gamma(\cdot)$ is the gamma function and $\nu > 2$ is the shape parameter which controls for the tail behaviour. It should be noted that as $\nu \rightarrow \infty$ the Student –*t* distribution converges to the normal distribution.

[13] The difference between $\gamma > 0$ and $\gamma \neq 0$ is that in the former case the parameter γ only takes a positive value and such an instance would imply that there is evidence for both leverage and asymmetric effects. In the latter case γ can take both positive and negative values. Should it take a negative value, then only evidence of asymmetric effects and not leverage effects exist in the data (Eviews, 2004: 597).

Nelson (1991) proposed use of the GED in order to account for the fat tails that are commonly observed in financial time series. The contribution to the log likelihood for observation *t* is:

$$l_t = -\frac{1}{2}log\left(\frac{\Gamma(1/r)^3}{\Gamma(3/r)(r/2)^2}\right) - -\frac{1}{2}log\sigma_t^2 - \left(\frac{\Gamma(3/r)(y_t - X_t^{'}\theta)^2}{\sigma_t^2\Gamma(1/r)}\right)^{r/2} \quad [4.7]$$

where the tail parameter is $r > 0$. The GED is a normal distribution if $r=2$, and fat tailed if $r < 2$[14].

4.4 DIAGNOSTIC CHECKS

After determining the best model and the corresponding distribution, it is essential to perform diagnostic checks in order to establish whether the model and distribution are correctly specified. Diagnostics for conditional heteroskedasticity models are generally divided into three categories: portmanteau tests of the Box-Pierce-Ljung type, Lagrange Multiplier (LM) tests and residual-based tests. The Box-Pierce-Ljung statistic is a widely used diagnostic which is readily computed from standardized residuals and has been applied in many empirical works (see Bollerslev 1990; Baillie and Myers 1991; Karolyi 1995). Given the wide use of this test we will use this test specifically to check for the presence of autocorrelation and heteroskedasticity both for the raw series and for the standardized residuals of the selected model. The diagnostic checks will involve computing the Ljung-Box Q and the squared Ljung-Box Q statistics.

4.5 EXAMINING THE LONG TERM TRENDS IN VOLATILITY

Partly following Frömmel and Menkhoff (2003) and Chinzara and Aziakpono (2009), the conditional variance was regressed against a constant and a time variable in order to analyse how volatility was trending over time. This is particularly important as volatility on equity markets can affect financial stability:

$$h_t = \beta_1 + \beta_2 T \quad [4.8]$$

[14] For a detailed discussion on the distributional properties of the Student- *t* and GED distributions refer to Knight and Satchell (2001: 153) and Zivot and Wang (2006: 257).

where h_t is the conditional variance for each index and T is the time parameter in days. If β_2 is positive (negative) and significant, this means that volatility for the respective index is increasing (decreasing) over time.

In order to analyse whether volatility is significantly influenced by financial crises and major shocks, Equation 4.8 was augmented by adding dummy variables in order to account for these events:

$$h_t = \beta_1 + \beta_2 T + \beta_3 DUM1 + \beta_4 DUM2 + \beta_5 DUM3 + u_t \qquad [4.9]$$

where h_t, T and β_2 are interpreted as in Equation 4.8. DUM1 represents the Asian crisis (1997/10/27 – 1998/12/21), DUM2 (period 2001/09/11 – 2002/03/13) represents the September 11 attacks and DUM3 represents the current financial crisis (2008/10/03 to present). If the dummy coefficients are positive and significant this implies that the volatility significantly increased during the respective event. If the coefficient is negative and significant this implies that volatility decreased during the respective event. If the coefficient is insignificant this implies that volatility neither significantly increased or decreased during the respective event.

4.6 PROXIES, DATA AND DATA ISSUES

Data used in empirical studies on the risk-return relationship on stock markets commonly falls in any of three categories. Firstly, some studies use an all-encompassing index as a proxy for the whole market (see Kovačić, 2008); secondly, some studies use sectoral indices (see Malik and Hassan, 2004) and lastly, other studies make use of individual stocks (see Morelli, 2003) in testing the risk premium hypothesis. As noted earlier, this study conducts the analysis on 4 JSE benchmark indices, 9 industries, 33 sectors (including 2 subsectors) on South Africa’s equity markets as defined by the ICB. The choice of the supersectors, sectors and subsectors indices that make up an industry was primarily chosen on the basis of data availability.

The dataset used in this analysis comprises daily closing indices for the period 30/06/1995 to 31/07/2009, totalling 3 677 observations,[15] and was obtained from the Thomson Datastream. As argued in Chapter 1, we used daily data because financial markets adopt information and incorporate it into prices very quickly, in a matter of minutes or seconds. Moreover, daily data captures the dynamic interactions that occur in a trading day, thus daily data were used in this study. However, one limitation of daily data is that distortions may arise from the fact that there will be days such as holidays and weekends where trading will not occur. To resolve this problem all the non-traded days were deleted from the series following the approach of Chowdhury (1994), Chang et al. (2006) and Chinzara and Aziakpono (2009).

The daily index series were converted into continuous compounded returns as follows:

$$y_t = (lnP_t – lnP_{t-1}) * 100 \quad [4.10]$$

where y_t denotes the continuous compounded returns at time t, P_t is the closing stock price index at time t and P_{t-1} is the closing stock price index for the previous day. The above formula has the advantage of removing the need to explicitly consider the rate at which the returns are compounded.

4.7 CONCLUSION

This chapter has set out the empirical framework to be used in order to examine the volatility on the South African equity market as well as analysing the risk-return relationship. The chapter began by describing the univariate GARCH models as well as the asymmetric extensions (EGARCH and TARCH models). The mean equation used was also described as well as the three distributional assumptions under which the GARCH models can be estimated. Also described is how long the long term trend of volatility will be analysed. Lastly the issues pertaining to the data sources, proxies and issues surrounding the data were discussed. The next chapter presents and analyses the results.

[15] See Table 1 for the classification of each index, the dates, JSE classification code and number of observations corresponding to each index.

CHAPTER FIVE
ANALYSIS OF EMPIRICAL RESULTS

5.1 INTRODUCTION

Having reviewed the theoretical framework, the existing relevant empirical literature, analysed the South African equity market, we now apply the analytical framework to address objectives set out in Chapter 1. The Chapter is organised as follows: Section 5.2 details descriptive statistics and the stationarity tests, Section 5.3 gives an analysis of volatility, Section 5.4 describes the risk-return relationship, Section 5.5 discusses the model selection and diagnostic checks, Section 5.6 analyses the trends and stock market volatility, and Section 5.7 provides the conclusion.

5.2 DESCRIPTIVE STATISTICS AND STATIONARITY TESTS

Table 5.1 provides the starting point of our analysis as it lays out the descriptive statistics and stationarity tests for the data used in the study. The reported statistics are sample means, median, maximum, minimum, standard deviation, skewness, kurtosis and the Jarque-Bera statistics. As for the stationarity/unit, root tests the ADF and the KPSS statistics are also reported as well as the tests for autocorrelation and heteroskedasticity.

Since the graphical plots of the returns (see Figure 5.1) did not show a trend, these tests were performed using the ‘no trend’ deterministic trend assumption. The lag length selection for the ADF test was determined by the SIC and the maximum lag length was set at 29. The Bartlett Kernel estimation method was used when estimating the KPSS test for stationarity.

The ADF tests the null hypothesis that the series has unit root, while the KPSS has a null hypothesis that the series is stationary. Therefore, in the case of the ADF test the rejection of the null hypothesis would mean that the series does not have a unit root while the rejection of the null hypothesis in the case of the KPSS test means that the series has unit root or is non-stationary. Results from both the ADF and KPSS tests show that the return series are stationary at the 1% level of significance

The descriptive statistics in Table 5.1 allow us to determine if highest returns are matched with highest standard deviations. With the exception of Forestry and Paper, Automobile and Parts, Household Goods and AltX we find that the returns are positive implying a bullish market over the sample period. Volatility (as measured by standard deviation) is greatest in the Consumer Goods industry, ranging from 0.548% to 1.372% while the Industrials industry is least volatile, ranging from 0.566% to 0.675%. If volatility is a common priced factor we would expect the highest mean returns to be matched by a high standard deviation. However, from the descriptive statistics this relationship is not apparent. It is evident that the highest mean returns are in the Pharmaceutical and Biotechnology sector (0.034%) while the lowest are in the Automobile and Parts sector (-0.02%). However the highest standard deviation is found in the Automobile and Parts sector (1.372) while the lowest standard deviation is found in the Real Estate sector (0.444)[16]. From this casual observation there is no discernable positive relationship between risk and return.

It is also evident from the descriptive statistics that the data exhibits characteristics that are common with financial data such as fat tails. This indicates the data is not normally distributed as we reject the null hypothesis of the Jarque-Bera test statistic at the 1% level of significance for all returns. The skewness and the kurtosis parameters also suggest that the data is not normally distributed as their values range from -1.824 to 3.477 and 4.724 to 429.033 respectively[17]. From the 53 indices estimated 39 were negatively skewed while 14 showed positive skewness. The majority of the returns are negatively skewed which points to the fact that there is greater probability of losses than gains. With respect to kurtosis, all the figures are greater than 3, implying that there are more frequent extremely large deviations from the mean than a normal distribution.

The Ljung-Box statistics LB(12) and $LB^2(12)$ for the returns and squared returns series are statistically significant. We therefore reject the hypothesis of no autocorrelation in the level of returns and squared returns. The significance of the LB(12) statistic is in contradiction with the information efficient hypothesis as there is a strong chance that investors could use historical data to earn above average gains. The $LB^2(12)$ test result suggests the presence of

[16] Although the Small and Mid Cap series has the lowest standard deviation, the Real Estate sector has the lowest standard deviation amongst the Industries and Sectors. This was done so as to see the relationship between mean returns and standard deviation without the influence of market capitalization.

[17] The skewness of a symmetric distribution, such as the normal distribution, is zero. Positive skewness means that the distribution has a long right tail and negative skewness implies that the distribution has a long left tail.

ARCH effects, i.e. time varying second moments, thus making the use of an AR(1) conditional mean model suitable for GARCH estimations. The significant $LB^2(12)$ also suggests the presence of volatility clustering in the distribution of the returns (Kovačić, 2008: 193; Magnus and Fosu, 2006: 2044).

A mere comparison of mean returns and standard deviation does not point to a clear relationship between returns and risk. We thus proceed to formally test the risk premium hypothesis by using ARCH type models. In the next section we analyse volatility by firstly looking at two tests for autocorrelation and then discussing the various coefficients of the estimated GARCH models.

5.3 ANALYSIS OF VOLATILITY

The mean equation [4.1a] as it appears in Chapter 4 is the starting point for all our estimations for each of the return series. This mean equation was estimated and tested for autocorrelation using the DW and the Breush-Godfrey Serial Correlation LW test. As can be seen in Table 5.2 there is evidence of autocorrelation for this specification of the mean equation. Consequently we added a single lagged value of the dependent variable to the right hand side of Equation 4.1a thus Equation 4.1b was used for all estimations. We found that this specification of the mean equation with an AR(1) component removed autocorrelation and we therefore used this mean equation for all GARCH estimations.

The univariate GARCH, EGARCH and TARCH models were estimated using the above mentioned mean equation. It should be noted that the size of the ARCH (α_1 and α_2) and the GARCH (β) terms shows the volatility persistence of a particular model. The degree of persistence is important in determining the relationship between volatility and returns, since only persistent volatility justifies changes in the risk premium (Devaney, 2001: 340). From the results reported in Table 5.3, the summation of α and β (and $\alpha_1 + \alpha_2 + \beta$ for 2, 1, 1 models marked with a $^+$) in the GARCH (1,1) model is generally less than one with the exception of Industrial Metals (GED)[18], Automobile and Parts (Student *–t* and GED), Personal Goods (Gaussian), Media (Student *–t*), Pharmaceutical and Biotechnology (Student *–t*) and Industrial Engineering (Student *–t* and GED) which are non-stationary. The TARCH model

[18] Where an error distribution appears in brackets e.g. (Gaussian and GED), this refers to the error distribution for that particular model, sector or industry.

shows a similar trend in volatility persistence. Most of the industrial returns show summations which are less than 1 with the exception of Automobiles and Parts (Gaussian and Student –*t*) and Pharmaceutical and Biotechnology (GED) returns. For those models that have a summation which is very close to 1, this means that the return generating process is characterized by a high degree of persistence or long memory in conditional variance. Therefore, a 'shock' at time *t* will persist for many future periods as the value becomes closer to 1 (Magnus and Fosu, 2046: 2006). The EGARCH model on the other hand has a summation of α and β which is greater than 1 with the exception of the Automobile and Parts (GED). The summation of the ARCH and GARCH coefficients is also an estimation at which the response function decays on a daily basis. Since the summations are mostly greater than 1 a new shock implies that the effect on returns will continue to grow infinitely into the future.

As noted in Chapter 4, the γ is the leverage or asymmetric coefficient and is unique to the EGARCH and TARCH models only. The results show that this coefficient has the expected sign both in the EGARCH (negative and significant) and in the TARCH (positive and significant) models with the exception of Automobile and Parts and Real Estate (Gaussian). For industries and sectors that have the expected sign, the asymmetric effect occurs when an unexpected drop in price (bad news) increases volatility more than an unexpected increase in price (good news) of similar magnitude. There are two common economic explanations for this phenomenon of leverage effects. The first explanation hinges on financial leverage or the leverage effect hypothesis postulated by Black (1976) and Christie (1982). If the price of a share drops (negative return), financial leverage increases, leading to an increase in stock return volatility. These financial 'leverage effects' have become associated or synonymous with asymmetric volatility and yet it is possible that the evidence of asymmetric volatility could simply reflect the existence of time varying risk premiums. The second explanation centres on the relationship between volatility and expected returns. In the event of an anticipated increase in volatility, expected returns tend to increase, leading to a decline in the stock price. This is because volatility is a measure of risk, and if investors are assumed to be risk averse, an increase in risk (volatility) will result in a decline in demand for that stock leading to a fall in price. For investors to hold or buy the risky asset they would require a higher return, thus there is a positive relationship between volatility and stock returns. If volatility is priced an increase in volatility raises the required return on equity, leading to an immediate share price decline, often referred to as the volatility feedback effect (Karmakar 2007: 108-109).

It is possible that both the (financial) leverage and volatility feedback effects could be at work concurrently. If for example there is an expectation in the market of an increase in volatility, the result is that market participants would place more sell orders than buy orders in anticipation of a volatile market. The end result is a drop in price to balance the buying and selling volume. Therefore, an anticipated increase in volatility leads to an immediate price decline, as predicted by the volatility feedback hypothesis. This drop in share prices will raise the leverage ratio, which according to the leverage effect hypothesis brings about a further decline in price (Karmakar, 2007: 109).

Regardless of the cause of the asymmetry, the implication affects the pricing of the securities and portfolio selection. From the results, the GARCH and TARCH models imply very different volatilities following a negative shock in comparison to EGARCH models. If returns are linked to volatility, the EGARCH model would suggest greater risk premiums since volatility indefinitely increases following negative news. On the other hand the GARCH and TARCH models (which show declining volatility persistence) would offer lower risk premiums in comparison to the EGARCH model. Furthermore, the dynamic hedging strategies associated with the two sets of volatilities would differ significantly based on the volatility persistence (Karmakar, 2007: 110).

Also reported in Table 5.3 is the F-LM statistic which shows whether a model fully captured ARCH effects. Most of the ARCH effects were captured by the GARCH model with the exception of Basic Materials (Gaussian, Student –*t* and GED), Mining (Gaussian, Student –*t* and GED), Platinum and Precious Metals (Gaussian, Student –*t* and GED), Food Producers (Gaussian), Life Insurance (Gaussian and Student –*t*), Oil and Gas (Gaussian, Student –*t* and GED), Oil and Gas Producers (Gaussian, Student –*t* and GED), Mobile Telecommunications (Gaussian, Student –*t* and GED), All Share (Gaussian) and Mid Cap (Student –*t* and GED). The EGARCH model mostly captured the ARCH effects except in the case of Basic Materials (Gaussian, Student –*t* and GED), General Mining (Gaussian, Student –*t* and GED), Mining (Gaussian, Student –*t* and GED), Platinum and Precious Metals (Gaussian, Student –*t* and GED), Consumer Goods (Gaussian, Student –*t* and GED), Beverages (Gaussian), Food Producers (Gaussian, Student –*t* and GED), Consumer Services (Gaussian, Student –*t* and GED), Food and Drug Retailers (Gaussian, Student –*t* and GED), General Retailers (Gaussian, Student –*t* and GED), Financials (Gaussian, Student –*t* and GED), Banks

(Gaussian), Life Insurance (Student –*t* and GED), General Financials (Gaussian, Student –*t* and GED), Health Care (Gaussian, Student –*t* and GED), Industrials (Student –*t*), General Industrials (Gaussian, Student –*t* and GED), Support Services (Gaussian, Student –*t* and GED), Oil and Gas (Gaussian, Student –*t* and GED), Telecommunications (Gaussian), Mobile Telecommunications (GED), All Share (Gaussian, Student –*t* and GED) and Mid Cap (Gaussian and Student –*t*) returns. Lastly, the TARCH model mostly captured the ARCH effects with the exception of General Mining (Gaussian), Mining (Gaussian, Student –*t* and GED), Platinum and Precious Metals (Gaussian, Student –*t* and GED), General Retailers (Gaussian), Financials (Gaussian), Life Insurance (Gaussian), General Industrials (Student –*t*), Oil and Gas (Gaussian) and Mid Cap (Student –*t*).

As we can see from the above, the presence of ARCH effects varies amongst the three models and the three distributions as well across the various industries and sectors. The next section discusses the risk-return relationship on the estimated return series.

5.4 RISK-RETURN RELATIONSHIP

The coefficient that measures the relationship between risk and return is denoted by δ. As is evident from Table 5.3, this coefficient in all three models is mostly negative and insignificant, followed by a relatively large number of industries and sectors showing a positive and insignificant relationship. Only a few of the estimated models showed a positive and significant relationship. The All Share series shows that on the JSE across all three models investors are not compensated for assuming more risk, i.e. volatility is not a priced factor. This result is supported by the findings of Chinzara and Aziakpono (2009). The same result is echoed at an industrial level as we notice that none of the industries shows any signs of a positive risk-return relationship. At best we notice a few industries, such as Consumer Services, Industrials and Technology, that show strong evidence of a negative relationship between risk and return. At a sectoral level the results are mixed across the three models and the three distributions.

Generally the GARCH model at a sectoral level does not show evidence of a risk premium, with the exception of Mining (Gaussian and Student –*t*), Platinum and Precious Metals (Gaussian, Student –*t* and GED) and Automobile and Parts (Gaussian). We also found evidence in support of a negative risk premium in the Construction and Materials (Gaussian, Student –*t* and GED) and Software and Computer Services (Gaussian and Student –*t*) sectors. The Benchmark category depicts the results of the sectors and shows a lack of a significant risk-return relationship, a result also echoed by the AltX series.

The EGARCH model tells a similar story with respect to the risk-return relationship. In this model we notice that only the General Mining (Gaussian and Student –*t*), Mining (Gaussian and Student –*t*), Platinum and Precious Metals (Gaussian, Student –*t* and GED) and Automobile and Parts (Gaussian and GED) sectors have a positive risk-return relationship. We also found a considerable number of sectors that have a negative risk premium: Food Producers (Gaussian), Media (Gaussian and Student –*t*) , Travel and Leisure (Gaussian), General Retailers (Gaussian, Student –*t* and GED), Non-Life Insurance (Gaussian, Student –*t* and GED), Health Care Equipment and Services (Gaussian and Student –*t*), Pharmaceutical and Biotechnology (Gaussian), Construction and Materials (Gaussian, Student –*t* and GED), Software and Computer Services (Gaussian), Mid (Gaussian and Student –*t*) and Small Cap (Gaussian, Student –*t* and GED).

Lastly, the TARCH model shows similar patterns to the GARCH and EGARCH models. We find that only the Platinum and Precious Metals (Student –*t* and GED), Automobile and Parts sector (Gaussian), Personal Goods (Gaussian), Pharmaceutical and Biotechnology (GED), Industrial Engineering (GED) and AltX (Student –*t*) sectors showed any evidence of a positive risk premium. There was also evidence of a negative risk premium in the Travel and Leisure (Gaussian), General Retailers (Gaussian, Student –*t* and GED), Non-Life Insurance (Student –*t*), Equity Investment Instruments (Gaussian, Student –*t* and GED), Health Care Equipment Services (Student –*t*), Pharmaceutical and Biotechnology (GED), Electronic and Electrical Equipment (Gaussian, Student –*t* and GED) and Software and Computer Services (Gaussian and Student –*t*) sectors. The Mid Cap (Gaussian), Small Cap (Gaussian, Student –*t* and GED) and AltX (Gaussian) also showed a negative and significant relationship.

The existence of a positive risk premium found in a few of the industries and sectors is in line with empirical literature (c.f. French et al., 1987; Campbell and Hentschel, 1992). As noted in Section 2.2.3, risk neutral investors have a linear risk-return relationship. Therefore, such investors will tend to invest in sectors and industries such as the AltX that has a risk-return coefficient which is very close to 1. On the other hand the negative and significant relationship that is observed in most of the industries and sectors is supported by the findings of Fraser and Power (1997), who did not find evidence of a positive risk premium in nine emerging markets. The lack of a positive and significant risk-return relationship on most of the returns on the South African equity markets violates the prediction of many asset pricing models such as the CAPM and the APT.

It is possible that the negative relationship observed on most of the returns on South Africa's equity markets could be attributable to the currency used to measure the returns. Since local investors are not faced with foreign exchange risk (when returns are measured in Rands) the premium would be negative and significant, while if the returns were converted to a foreign currency such as the dollar this would imply that risk would not only incorporate volatility on the local markets but also incorporate foreign exchange risk. This finding is supported by Koutmos et al. (1993) who found a statistically significant relationship between risk and return when returns were converted from the local currency to US dollars.

5.5 MODEL SELECTION AND DIAGNOSTIC CHECKS

We now move onto selecting the most appropriate model and the distribution under which this model performs best. The selected model will be subject to diagnostic checks in order to assess whether the model was correctly specified.

The selection criterion amongst the three models was based on four criteria. Firstly, we look at the summation of α and β coefficients which should be less than 1 for the model to be stationary. Secondly, the model should be able to capture asymmetry in the data. Thirdly, the model should also be able to capture the ARCH effects as shown by the F-LM statistic. Fourthly, should the selected model have similar attributes to the three above-mentioned criteria across the three distributions, the Schwartz Bayesian Information Criteria (SIC) will be used to select the most appropriate distribution. The SIC was chosen because it embodies a much stiffer penalty term in comparison to the Akaike Information Criterion (AIC) (Brooks, 2002: 257).

From Table 5.3 the models marked with an asterisk (*) next to the SIC coefficient represent the selected model based on the above-mentioned criteria. The TARCH model with the GED assumption is the best model for 38 out of the 53 models. Therefore, Table 5.4 reports the coefficients for the TARCH-M model based on the GED assumption.

Table 5.5 reports the summary statistics for the raw returns and the standardized residuals for the TARCH-M based on the GED assumption. The results reveal that kurtosis is lower in the selected model with the exception of Industrial Metals, Pharmaceutical and Biotechnology , Automobile and Parts, Technology and Software and Computer Services. Furthermore, skewness is closer to zero in the selected model with the exception of Basic Materials, Industrial Metals, Automobile and Parts, Food and Drug Retailers, Non-Life Insurance, Health Care Equipment and Services and Industrial Engineering. The LB(12) statistics for the absence of autocorrelation in the raw series are all significant while the same statistic for the standardized residuals are all insignificant with the exception of Forestry and Paper, Platinum and Precious Metals, Consumer Services, Food and Drug Retailers, General Retailers, Non-Life Insurance, Real Estate, General Financials, Pharmaceuticals and Biotechnology, Electronic and Electrical Equipment, Oil and Gas Producers Technology and Software and Computer services Mid Cap, Small Cap and AltX. This confirms that returns have no remaining ARCH effects. The $LB^2(12)$ statistics for the absence of heteroskedasticity in the standardized residuals are all insignificant with the exception of Basic Materials, Mining, Platinum and Precious Metals, Consumer Goods, Food Producers, Travel and Leisure, Equity Investment Instruments, Pharmaceutical and Biotechnology, General Industrials, Industrial Engineering, Oil and Gas and Oil and Gas Producers series. These tests confirm that this model is well specified for most of the estimated series.

Based on the selected model, volatility for each of the industries and sectors was generated and will be used in the analysis below.

5.6 ANALYSIS OF THE TRENDS OF THE STOCK MARKET VOLATILITY

Financial markets play a very significant role in the growth and development of emerging markets through the facilitation of savings and channelling funds from savers to investors. Stock market volatility may detract the smooth functioning of the financial markets and subsequently affect the growth and performance of an economy in two ways. Firstly, stock market volatility creates uncertainty in an economy which usually results in capital flight. This complicates the task of macro-economic policy makers who are tasked with creating an environment that fosters real economic growth by controlling policy variables such as interest rates which are significantly influenced by capital flows. Secondly, because a rise in volatility on the equity markets is usually interpreted as a rise in risk of equities, this could subsequently cause a shift in investment funds to flow towards less risky assets. This move could increase the cost of funds for new firms as investors seek to invest in 'blue chip' companies. This flow of funds away from equity markets could make it difficult for both new and well-established firms to accurately plan and budget for long term projects as the availability of investment funds from the stock markets becomes uncertain. The effect of these factors could adversely impact the performance of an economy at large. Therefore, it is imperative that both investors and policy makers have knowledge of stock market volatility over time. On the one hand investors are interested in stock market volatility as the central idea of investment in stock markets (and financial markets at large) is based on the ability to maximise return per unit of risk. Moreover, investors would be interested in the trends of volatility over time on the stock markets as this would inform their investment decisions such as portfolio diversification. Policy makers on the other hand are interested in stock market volatility as they are interested in creating a suitable environment that allows for savings to be channelled towards investment. To analyse the trend of volatility we first show the graphical plots of the conditional volatility series as this gives a general trend of volatility over the sample period. We test this relationship empirically by regressing the conditional volatility series with a time variable (see Equation 4.8).

From Figure 5.2, it can be seen that all industry and sectoral returns show evidence of excess volatility. Conditional volatility on most of the industries and sectors is increasing except for Chemicals, Food Producers, Media, Food and Drug Retailers, Travel and Leisure, Industrials, General Industrials, Industrial Transport, Media, Health Care Health Care Equipment and Services, Financials and Small and Mid Cap. The results of Equation 4.8 are reported in Table 5.6. The results show that the All Share Index is showing a significant increase in volatility, a relationship also evident in the secondary markets as seen by the AltX coefficient. In the Basic Materials industry, only volatility in the Chemicals sector is significantly decreasing over time while the other sectors show a significant increase in volatility. Volatility in the Basic Materials industry (specifically in the gold and mining sector) could be partly explained by the closure of some of the gold mines in early 2008 owing largely to electricity problems (Fin24, 2009). Such closures could have added uncertainty about the gold production levels and thus contributed to the increase in volatility of the constituent companies in this sector. Moreover, the general decline in the price of gold and the strengthening of the rand has added to the uncertainty in the Basic Materials industry as investors may be concerned about the ability of gold and platinum producing companies to maintain production levels in the face of the continued decline in prices. The global financial crisis has also impacted the Financial industry, as is evident from the significant increase in volatility in the industry at large as well as in the constituent sectors, with the exception of Equity Investment Instruments. The current crisis specifically impacted the banks because of the limited liquidity available from international capital markets. This led to the increase in the solvency risk of South African banks, therefore raising their default probability. The result of this was an increase of volatility on the Financial industry as there was much concern about the ability of banks to 'weather the storm' of the global financial crisis (IMF, 2009).

The Financial industry in general experienced net capital outflow during this period. This outflow consisted primarily of portfolio adjustments which were occurring worldwide and South Africa was no exception. This outflow contributed to a 12% fall in the All Share index and a 20% fall in the rand against the US dollar. This outflow reflected the sensitivity of South Africa's equity markets to international capital flows (IMF, 2009).

While the Consumer Goods industry, does not show significant evidence of declining volatility, the Beverages and the Food Producers sectors show declining volatility. In the Consumer Services industry, Travel and Leisure and Food and Drug Retailers are showing a significant decline in volatility over time. Similarly, in the Health Care industry only the Health Care Equipment and Services sector shows a decline in volatility over time. The Industrials industry shows decreasing volatility over time while the constituent sectors, with the exception of General Industrials and Industrial Engineering, show a significant rise in volatility. The Oil and Gas industry and Oil and Gas Producers sector all show significant increases in volatility. In the Technology industry there is an increase in volatility over time at the 1% level of significance. While the Telecommunications industry shows significant evidence of increasing volatility, the Fixed Line Telecommunications sector shows significant evidence of a decline in volatility. Both the Small and Mid Cap series show declining volatility although only the Mid Cap is statistically significant.

An important issue to consider is the behaviour of volatility during financial crises and major world shocks such as the Asian crisis of 1997, the September 11 attacks on the United States and the current global financial crisis. During such periods net capital flows to emerging markets such as South Africa are expected to be significantly lower than the substantial inflows of recent years (IMF, 2009). By looking at the graphical plots (Figure 5.2) of the conditional volatility, it can be seen that most of the industries and sectors show an increase in volatility during these times. In order to test whether there was a significant increase in volatility during these periods, dummy variables were added into the volatility trend equation (see Equation 4.9). The results reported in Table 5.7 show that volatility on the JSE, as shown by the All Share series, increased during these three periods. All 9 industries also showed an increase in volatility during these periods. However, the volatility of the sectors within these industries did not all paint a similar picture. In the Basic Materials industry, for instance, only the Forestry and Paper, Industrial Metals and Mining sectors showed an increase in volatility during all three periods. In the Consumer Goods industry, Beverages was the only sector whose volatility positively increased during these periods. A similar pattern is evident in the Consumer Services industry, only the Food and Drug Retailers did not show evidence of increased volatility during the three periods. This pattern is different in the Financials industry, as we notice that the volatility of all the sectors significantly increased during these periods. In the Health Care, Oil and Gas and Technology industries, the volatility of only one sector reacted positively to these three shocks which are the Pharmaceutical and Biotechnology and the Oil and Gas Producers and Software and Computer and Services sectors respectively. In the Industrials industry all the sectors except Industrial Engineering and Electronic and Electrical Equipment showed a positive reaction of volatility in all three periods. The Small Cap series showed a significant increase in volatility for all three periods.

The results also indicate that the volatility of the Chemicals, General Mining, Platinum and Precious Metals, Food Producers, Food and Drug Retailers, Electronic and Electrical Equipment, Industrial Engineering and Fixed Line Telecommunications sectors did not react positively to the 9/11 attacks on the US. This was also the case with the Mid Cap series. The Automobile and Parts sector was the only sector that did not show any volatility reaction during any of the three periods. Due to data unavailability, the volatility of the Personal Goods, Household Goods and AltX series was only shown to have reacted to the current financial crisis.

From the results we notice that in all of the industries and most of the sectors there has been a significant increase in volatility during the Asian crisis. The reason for this is that the crisis was a major shock to the global economy, especially emerging markets. Inasmuch as South Africa was not well integrated into the global financial markets during the time of the crisis, the effects were felt indirectly due to declining world commodity prices, shrinking export markets (see Table 5.8) and reduced investment and other financial inflows. These pressures led to a general decline on SA equity market, which was evidenced by a general increase in yield on long term-bonds and a significant depreciation of the rand, despite increases in domestic interest rates and central bank intervention in the exchange markets.

Much like the effects of the Asian crisis, the South African stock market was not immune to the effects of the current global crisis as seen by a positive and significant coefficient. The impact affected all of the industries because exports markets shrank significantly, commodity prices lowered and there were large amounts of capital outflow. The South African industries (and the economy at large) were significantly impacted by the crisis as evident from South Africa's high current account deficit[19] (IMF, 2009). Capital outflow particularly affected the Automobile and Parts, Mining and Retail sectors as these sectors depend heavily on foreign investment. This crisis has had a profound impact on inflation and real economic activity through its effect on the exchange rate and cost of capital.

The September 11 attacks were significantly felt in most industries. The aftershock of 9/11 reduced confidence and raised uncertainty on a global scale. The effects were particularly felt in the Travel and Leisure sectors as consumers were sceptical about travel.

5.7 CONCLUSION

This chapter presented and analysed the results pertaining to various issues concerning the nature of volatility and the risk-return relationship in the South African equity market. We first presented and discussed the descriptive statistics of the data as well as the stationarity tests on the data set. The basic picture revealed that the data exhibits properties that are in line with properties of financial data such as non-normality, excess kurtosis and excess volatility. It was also shown that the descriptive statistics did not point to an apparent risk-return relationship.

[19] South Africa had a current account deficit of 7.4% of GDP in 2008 which was higher than most emerging markets (excluding emerging markets in Europe) (IMF, 2009).

Next, the volatility of the sectors and industries were analysed, and subsequently the risk-return relationship was formally investigated using the GARCH, EGARCH and TARCH models assuming three different distributions, namely Gaussian, Student –*t* and GED. The results of this investigation showed that volatility is persistent and asymmetrical. The results also showed that risk is not a priced factor in most of the industries and sectors. Thereafter, the long term trends in volatility were analysed by regressing the generated conditional volatility against a time parameter. The results showed that the industries and sectors generally showed an increase in volatility. The behaviour of volatility during financial crises and major global shocks was also investigated to ascertain whether major shocks such as the Asian crisis, the 9/11 attacks on the US and the recent financial crisis had any significant impact on the local industries and sectors. The results showed that conditional volatility for all industries and most of the sectors increased during these periods, and that these shocks entered mainly through trade links and capital outflows.

CHAPTER SIX
SUMMARY FINDINGS, POLICY RECOMMENDATIONS AND AREAS OF FURTHER RESEARCH

6.1 SUMMARY OF THE STUDY AND CONCLUSIONS

This study analysed volatility and the risk-return relationship in the South African equity market, as well as the behaviour and long term trend of volatility. We used daily data for 4 JSE benchmark indices, 9 industries, 33 sectors and 2 subsectors. The GARCH family models were estimated under 3 error distributional assumptions. A total of 432 models were estimated.

The first step in our analysis was to review the relevant theoretical and empirical literature. The theoretical literature was reviewed with the aim of understanding the relevant models on the risk-return relationship. After this, the empirical literature was reviewed for developed, emerging and South African markets. The empirical literature showed that there is no consensus as to the existence of a premium for assuming more risk. We reviewed some of the institutional and technical issues on the JSE. In this section we also looked at the composition of the various industries and sectors with a view to understanding whether there is evidence or trends that could point towards the nature of the risk-return relationship as well as trends in volatility.

In order to address our objectives, we used the GARCH, EGARCH and TARCH models assuming three different distributions, namely Gaussian, Student –*t* and the GED. A total of 432 models were estimated. The results showed that for all the industries, sectors (with the exception of Automobile and Parts and Real Estate) and benchmark series, volatility is persistent and asymmetric. It was also found that volatility is not a priced factor for most of the estimated series. The three models were compared and it was found that the TARCH model estimated under the GED assumption was the best model for all the benchmarks, industries and sectors. Based on this model and distribution, conditional volatility was generated and used as a measure or proxy for volatility. From this, the long term behaviour of volatility was investigated. It was found that the market average as measured by the All Share and AltX showed a general increase in volatility. This was also the case in all the industries (except for Industrials and Health Care) and all the sectors (except for Chemicals, General

Industrials, Food Producers, Media, Travel and Leisure and Food and Drug Retailers). We then moved to analyse the response of volatility during the Asian crisis and the recent financial crisis as well as the 9/11 attacks on the US. The results showed that the market volatility of the All Share and all the Industries increased during all three periods. However, the results were mixed at a sectoral level.

Overall, the results from this study indicate that volatility is not a priced factor on the SA equity markets. It was also observed that volatility is generally increasing overtime and generally increases during global financial crises and major global shocks.

6.2 POLICY AND INVESTMENT IMPLICATIONS

The findings of this study have important implications for investment and policy strategies. The fact that volatility is generally not priced would have an implication on factors to consider when investing. When investors are choosing which industries or sectors to invest in, they would need to consider more than just the deviation of actual returns from mean returns (standard deviation) as a measure of risk. It is possible that factors such as skewness influence stock returns. Harvey and Siddique (2000) note that investors prefer stocks that are right-skewed to portfolios that are left-skewed. Investors may also need to consider other factors such as book-to-market or the relative size of the firms.

The general increase in volatility in most of the industries and sectors is another issue that investors and policy makers need to be aware of. For investors it would be worthwhile to invest in industries and sectors that are generally more stable or less volatile, especially if this general increase in volatility is not matched by an increase in returns. For policy makers increasing volatility is problematic as it may cause large amounts of capital outflow. This could cause financial instability which might ultimately trigger macroeconomic instability.

As stated earlier, the volatility on most of the industries and sectors increased during the 9/11 attacks, Asian crisis and the recent global crisis. This situation could potentially threaten the financial stability of the economy every time there is an external shock. If such shocks are constantly transmitted to the equity markets, this could in turn be transmitted to other domestic markets such as the bond and money markets (see Hurditt, 2004 and Chinzara and Aziakpono, 2009). Although it is often difficult to minimise the transmission of volatility from one market to the other, one way of minimising volatility transmission would be to ensure a stable macroeconomic and political environment. Policy makers therefore need to be cognisant of the behaviour of the South African equity market in response to external shocks.

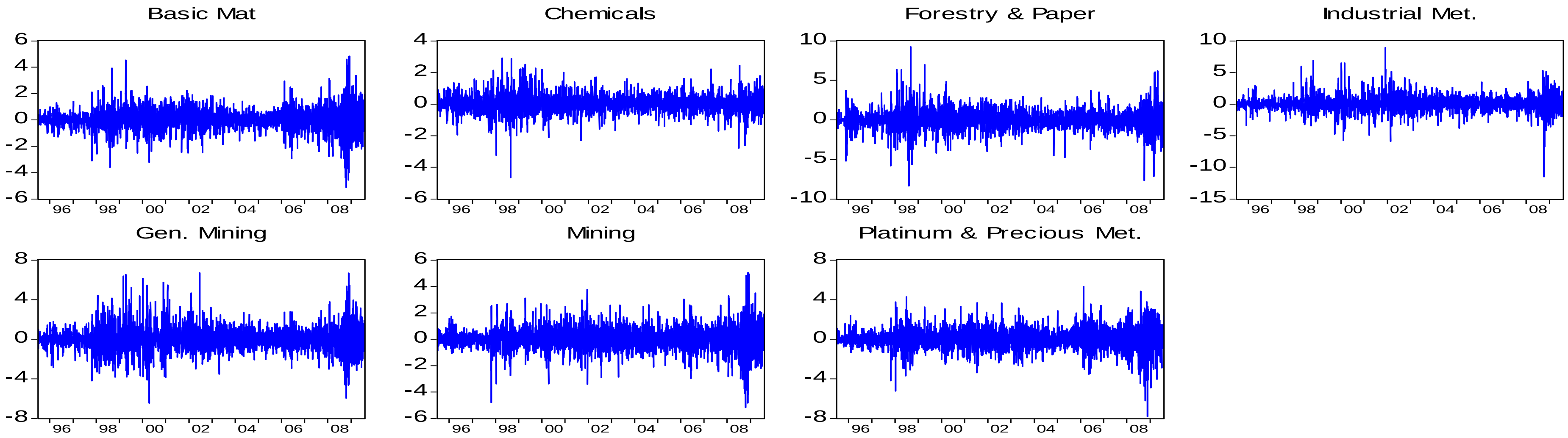
6.3 AREAS FOR FURTHER RESEARCH

While this study estimated the GARCH-M models based on standard deviation, an emerging trend in recent studies (c.f. Harvey and Siddique, 2000 and Lanne and Saikkonen, 2004) is to use GARCH models that cater for skewness. This option was not explored because the available software could not estimate this. Furthermore, since this study was mainly done at industrial and sectoral level it could be worthwhile to extend this study to a supersectoral level and at a company level.

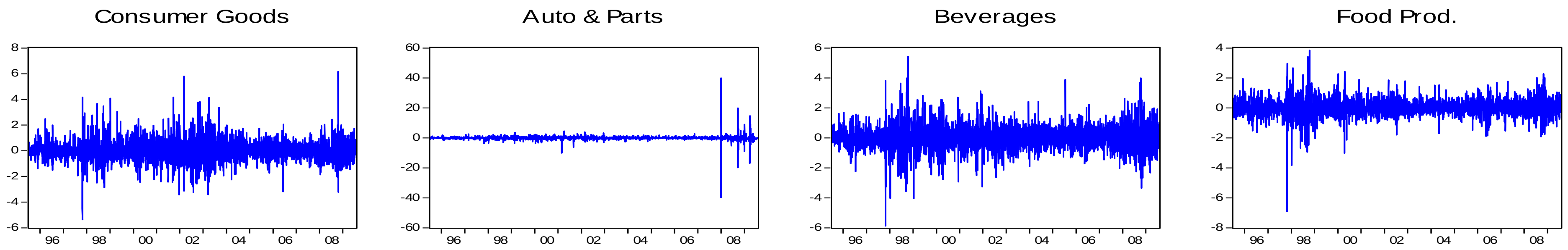
APPENDIX

Figure 5.1: Graphical plots of return series

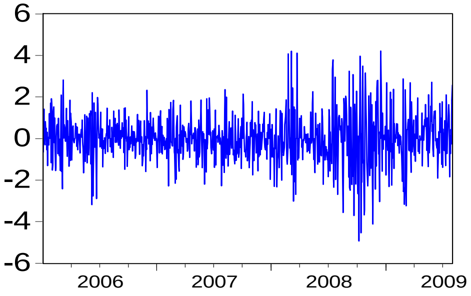
Basic Materials



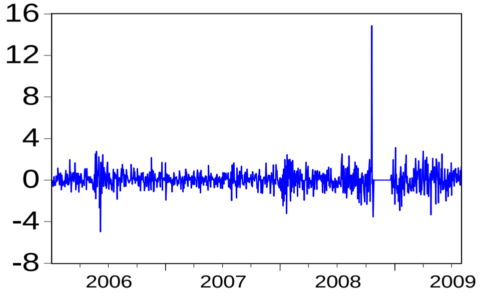
Consumer Goods



Household Gds.

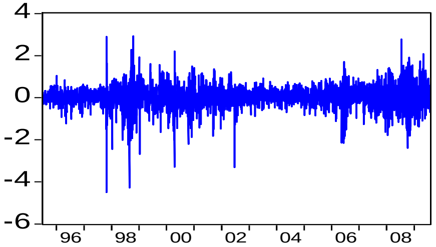


Personal Gds.

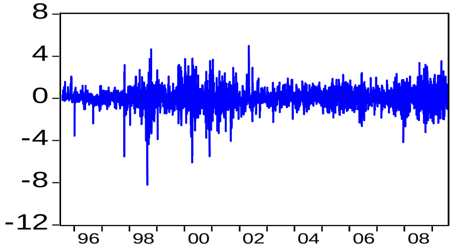


<u>Consumer Services</u>

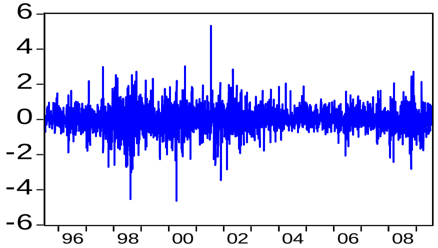
Consumer Svs



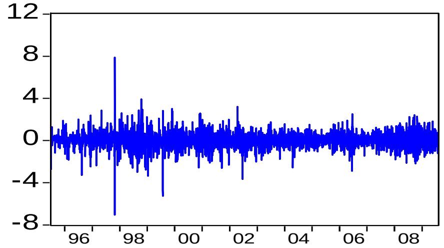
Media



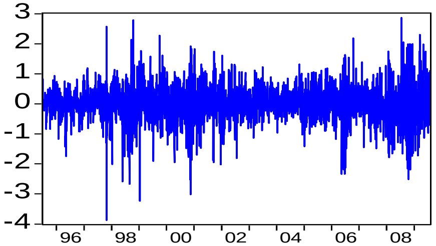
Travel and Leis.



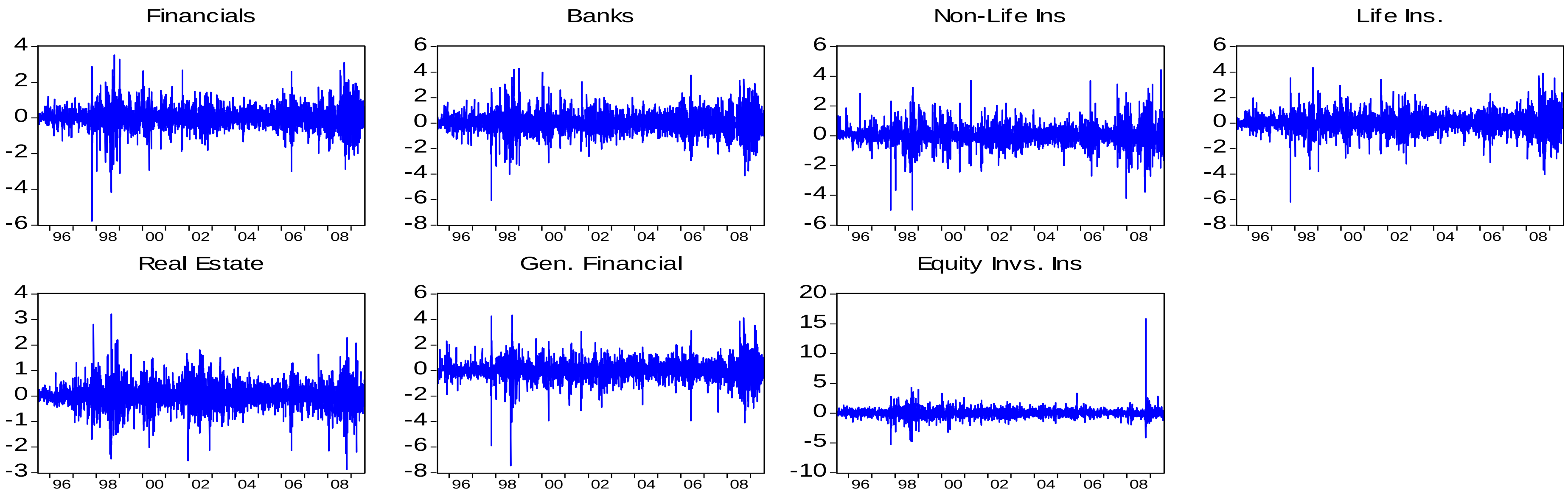
Food & Drug Rtl.



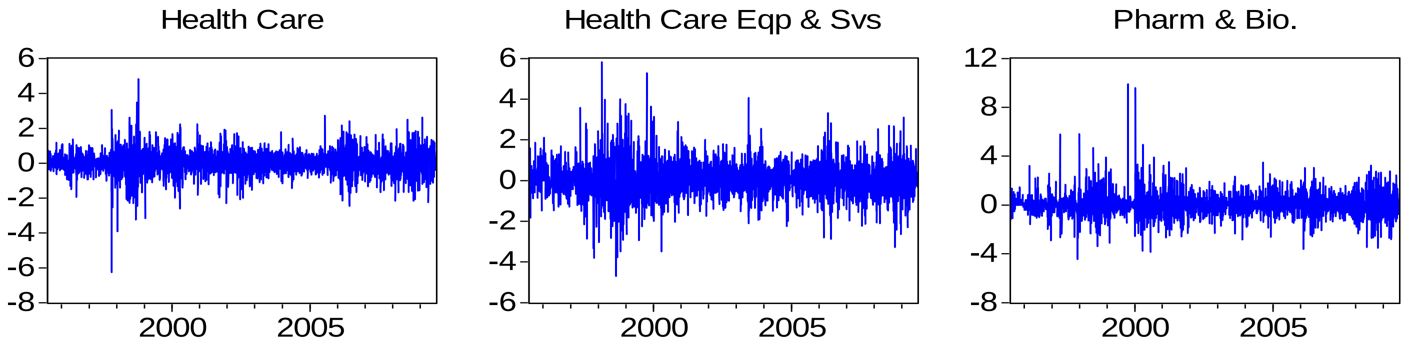
General Rtls



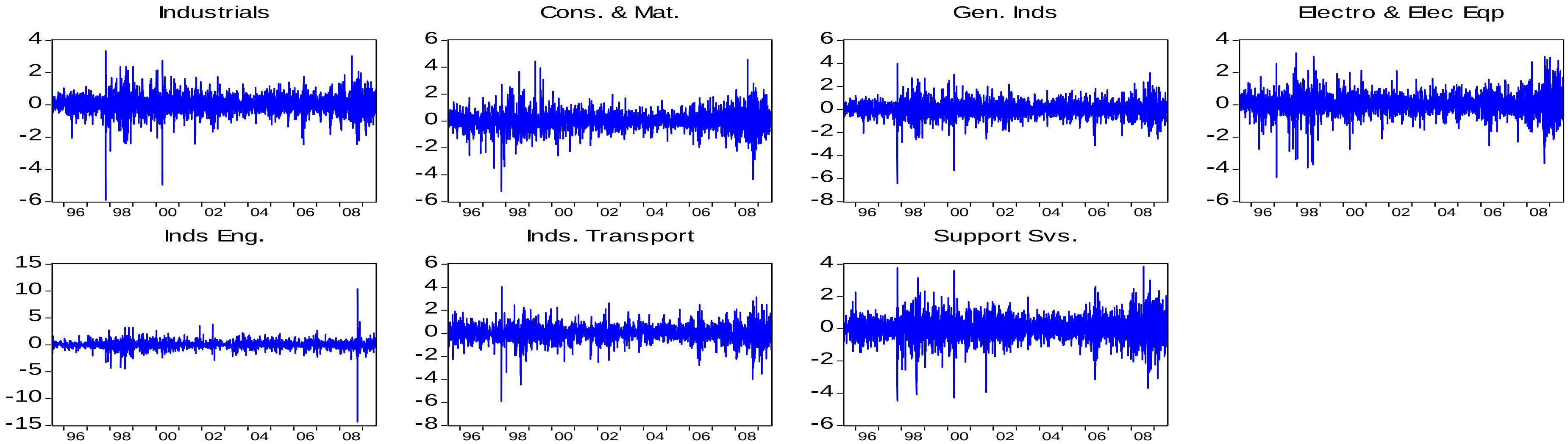
Financials



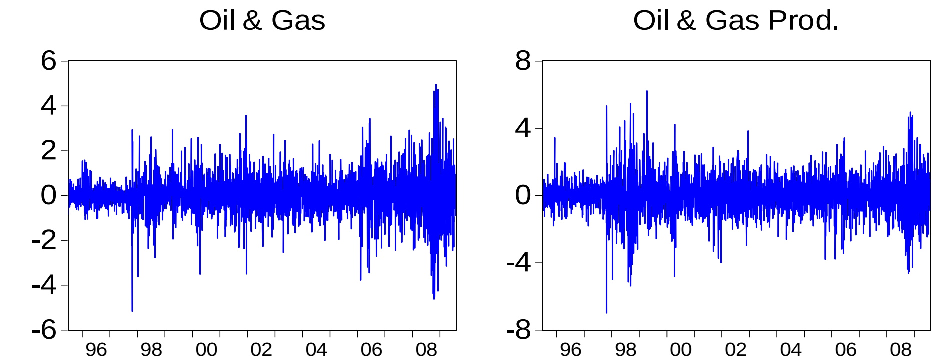
Health Care



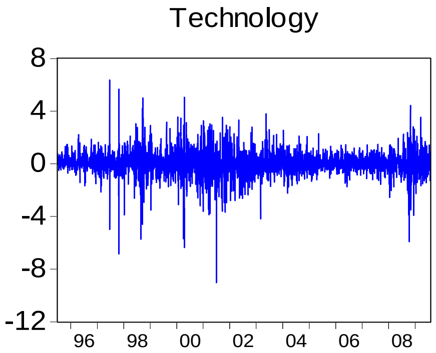
Industrials

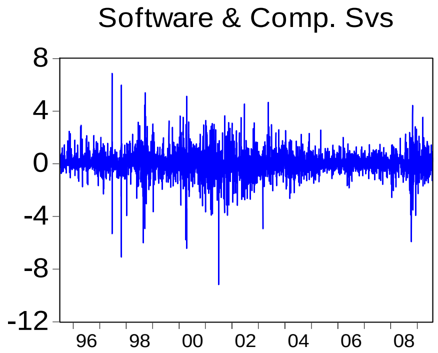


Oil and Gas

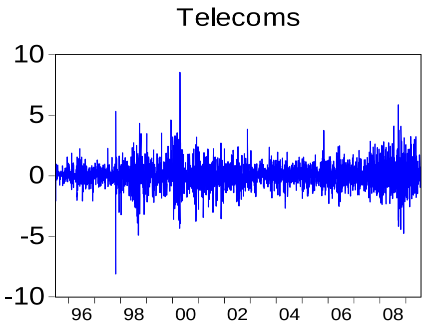


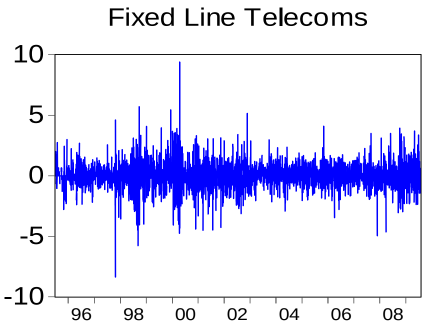
Technology

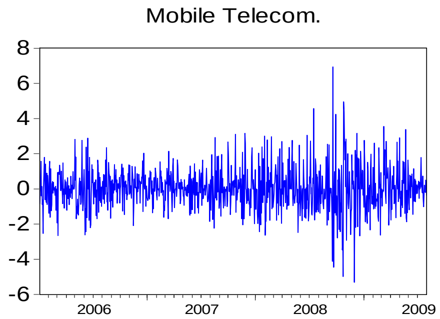




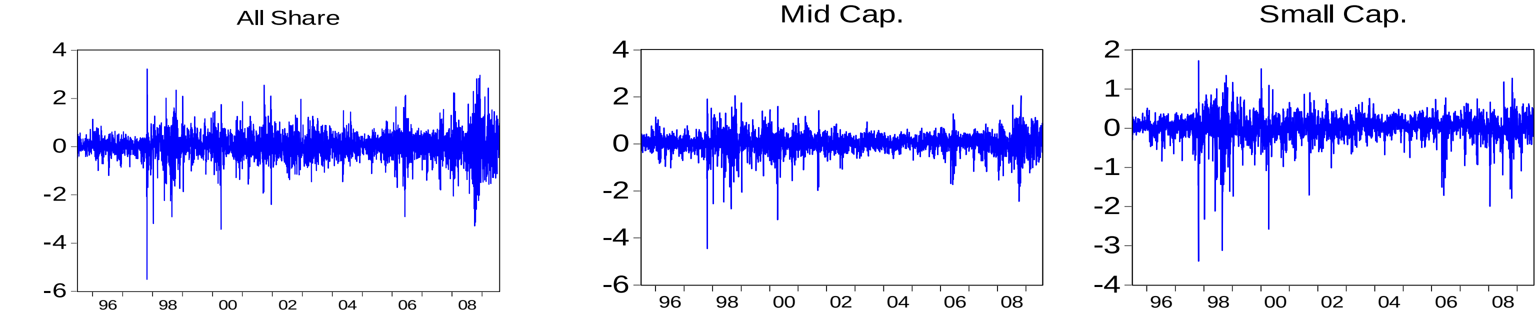
<u>Telecommunications</u>







<u>Benchmark</u>



Secondary Markets

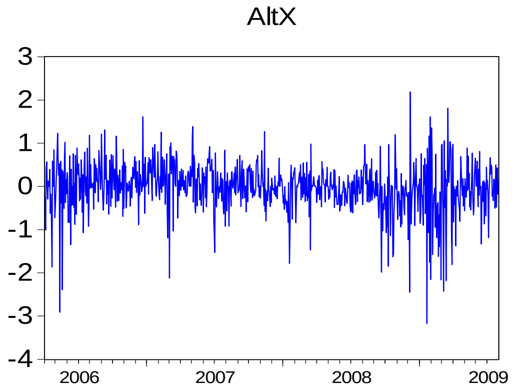
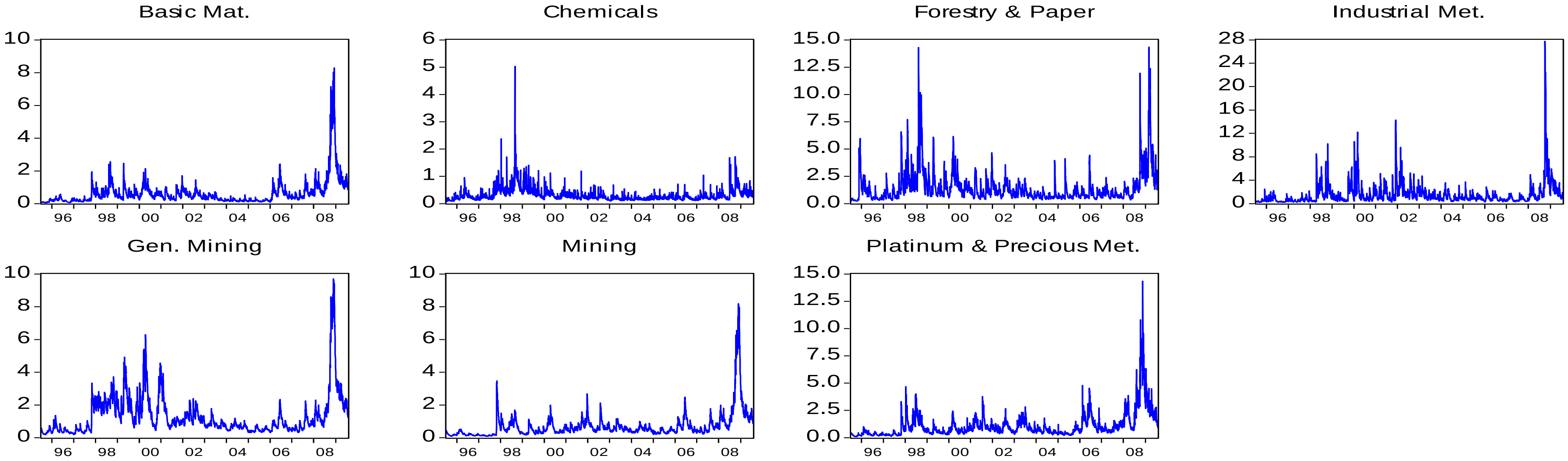
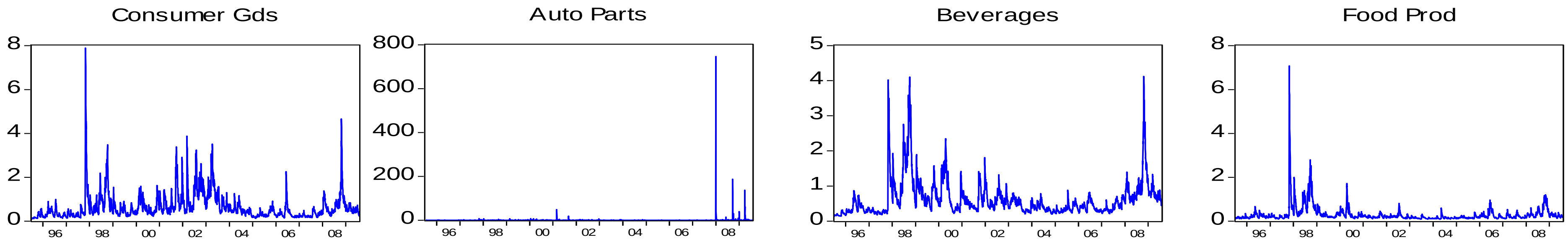


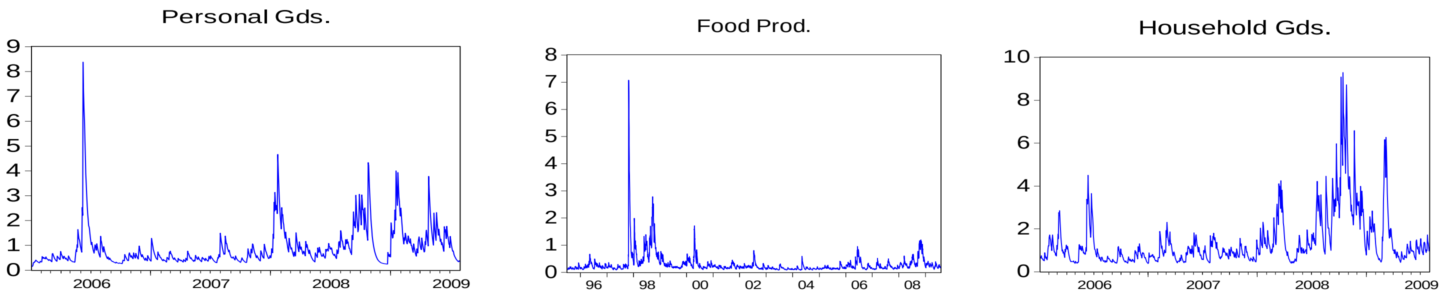
Figure 5.2: Trends in volatility

Basic Materials

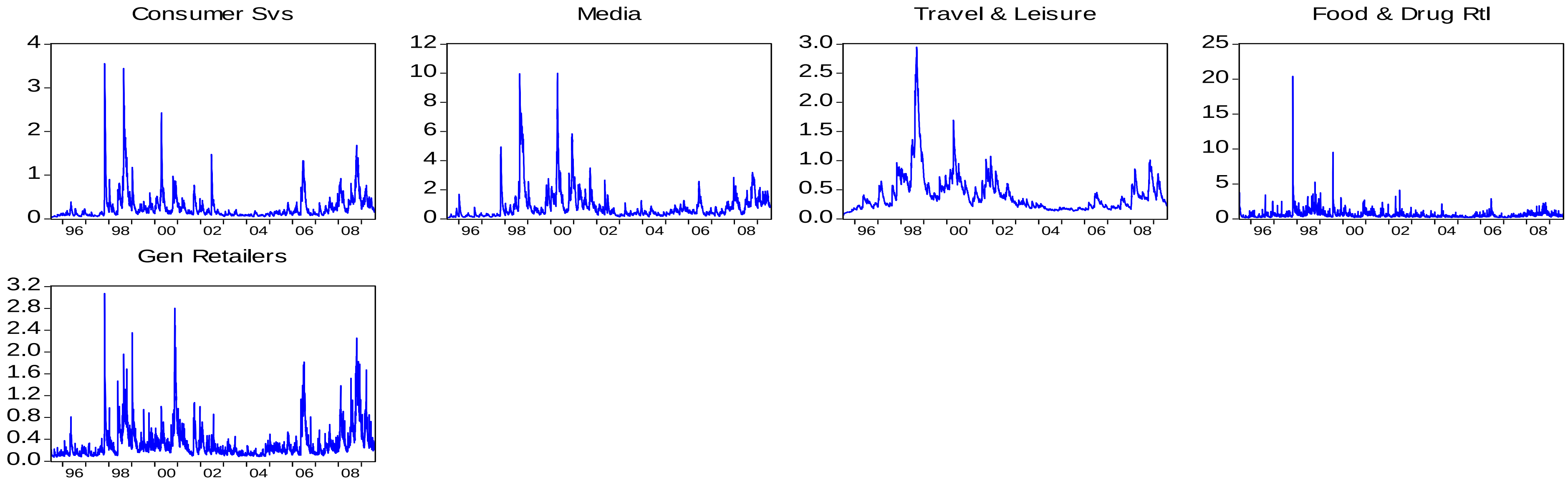


Consumer Goods

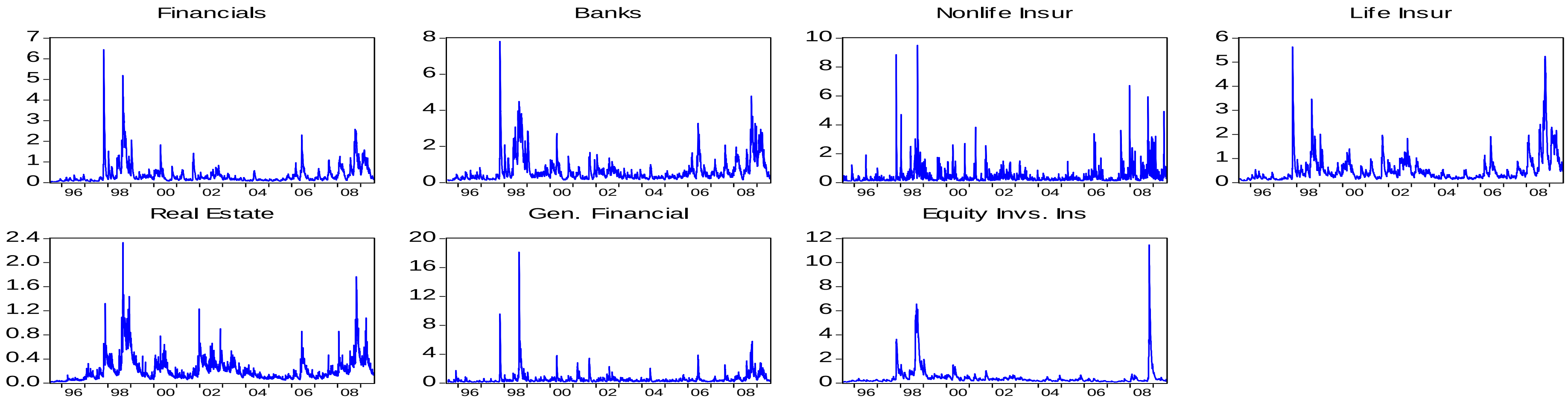




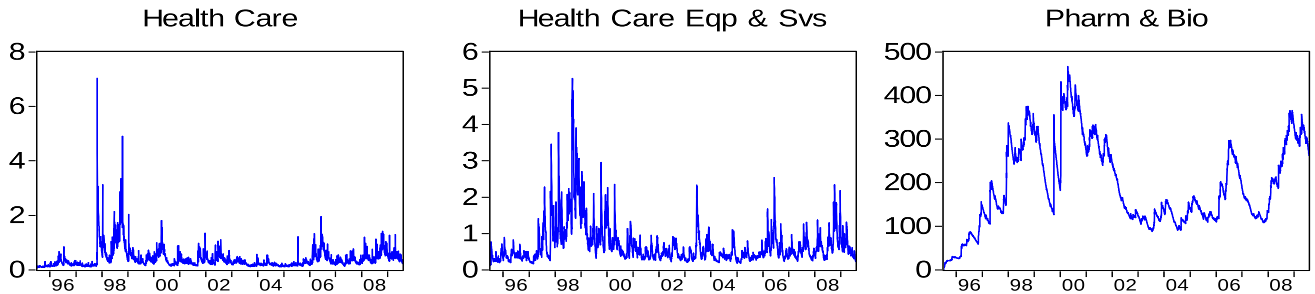
<u>Consumer Services</u>



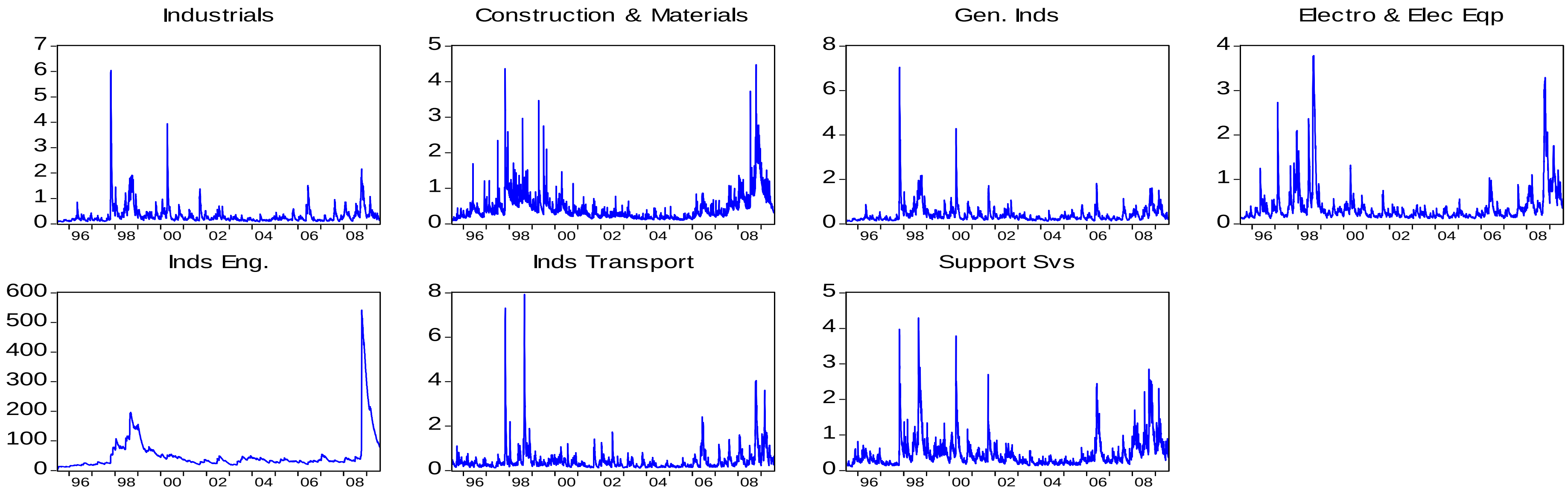
Financials



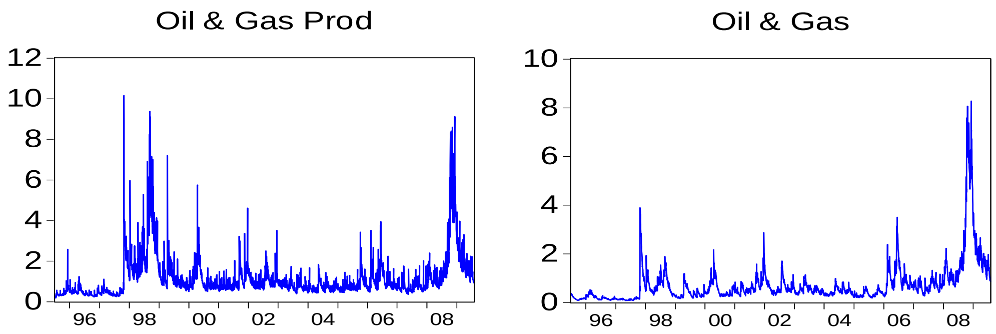
Health Care



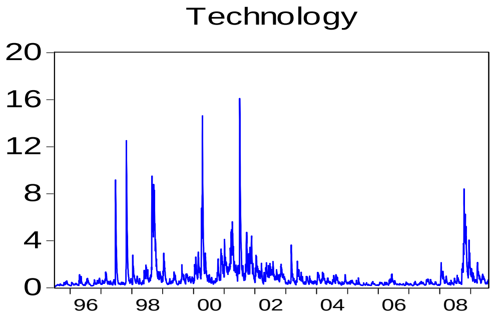
Industrials

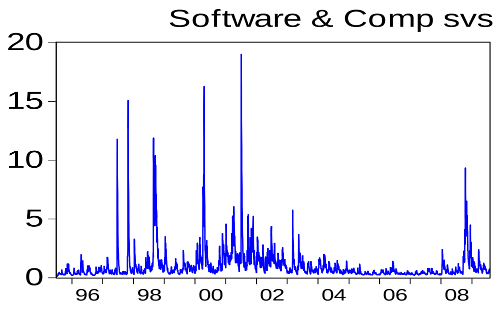


Oil and Gas

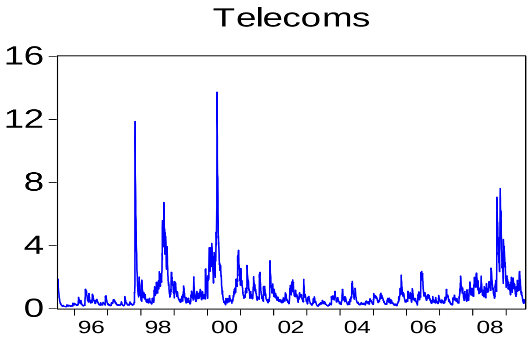


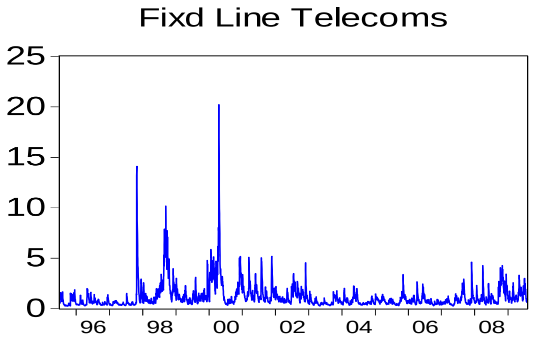
Technology

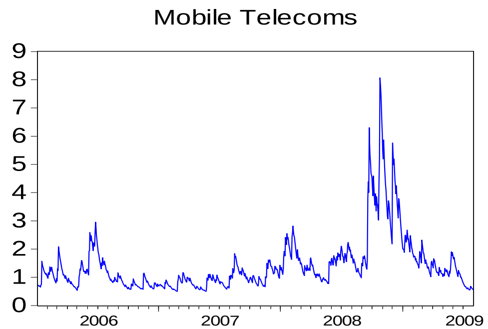




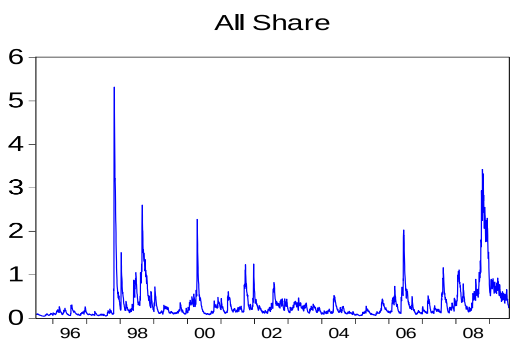
Telecommunications

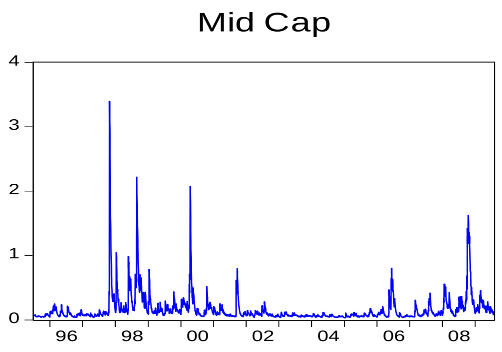


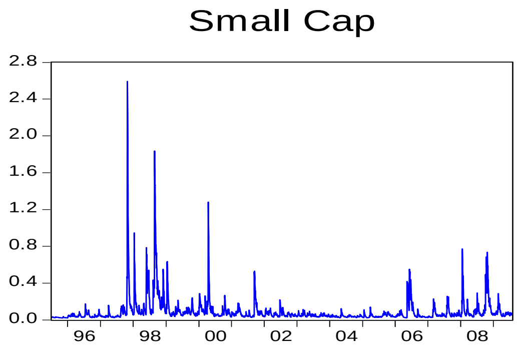




Benchmark







Secondary Markets

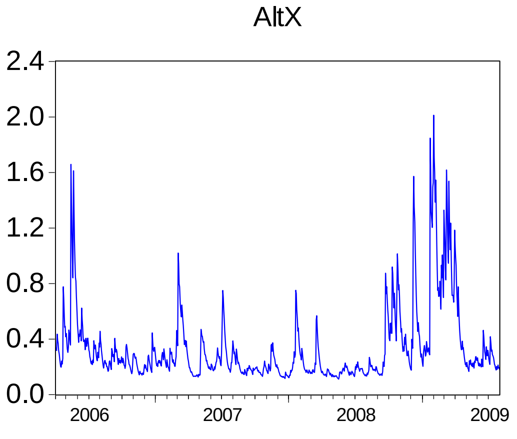


Table 1: Industries and Sectors used in estimations			
Index	**Index Code**	**Date**	**Number of observations**
Basic Materials			
FTSE/JSE BASIC MATERIALS	J510	30/06/1995-31/07/2009	3676
FTSE/JSE CHEMICALS	J153	30/06/1995-31/07/2009	3676
FTSE/JSE FORESTRY & PAPER	J173	30/06/1995-31/07/2009	3676
FTSE/JSE INDUSTRIAL METALS	J175	30/06/1995-31/07/2009	3676
FTSE/JSE GENERAL MINING	J154	30/06/1995-31/07/2009	3676
FTSE/JSE MINING	J177	30/06/1995-31/07/2009	3676
FTSE/JSE PLATINUM & PRECIOUS METALS	J153	30/06/1995-31/07/2009	3676
Consumer Goods			
FTSE/JSE CONSUMER GOODS	J530	30/06/1995-31/07/2009	3676
FTSE/JSE AUTO & PARTS	J335	30/06/1995-31/07/2009	3676
FTSE/JSE BEVERAGES	J353	30/06/1995-31/07/2009	3676
FTSE/JSE FOOD PRODUCERS	J357	30/06/1995-31/07/2009	3676
FTSE/JSE HOUSEHOLD GOODS	J372	03/01/2006-31/07/2009	934
FTSE/JSE PERSONAL GOODS	J376	03/01/2006-31/07/2009	934
Consumer Services			
FTSE/JSE CONSUMER SERVICES	J550	30/06/1995-31/07/2009	3676
FTSE/JSE MEDIA	J555	30/06/1995-31/07/2009	3676
FTSE/JSE TRAVEL & LEISURE	J575	30/06/1995-31/07/2009	3676
FTSE/JSE FOOD & DRUG RETAIL	J533	30/06/1995-31/07/2009	3676
FTSE/JSE GENERAL RETAILERS	J537	30/06/1995-31/07/2009	3676
Financials			
FTSE/JSE FINANCIALS	J580	30/06/1995-31/07/2009	3676
FTSE/JSE BANKS	J835	30/06/1995-31/07/2009	3676
FTSE/JSE NON-LIFE INSURANCE	J853	30/06/1995-31/07/2009	3676
FTSE/JSE LIFE INSURANCE	J857	30/06/1995-31/07/2009	3676
FTSE/JSE REAL ESTATE	J853	30/06/1995-31/07/2009	3676
FTSE/JSE EQUITY INVESTMENT INSTRUMENTS	J898	30/06/1995-31/07/2009	3676
FTSE/JSE GENERAL FINANCIALS	J877	30/06/1995-31/07/2009	3676
Health Care			
FTSE/JSE HEALTH CARE	J540	30/06/1995-31/07/2009	3676
FTSE/JSE HEALTH CARE EQUIPMENT & SERVICES	J453	30/06/1995-31/07/2009	3676
FTSE/JSE PHARMACEUTICALS & BIOTECHNOLOGY	J457	30/06/1995-31/07/2009	3676
Industrials			
FTSE/JSE INDUSTRIALS	J520	30/06/1995-31/07/2009	3676
FTSE/JSE CONSTRUCTION & MATERIALS	J235	30/06/1995-31/07/2009	3676
FTSE/JSE GENERAL INDUSTRIALS	J272	30/06/1995-31/07/2009	3676
FTSE/JSE ELETRONIC &ELECTRICAL EQUIPMENT	J273	30/06/1995-31/07/2009	3676
FTSE/JSE INDUSTRIAL ENGINEERING	J275	30/06/1995-31/07/2009	3676
FTSE/JSE INDUSTRIAL TRANSPORTATION	J277	30/06/1995-31/07/2009	3676
FTSE/JSE SUPPORT SERVICES	J279	30/06/1995-31/07/2009	3676
Oil and Gas			
FTSE/JSE OIL & GAS	J500	30/06/1995-31/07/2009	3676
FTSE/JSE OIL & GAS PRODUCERS	J055	30/06/1995-31/07/2009	3676
Technology			
FTSE/JSE TECHNOLOGY	J590	30/06/1995-31/07/2009	3676
FTSE/JSE SOFTWARE & COMPUTER SERVICES	J953	30/06/1995-31/07/2009	3676
Telecommunications			
FTSE/JSE FIXED LINE TELECOMMUNICATIONS	J653	30/06/1995-31/07/2009	3676
FTSE/JSE MOBILE TELECOMMUNICATIONS	J657	03/01/2006-31/07/2009	934
FTSE/JSE TELECOMMUNICATION	J560	30/06/1995-31/07/2009	3676
Benchmark			
FTSE/JSE MID CAP	J201	30/06/2009-31/07/2009	3676
FTSE/JSE SMALL CAP	J202	30/06/2009-31/07/2009	3676
FTSE/JSE ALL SHARE	J203	30/06/1995-31/07/2009	3676
Secondary Markets			
FTSE/JSE ALT-X	J232	03/04/2006-31/07/2009	870

Table 3.1: FTSE/DOW Jones Industry Classification System (Industry Classification Benchmark- ICB) BENCHMARK- ICB)

Industry	Supersector	Sector	Subsector
Oil & Gas+	Oil & Gas	Oil & Gas Producers+	Exploration & Production Integrated Oil & Gas
		Oil Equipment & Services+	Oil Equipment & Services Pipelines
Basic Materials+	Chemicals	Chemicals+	Commodity Chemicals Specialty Chemicals
	Basic Resources	Forestry & Paper+	Forestry Paper
		Industrial Metals+	Aluminum Nonferrous Metals Steel
		Mining+	Coal Diamonds & Gemstones General Mining+ Gold Mining Platinum & Precious Metals+
Industrials+	Construction & Materials	Construction & Materials+	Building Materials & Fixtures Heavy Construction
	Industrial Goods & Services	Aerospace & Defense	Aerospace Defense
		General Industrials+	Containers & Packaging Diversified Industrials
		Electronic & Electrical Equipment+	Electrical Components & Equipment Electronic Equipment
		Industrial Engineering+	Commercial Vehicles & Trucks Industrial Machinery
		Industrial Transportation+	Delivery Services Marine Transportation Railroads Transportation Services Trucking
		Support Services+	Business Support Services Business Training & Employment Agencies Financial Administration Industrial Suppliers Waste & Disposal Services
Consumer Goods+	Automobiles & Parts	Automobiles & Parts+	Automobiles Auto Parts Tires
	Food & Beverage	Beverages+	Brewers Distillers & Vintners Soft Drinks
		Food Producers+	Farming & Fishing Food Products
	Personal & Household Goods	Household Goods+	Durable Household Products Nondurable Household Products Furnishings Home Construction
		Leisure Goods+	Consumer Electronics Recreational Products

Table 3.1: FTSE/DOW Jones Industry Classification System (Industry Classification Benchmark- ICB) BENCHMARK- ICB)			
Industry	**Supersector**	**Sector**	**Subsector**
			Toys
		Personal Goods+	Clothing & Accessories Footwear Personal Products
		Tobacco+	Tobacco
Health Care+	Healthcare	Health Care Equipment & Services+	Health Care Providers Medical Equipment Medical Supplies
		Pharmaceuticals & Biotechnology+	Biotechnology Pharmaceuticals
Consumer Services+	Retail	Food & Drug Retailers+	Drug Retailers Food Retailers & Wholesalers
		General Retailers+	Apparel Retailers Broadline Retailers Home Improvement Retailers Specialized Consumer Services Specialty Retailers
	Media	Media+	Broadcasting & Entertainment Media Agencies Publishing
	Travel & Leisure	Travel & Leisure+	Airlines Gambling Hotels Recreational Services Restaurants & Bars Travel & Tourism
Telecommunications+	Telecommunications	Fixed Line Telecommunications+	Fixed Line Telecommunications
		Mobile Telecommunications+	Mobile Telecommunications
Utilities	Utilities	Electricity	Electricity
		Gas, Water & Multiutilities	Gas Distribution Multiutilities Water
Financials+	Banks	Banks+	Banks
	Insurance	Nonlife Insurance+	Full Line Insurance Insurance Brokers Property & Casualty Insurance Reinsurance
		Life Insurance+	Life Insurance
	Financial Services	Real Estate+	Real Estate Holding & Development Real Estate Investment Trusts
		General Financials+	Asset Managers Consumer Finance Specialty Finance Investment Service Mortgage Finance
		Equity Investment Instruments+	Equity Investment Instruments
		Nonequity Investment Instruments	Nonequity Investment Instruments
Technology+	Technology	Software & Computer Services+	Computer Services Internet Software
		Technology Hardware & Equipment	Computer Hardware

Table 3.1: FTSE/DOW Jones Industry Classification System (Industry Classification Benchmark- ICB) BENCHMARK- ICB)

Industry	Supersector	Sector	Subsector
			Electronic Office Equipment
			Semiconductors
			Telecommunications Equipment

Source: Adapted from Faure (2005)

Notes:

+ represents estimated indices.

Table 5.1: Descriptive statistics and stationarity tests

Index	Mean	Median	Max.	Min.	Std.Dev	Skewness	Kurtosis	Jarque-Bera	LB(12)	$LB^2(12)$	ADF (Level)	KPSS(Level)
Basic Materials												
Basic Materials	0.017	0.000	4.848	-5.130	0.768	-0.020	8.263	4242.369[a]	67.886[a]	2864.921[a]	-35.1485[a]	0.145[a]
Chemicals	0.016	0.000	2.919	-4.656	0.529	-0.040	7.706	3392.829[a]	93.168[a]	338.211[a]	-38.1738[a]	0.144[a]
Forestry & Paper	-0.004	0.000	9.259	-8.368	1.140	0.146	9.426	6338.809[a]	50.861[a]	426.552[a]	-54.8889[a]	0.122[a]
Industrial Metals	0.025	0.000	8.939	-11.499	1.087	0.104	12.173	12894.430[a]	49.731[a]	350.451[a]	-54.8780[a]	0.178[a]
General Mining	0.015	0.000	6.697	-6.471	1.120	0.398	7.320	2955.623[a]	49.749[a]	984.773[a]	-56.4888[a]	0.219[a]
Mining	0.024	0.000	5.045	-5.197	0.823	-0.017	7.537	3153.184[a]	63.187[a]	2563.115[a]	-35.4296[a]	0.067[a]
Platinum & Precious Metals	0.032	0.000	5.342	-7.837	0.998	-0.332	6.830	2314.704[a]	106.642[a]	1308.915[a]	-36.5265[a]	0.084[a]
Consumer Goods												
Consumer Goods	0.026	0.000	6.172	-5.361	0.781	0.336	8.175	4170.637[a]	23.827[b]	521.021[a]	-58.5769[a]	0.051[a]
Automobile & Parts	-0.020	0.000	40.085	-39.747	1.372	-0.192	429.033	27800444.000[a]	483.882[a]	905.263[a]	-58.2119[a]	0.179[a]
Beverages	0.016	0.000	5.443	-5.890	0.778	0.040	7.269	2792.709[a]	30.482[a]	788.766[a]	-58.0677[a]	0.077[a]
Food Producers	0.018	0.003	3.847	-6.912	0.548	-0.579	14.581	20747.720[a]	40.174[a]	695.422[a]	-56.1169[a]	0.246[a]
Personal Goods	0.031	0.000	14.858	-4.972	0.981	3.477	59.314	125295.900[a]	27.085[a]	156.277[a]	-33.1210[a]	0.048[a]
Household Goods	-0.002	0.000	4.215	-4.934	1.155	0.020	4.724	115.720[a]	54.525[a]	398.845[a]	-20.5918[a]	0.116[a]
Consumer Services												
Consumer Services	0.014	0.013	2.933	-4.502	0.513	-0.752	9.792	7412.333[a]	124.98[a]	991.223[a]	-52.2216[a]	0.191[a]
Media	0.022	0.006	5.009	-8.217	0.888	-0.525	9.657	6956.925[a]	75.833[a]	1037.214[a]	-53.7212[a]	0.204[a]
Travel and Leisure	0.007	0.000	5.338	-4.635	0.640	-0.253	8.529	4721.492[a]	88.877[a]	430.541[a]	-53.1173[a]	0.342[a]
Food & Drug Retailers	0.032	0.000	7.901	-7.043	0.718	-0.146	12.631	14221.600[a]	21.113[b]	672.025[a]	-57.1265[a]	0.073[a]
General Retailers	0.014	0.008	2.866	-3.868	0.562	-0.392	6.706	2197.788[a]	202.86[a]	1082.716[a]	-50.2773[a]	0.122[a]
Financials												
Financials	0.015	0.000	3.524	-5.781	0.596	-0.428	10.000	7616.786[a]	85.993[a]	1266.423[a]	-52.7078[a]	0.089[a]
Banks	0.021	0.000	4.299	-6.064	0.785	-0.052	7.009	2463.041[a]	90.755[a]	1119.856[a]	-53.5091[a]	0.056[a]
Non-life Insurance	0.019	0.000	4.444	-5.006	0.626	-0.059	10.814	9353.620[a]	25.121[a]	334.981[a]	-59.1077[a]	0.097[a]
Life Insurance	0.007	0.000	4.348	-6.180	0.713	-0.261	8.387	4486.891[a]	42.326[a]	1091.425[a]	-56.4558[a]	0.079[a]
Real Estate	0.012	0.000	3.220	-2.877	0.444	0.019	8.072	3939.813[a]	40.964[a]	768.491[a]	-58.6488[a]	0.151[a]
General Financials	0.018	0.000	4.345	-7.467	0.730	-0.729	12.942	15464.370[a]	100.671[a]	1397.325[a]	-52.8560[a]	0.158[a]
Equity Investment Instrument	0.014	0.000	15.856	-5.293	0.682	3.004	88.458	1124110.000[a]	74.275[a]	74.142[a]	-35.8700[a]	0.079[a]
Health Care												
Health Care	0.017	0.000	4.827	-6.248	0.621	-0.289	9.691	6908.040[a]	42.751[a]	607.636[a]	-55.8723[a]	0.178[a]
Health Care Equipment & Services	0.031	0.000	5.828	-4.706	0.791	0.236	7.271	2828.572[a]	41.621[a]	449.131[a]	-55.9678[a]	0.169[a]
Pharmaceuticals & Biotechnology	0.034	0.000	9.925	-4.454	0.856	1.154	15.706	25543.140[a]	34.267[a]	49.6813[a]	-56.8247[a]	0.139[a]
Industrials												
Industrials	0.019	0.012	3.338	-5.913	0.566	-0.578	10.453	8712.553[a]	35.181[a]	692.371[a]	-55.6854[a]	0.110[a]
Construction & Materials	0.013	0.000	4.550	-5.238	0.650	-0.153	8.704	4997.495[a]	109.471[a]	587.283[a]	-52.1896[a]	0.579[a]
General Industrials	0.023	0.000	4.011	-6.446	0.637	-0.374	9.559	6674.509[a]	18.223[c]	608.825[a]	-57.5262[a]	0.094[a]
Electronic & Electrical Equipment	0.012	0.000	3.234	-4.504	0.620	-0.422	8.442	4644.961[a]	82.881[a]	1464.514[a]	-54.5328[a]	0.134[a]
Industrials Engineering	0.010	0.000	10.430	-14.364	0.674	-1.820	78.482	874697.500[a]	46.713[a]	587.3589[a]	-26.9095[a]	0.507[a]
Industrials Transport	0.003	0.000	4.037	-5.942	0.639	-0.626	9.554	6820.250[a]	48.315[a]	970.2861[a]	-55.3287[a]	0.138[a]
Support Services	0.010	0.000	3.883	-4.491	0.675	-0.285	7.192	2741.752[a]	22.919[b]	918.923[a]	-61.0217[a]	0.091[a]
Oil and Gas												
Oil & Gas	0.023	0.000	4.966	-5.155	0.832	0.033	7.530	3144.142[a]	50.888[a]	2311.191[a]	-56.2555[a]	0.060[a]
Oil & Gas Producers	0.026	0.000	6.239	-6.987	1.038	-0.038	6.802	2214.917[a]	55.235[a]	1078.338[a]	-37.0337[a]	0.052[a]
Technology												
Technology	0.010	0.000	6.373	-9.033	0.927	-0.685	12.356	13695.310[a]	74.333[a]	827.625[a]	-38.4416[a]	0.357[a]
Software Computer & Services	0.012	0.000	6.869	-9.176	0.976	-0.555	11.724	11845.730[a]	68.679[a]	751.747[a]	-54.5991[a]	0.408[a]
Telecommunications												
Telecommunications	0.030	0.004	8.534	-8.115	0.950	0.057	9.154	5803.355[a]	35.145[a]	754.347[a]	-56.0250[a]	0.074[a]
Fixed Line Telecommunications	0.020	0.000	9.392	-8.387	1.028	-0.008	9.034	5577.457[a]	44.728[a]	563.616[a]	-55.1629[a]	0.072[a]
Mobile Telecommunications	0.032	0.000	6.933	-5.315	1.194	0.328	5.666	293.459[a]	37.458[a]	198.941[a]	-24.4286[a]	0.116[a]
Benchmark												
All Share	0.019	0.009	3.224	-5.511	0.568	-0.502	9.512	6649.647[a]	49.692[a]	1371.736[a]	-56.0599[a]	0.063[a]
Mid Cap	0.021	0.023	2.058	-4.453	0.408	-1.153	13.013	16172.900[a]	223.421[a]	920.071[a]	-36.2782[a]	0.092[a]
Small Cap	0.018	0.029	1.723	-3.393	0.313	-1.824	17.201	32928.850[a]	630.672[a]	942.031[a]	-26.8487[a]	0.202[a]
Secondary Markets												
ALT X	-0.015	0.000	2.188	-3.171	0.573	-0.918	6.825	652.646[a]	37.279[a]	160.368[a]	-29.6414[a]	0.315[a]

Source: Author's own estimates

Notes:

The critical value for the ADF test at 1% critical value is -2.565592 and the KPSS 1% critical value is 0.739000. Thus a denotes rejection of a unit root/nonstationarity for both tests.

The lag order was determined by the SIC and the spectral estimation method is the Bartlett Kennel for ADF and KPSS respectively.

LB(12) and $LB^2(12)$ are Ljung-Box statistics for 12 lags calculated for returns and squared returns respectively.

Table 5.2: Results for the mean equation						
Index	**DW**	**B-G**	**DW- AR(1)**	**B-G AR(1)**	**ARCH LM**	**ARCH LM AR(1)**
Basic Materials						
Basic Materials	1.801	8.771[a]	2.005	20.344[a]	40.275[a]	17.475[a]
Chemicals	1.751	33.117[a]	2.012	5.292	65.114[a]	10.565[a]
Forestry & Paper	1.803	17.980[a]	2.000	1.838	35.641[a]	13.675[a]
Industrial Metals	1.803	18.947[a]	2.004	2.183	37.537[a]	14.366[a]
General Mining	1.860	9.277[a]	2.001	0.597	18.475[a]	10.913[a]
Mining	1.827	15.410[a]	2.003	5.392[a]	30.589[a]	10.765[a]
Platinum & Precious Metals	1.725	39.370[a]	1.985	11.346[a]	77.151[a]	22.577[a]
Consumer Goods						
Consumer Goods	1.934	2.138	1.999	0.309	4.275	15.619[a]
Automobile & Parts	2.696	305.709[a]	2.109	50.067[a]	524.592[a]	97.582 [a]
Beverages	1.915	4.662[a]	1.997	4.511[b]	9.308[a]	9.010 [b]
Food Producers	1.848	10.938[a]	2.002	1.508	21.764[a]	13.017[b]
Personal Goods	2.164	0.109	1.997	1.357	6.502[b]	8.218[b]
Household Goods	1.865	12.295[a]	1.975	10.24[a]	24.034[a]	20.133[a]
Consumer Services						
Consumer Services	1.706	40.873[a]	2.003	0.427	80.032[a]	10.854[a]
Media	1.761	26.712	2.001	0.303	52.697[a]	12.606[a]
Travel and Leisure	1.738	33.917[a]	1.992	2.402[c]	66.659[a]	4.802[c]
Food & Drug Retailers	1.885	6.086[a]	1.995	0.593	12.141[a]	11.186[a]
General Retailers	1.632	66.044[a]	2.010	2.467[c]	127.607[a]	14.932[a]
Financials						
Financials	1.723	35.821[a]	1.998	0.844	70.327[a]	11.688[a]
Banks	1.753	31.737[a]	1.989	5.894[a]	62.447[a]	11.762[a]
Non-life Insurance	1.952	3.033[c]	1.999	2.154	6.060[a]	14.307[a]
Life Insurance	1.858	9.848[a]	1.997	2.153	19.607[a]	14.306[a]
Real Estate	1.936	5.743[a]	2.003	4.028[b]	11.459[a]	8.046[b]
General Financials	1.729	34.431[a]	2.002	0.481	67.649[a]	10.963[a]
Equity Investment Instrument	1.814	19.183[a]	2.008	14.379 [a]	38.001[a]	28.566[a]
Health Care						
Health Care	1.839	12.314	1.998	0.652	24.484[a]	9.313[a]
Health Care Equipment & Services	1.844	13.481[a]	1.995	2.082	26.787[a]	14.165[a]
Pharmaceuticals & Biotechnology	1.874	7.406[a]	1.999	0.196	14.764[a]	14.996[a]
Industrials						
Industrials	1.832	12.844	1.999	0.422	25.531[a]	10.844[a]
Construction & Materials	1.704	41.143[a]	1.998	0.755	80.549[a]	11.511[a]
General Industrials	1.897	4.744[a]	1.999	0.268	9.472[a]	10.537[a]
Electronic & Electrical Equipment	1.790	21.111[a]	2.004	1.084	41.777[a]	12.169[a]
Industrials Engineering	2.097	6.581[a]	1.997	4.218[b]	13.124[a]	18.427[a]
Industrials Transport	1.818	17.396[c]	2.004	2.598[c]	34.494[a]	15.195[a]
Support Services	2.014	0.545	2.000	0.464	1.0901	10.929[a]
Oil and Gas						
Oil & Gas	1.852	10.229[a]	2.000	1.789	20.362[a]	13.579[a]
Oil & Gas Producers	1.849	11.526[a]	1.996	3.780[b]	22.927[a]	17.553[a]
Technology						
Technology	1.783	26.751[a]	2.011	5.903	52.775[a]	11.781[b]
Software Computer & Services	1.792	23.956[a]	2.009	5.155[a]	47.333[a]	10.292[a]
Telecommunications						
Telecommunications	1.845	12.447	1.995	2.519	24.746[a]	15.347[c]
Fixed Line Telecommunications	1.813	16.271	2.001	1.854	32.283[a]	13.708[a]
Mobile Telecommunications	1.994	7.522[a]	2.000	0.002	14.852[a]	14.882[a]
Benchmark						
All Share	1.846	12.288[a]	2.003	2.423	40.180[a]	17.102[b]
Mid Cap	1.592	83.900[a]	2.018	4.197[b]	160.604[a]	8.384 [b]
Small Cap	1.466	153.174[a]	2.042	26.361[a]	282.996[a]	52.033
Secondary Markets						
ALT X	2.013	0.364	2.000	0.579	0.731	11.162

Source: Author's own estimates

Notes:

[a,b,c] implies coefficient is significant at 1%, 5% and 10% respectively.

B-G -Breusch-Godfrey Serial Correlation LM Test

Table 5.3: Estimated GARCH models															
Index	**GARCH-M**					**EGARCH-M**					**TARCH-M**				
	δ	α+β	γ	F-LM	SIC	δ	α+β	γ	F-LM	SIC	δ	α+β	γ	F-LM	SIC
Basic Materials															
Basic Materials															
Gaussian Distribution	0.055	0.999^{+}		8.773^{a}	1.949	0.038	1.139^{+}	-0.021^{a}	21.397^{a}	1.952	0.046	0.956	0.074^{a}	2.157	1.949
Student -t Distribution	0.041	1.002^{+}		8.325^{a}	1.893	0.027	1.142^{+}	-0.030^{a}	25.284^{a}	1.892	0.025	0.938	0.107^{a}	2.231	1.893
Generalised Error Distribution	0.009	1.000^{+}		7.879^{a}	1.886	0.001	1.143^{+}	-0.026^{a}	22.518^{a}	1.886	0.015	0.938	0.102^{a}	2.273	1.887*
Chemicals															
Gaussian Distribution	-0.005	0.997		0.028	1.435	-0.019	1.015	-0.021^{a}	0.258	1.447	0.006	0.970	0.033^{a}	5.974	1.444
Student -t Distribution	0.019	0.997		0.892	1.335	-0.037	1.144	-0.036^{a}	2.966	1.341	0.011	0.981	0.028^{a}	1.147	1.335
Generalised Error Distribution	0.013	0.997		0.852	1.324	-0.033	1.122	-0.035^{a}	3.477	1.331	0.016	0.983	0.023^{a}	1.122	1.324*
Forestry & Paper															
Gaussian Distribution	0.076	0.996		1.166	2.893	0.012	1.117	-0.040^{a}	1.343	2.893	0.065	0.981	0.031^{a}	1.052	2.873
Student -t Distribution	0.051	0.994		1.152	2.719	0.011	1.117	-0.043^{a}	1.481	2.748	0.045	0.972	0.026^{a}	1.049	2.755
Generalised Error Distribution	0.001	1.004		0.368	2.724	0.015	1.134	-0.037^{a}	0.694	2.721	0.031	0.958	0.079^{a}	1.884	2.723*
Industrial Metals															
Gaussian Distribution	0.027	0.993		1.909	2.789	-0.011	1.094	-0.010^{a}	1.719	2.811	0.025	0.990	0.005^{a}	2.096	2.791
Student -t Distribution	0.015	0.996		1.816	2.479	-0.001	1.283	-0.003^{a}	0.109	2.559	0.031	0.992	0.024^{a}	2.231	2.565
Generalised Error Distribution	0.001	1.021		0.111	2.482	-0.003	1.236	-0.002^{a}	0.242	2.476	0.001	0.991	0.018^{a}	0.118	2.488*
General Mining															
Gaussian Distribution	0.083	0.998		2.236	2.813	0.093^{c}	1.128^{+}	-0.032^{a}	13.647^{a}	2.813	0.063	0.977^{+}	0.043^{a}	3.475^{b}	2.805
Student -t Distribution	0.017	1.002		0.154	2.737	0.071^{c}	1.134^{+}	-0.025^{a}	18.211^{a}	2.733	0.011	0.975	0.055^{a}	0.447	2.735
Generalised Error Distribution	0.000	0.999		0.447	2.726	0.059	1.132^{+}	-0.027^{a}	15.399^{a}	2.724	0.002	0.975	0.938^{a}	0.929	2.724*
Mining															
Gaussian Distribution	0.094^{c}	0.935^{+}		8.089^{a}	2.168	0.093^{c}	1.128^{+}	-0.032^{a}	13.647^{a}	2.168	0.071	0.978^{+}	0.037^{a}	5.873^{a}	2.167
Student -t Distribution	0.074^{c}	0.931^{+}		6.521^{a}	2.120*	0.071^{c}	1.134^{+}	-0.025^{a}	18.211^{a}	2.120	0.066	0.984^{+}	0.032^{a}	5.231^{a}	2.123
Generalised Error Distribution	0.062	0.933^{+}		7.001^{a}	2.124	0.059	1.132^{+}	-0.027^{a}	15.399^{a}	2.124	0.052	0.982^{+}	0.033^{a}	5.495^{a}	2.126
Platinum & Precious Metals															
Gaussian Distribution	0.090^{c}	0.997^{+}		4.016^{b}	2.551	0.110^{b}	1.124^{+}	-0.035^{a}	7.826^{a}	2.556	0.066	0.978^{+}	0.036^{a}	3.790^{b}	2.55
Student -t Distribution	0.105^{b}	1.002^{+}		3.336^{b}	2.510	0.111^{a}	1.136^{+}	-0.024^{b}	7.680^{a}	2.513	0.097^{b}	0.989^{+}	0.024^{c}	3.126^{b}	2.512
Generalised Error Distribution	0.110^{a}	1.000^{+}		6.659^{a}	2.508	0.127^{a}	1.132^{+}	-0.028^{c}	6.953^{a}	2.511	0.108^{b}	0.986^{+}	0.027^{c}	2.999^{c}	2.509*
Consumer Goods															
Consumer Goods															
Gaussian Distribution	0.026	0.990		1.619	2.347	0.016	1.141^{+}	-0.059^{a}	2.937^{c}	2.119	0.004	0.956	0.077^{a}	1.291	2.121
Student -t Distribution	-0.005	0.990		1.246	2.072	-0.009	1.137^{+}	-0.062^{a}	2.530^{c}	2.065	-0.009	0.950	0.088^{a}	2.513	2.068
Generalised Error Distribution	-0.005	0.989		1.108	2.063	-0.01	1.137^{+}	-0.064^{a}	2.441^{c}	2.056	-0.011	0.949	0.092^{a}	2.149	2.059*
Automobile & Parts															
Gaussian Distribution	0.310^{c}	0.680		0.081	3.041	0.148^{b}	1.212	0.164^{a}	0.007	2.987	0.161^{c}	1.311	-0.568^{a}	0.052	3.017
Student -t Distribution	0.000	908.436		0.003	1.770	-0.007	1.563	0.061	0.002	1.761	0.001	630.984	596.149	0.003	1.77
Generalised Error Distribution	0.000	1.714		0.002	1.329	0.618^{a}	-0.104	0.055^{a}	0.269	2.138	0.002	0.476	0.273	0.003	1.695*
Beverages															
Gaussian Distribution	-0.059	0.994		0.379	2.152	-0.071	1.076^{+}	-0.028^{a}	2.845^{c}	2.164	-0.06	0.982	0.026^{a}	0.984	2.151
Student -t Distribution	-0.046	0.992		1.539	2.092	-0.058	1.101	-0.037^{a}	1.636	2.089	-0.034	0.966	0.054^{a}	1.417	2.09
Generalised Error Distribution	-0.016	0.990		1.964	2.084	-0.015	1.086	-0.036^{a}	1.973	2.083	-0.009	0.965	0.052^{a}	1.863	2.082*
Food Producers															
Gaussian Distribution	-0.065	0.984^{+}		4.365^{b}	1.378	-0.138^{b}	1.084^{+}	-0.037^{a}	9.944^{a}	1.395	-0.087	0.945	0.060^{a}	9.395	1.378
Student -t Distribution	-0.038	0.986		1.435	1.306	-0.063	1.112^{+}	-0.035^{a}	5.950^{a}	1.308	-0.058	0.945	0.064^{a}	4.038	1.304
Generalised Error Distribution	-0.027	0.984		2.185	1.302	-0.045	1.098^{+}	-0.034^{a}	7.143^{a}	1.307	-0.043	0.942	0.062^{a}	5.142	1.301*
Personal Goods															
Gaussian Distribution	-0.074	1.030		0.322	2.560	-0.024	1.358	-0.035^{a}	0.111	2.535	0.214^{b}	0.889	0.211^{a}	0.057	2.551
Student -t Distribution	0.043	0.968		0.188	2.401	0.001	1.349	-0.024^{b}	0.006	2.357	0.136	0.875	0.189^{a}	0.054	2.397
Generalised Error Distribution	0.015	0.973		0.228	2.382	0.002	1.261	-0.028^{c}	0.061	2.342	0.008	0.857	0.260^{a}	0.054	2.378*
Household Goods															
Gaussian Distribution	0.073	0.957		0.149	2.967	0.085	1.206	-0.101^{a}	1.215	2.968	0.092	0.874	0.155^{a}	0.641	2.965
Student -t Distribution	0.043	0.960		0.262	2.960	0.069	1.225	-0.104^{a}	1.151	2.963	0.071	0.880	0.160^{b}	0.693	2.959
Generalised Error Distribution	0.019	0.963		0.267	2.948	0.031	1.224	-0.101^{a}	1.122	2.951	0.031	0.884	0.160^{b}	0.691	2.948*
Consumer Services															
Consumer Services															
Gaussian Distribution	-0.063	0.991		1.385	1.170	-0.153	1.136^{+}	-0.056^{a}	2.419^{c}	1.163	-0.131	0.944	0.087^{a}	0.689	1.162
Student -t Distribution	-0.055	0.993		1.616	1.112	-0.123^{a}	1.152^{+}	-0.044^{a}	3.422^{b}	1.108	-0.094^{c}	0.962	0.052^{a}	1.569	1.109*
Generalised Error Distribution	-0.063	0.992		1.987	1.116	-0.120^{a}	1.146^{+}	-0.049^{a}	2.625^{c}	1.114	-0.097^{b}	0.956	0.064^{a}	1.114	1.114
Media															
Gaussian Distribution	-0.068	0.986		1.755	2.290	-0.046	1.099	-0.016^{a}	0.393	2.294	-0.083	0.968	0.032^{a}	1.654	2.291
Student -t Distribution	-0.071	1.016		0.597	2.161	-0.085^{a}	1.165	-0.025^{b}	1.999	2.153	-0.081	0.993	0.038^{b}	0.246	2.161
Generalised Error Distribution	-0.072	1.001		0.984	2.150	-0.066^{b}	1.120	-0.019^{b}	0.042	2.147	-0.079	0.982	0.037^{a}	0.931	2.151*
Travel and Leisure															

Table 5.3: Estimated GARCH models

Index	GARCH-M					EGARCH-M					TARCH-M				
	δ	α+β	γ	F-LM	SIC	δ	α+β	γ	F-LM	SIC	δ	α+β	γ	F-LM	SIC
Gaussian Distribution	-0.113^{c}	0.998		0.086	1.622	-0.154^{a}	1.049	-0.026^{a}	0.057	1.747	-0.161^{b}	0.977	0.035^{a}	13.853	1.75
Student -t Distribution	-0.050	1.000		0.572	1.632	-0.064	1.067	-0.022^{a}	0.326	1.639	-0.064	0.977	0.038^{a}	10.861	1.643
Generalised Error Distribution	0.001	0.998		0.483	1.622	-0.016	1.057	-0.023^{a}	0.172	1.628	-0.004	0.978	0.025^{a}	0.498	1.630*
Food & Drug Retailers															
Gaussian Distribution	-0.084	0.985		1.677	2.010	-0.126	1.122^{+}	-0.019^{a}	4.891^{a}	2.014	-0.088	0.973	0.018^{b}	1.454	2.011
Student -t Distribution	-0.056	0.987		1.555	1.896	-0.162	1.153^{+}	-0.006^{a}	4.009^{a}	1.914	-0.057	0.959	-0.001	2.996	1.924
Generalised Error Distribution	-0.002	0.986		0.592	1.898	-0.013	1.137^{+}	-0.016^{a}	3.579^{b}	1.897	0.003	0.978	0.015	0.429	1.900*
General Retailers															
Gaussian Distribution	-0.112	0.971		2.275	1.440	-0.174^{a}	1.117^{+}	-0.041^{a}	3.841^{b}	1.440	-0.134^{a}	0.971	0.035^{a}	2.579^{c}	1.436
Student -t Distribution	-0.052	0.991		1.735	1.388	-0.126^{b}	1.142^{+}	-0.037^{a}	2.900^{c}	1.388	-0.103^{c}	0.969	0.042^{a}	1.629	1.386
Generalised Error Distribution	-0.068	0.977		2.054	1.382	-0.118^{b}	1.137^{+}	-0.038^{a}	2.881^{c}	1.382	-0.098^{c}	0.966	0.042^{a}	1.653	1.380*
Financials															
Financials															
Gaussian Distribution	0.012	0.994		2.242	1.428	-0.041	1.167^{+}	-0.069^{a}	3.701^{b}	1.413	-0.034	0.959^{+}	0.077^{a}	3.329^{b}	1.417
Student -t Distribution	0.000	0.996		1.671	1.376	-0.036	1.177^{+}	-0.066^{a}	3.506^{b}	1.366	-0.035	0.944	0.101^{a}	1.987	1.370*
Generalised Error Distribution	0.002	0.993		1.639	1.380	-0.031	1.172^{+}	-0.067^{a}	3.254^{b}	1.370	-0.032	0.945	0.097^{a}	2.141	1.374
Banks															
Gaussian Distribution	0.065	0.980		1.953	2.085	0.041	1.141^{+}	-0.060^{a}	2.453^{c}	2.078	0.046	0.956	0.074^{a}	2.157	2.074
Student -t Distribution	0.036	0.990		1.967	2.035	0.019	1.170	-0.065^{a}	1.049	2.027	0.025	0.938	0.107^{a}	2.231	2.03
Generalised Error Distribution	0.031	0.986		1.841	2.034	0.013	1.161	-0.063^{a}	1.205	2.027	0.015	0.938	0.102^{a}	2.273	2.030*
Non-life Insurance															
Gaussian Distribution	-0.021	0.991		0.031	1.642	-0.103^{b}	1.201	-0.034^{a}	1.521	1.646	-0.079	0.960	0.061^{a}	0.131	1.623
Student -t Distribution	-0.035	0.995		1.873	1.465	-0.056^{c}	1.187	-0.048^{a}	7.214	1.463	-0.068^{c}	0.974	0.081^{a}	0.697	1.464
Generalised Error Distribution	0.001	0.967		1.972	1.432	-0.067^{b}	1.138	-0.033^{a}	12.284	1.418	-0.001	0.890	0.131^{a}	2.202	1.436*
Life Insurance															
Gaussian Distribution	0.001	0.996^{+}		2.646^{c}	1.889	-0.027	1.138	-0.037^{a}	4.804	1.886	-0.034	0.973^{+}	0.042^{a}	2.345^{c}	1.886
Student -t Distribution	-0.021	0.997^{+}		3.508^{b}	1.823	-0.041	1.147^{+}	-0.031^{a}	5.782^{a}	1.821	-0.042	0.972	0.046^{a}	2.087	1.823
Generalised Error Distribution	-0.022	0.996		2.072	1.822	-0.045	1.145^{+}	-0.034^{a}	4.814^{a}	1.820	-0.041	0.969	0.050^{a}	2.141	1.822*
Real Estate															
Gaussian Distribution	-0.013	1.000		1.322	0.965	-0.016	1.100	0.992^{a}	1.981	0.972	-0.032	0.990	0.021	1.078	0.964
Student -t Distribution	-0.029	1.002		1.359	0.852	-0.019	1.108	-0.015^{c}	1.399	0.884	-0.016	0.995	0.016^{a}	2.504	0.882
Generalised Error Distribution	-0.025	1.000		1.392	0.870	-0.017	1.103	-0.017^{b}	1.222	0.874	-0.029	0.991	0.019^{a}	1.209	0.871*
General Financials															
Gaussian Distribution	0.084	0.943		0.346	1.893	0.004	1.205^{+}	-0.054^{a}	2.730^{c}	1.899	0.029	0.897	0.088^{a}	0.337	1.891
Student -t Distribution	0.039	0.980		0.222	1.813	-0.006	1.218^{+}	-0.036^{a}	4.502^{b}	1.811	0.016	0.941	0.071^{a}	0.151	1.814
Generalised Error Distribution	0.015	0.966		0.214	1.802	0.012	1.213^{+}	-0.041^{a}	3.432^{b}	1.800	-0.003	0.926	0.078^{a}	0.138	1.802*
Equity Investment Instruments															
Gaussian Distribution	0.001	0.989		0.142	1.638	-0.052	1.162	-0.045^{a}	0.377	1.633	-0.130^{b}	0.954	0.052^{a}	1.757	1.633
Student -t Distribution	-0.036	0.993		0.159	1.513	-0.051	1.117	-0.032^{a}	0.912	1.502	-0.101^{c}	0.950	0.062^{a}	1.467	1.511
Generalised Error Distribution	-0.001	0.989		0.029	1.500	-0.004	1.129	-0.038^{a}	0.758	1.492	-0.090^{c}	0.949	0.060^{a}	1.477	1.498*
Health Care															
Health Care															
Gaussian Distribution	-0.065	0.993		9.702	1.679	-0.086	1.085^{+}	-0.026^{a}	4.304^{a}	1.687	-0.084	0.983	0.019^{a}	1.682	1.67
Student -t Distribution	-0.043	0.965		0.178	1.599	-0.068	1.105^{+}	-0.034^{a}	2.306^{c}	1.600	-0.053	0.975	0.035^{a}	0.378	1.597
Generalised Error Distribution	-0.054	0.992		0.548	1.596	-0.057	1.096^{+}	-0.030^{a}	2.774^{c}	1.598	-0.056	0.978	0.028^{b}	0.745	1.593*
Health Care Equipment & Services															
Gaussian Distribution	-0.079	0.983		2.233	2.206	-0.131^{b}	1.108	-0.019^{a}	0.374	2.208	-0.082	0.979	0.025^{a}	0.369	2.204
Student -t Distribution	-0.099	0.991		1.694	2.125	-0.117^{b}	1.125	-0.021^{b}	0.174	2.122	-0.103^{c}	0.973	0.037^{a}	1.627	2.126
Generalised Error Distribution	-0.001	0.982		0.803	2.094	0.006	1.133	-0.023^{a}	0.061	2.091	-0.002	0.964	0.048^{c}	0.943	2.095*
Pharmaceutical & Biotechnology															
Gaussian Distribution	-0.103	0.934		0.035	2.422	-0.114^{c}	1.131	-0.064^{a}	0.134	2.420	-0.114	0.922	0.075^{a}	0.042	2.419
Student -t Distribution	-0.019	1.256		0.042	2.128	-0.011	1.369	-0.138^{a}	0.022	2.114	-0.005	0.988	0.180^{a}	2.435	2.110*
Generalised Error Distribution	-0.011	0.991		0.091	1.975	0.051	1.600	-0.252^{a}	0.919	1.142	0.001^{a}	2.804	1.331^{a}	0.286	0.19
Industrials															
Industrials															
Gaussian Distribution	-0.024	0.981		2.001	1.467	-0.104^{c}	1.130	-0.068^{a}	1.957	1.458	-0.079	0.928	0.101^{a}	1.415	1.455
Student -t Distribution	-0.049	0.981		1.621	1.412	-0.105^{c}	1.149^{+}	-0.059^{a}	3.114^{b}	1.408	-0.079	0.936	0.082^{a}	1.465	1.408
Generalised Error Distribution	-0.057	0.979		2.167	1.413	-0.094^{b}	1.143	-0.064^{a}	2.155	1.408	-0.079	0.931	0.091^{a}	1.286	1.407*
Construction & Materials															
Gaussian Distribution	-0.159^{a}	0.999		1.253	1.747	-0.172^{a}	1.041	-0.008^{a}	2.234	1.766	-0.164	0.997	0.004^{c}	1.072	1.749
Student -t Distribution	-0.157^{b}	0.991		0.183	1.660	-0.170^{a}	1.154	-0.011^{a}	0.338	1.659	-0.162	0.982	0.017^{a}	0.18	1.661
Generalised Error Distribution	-0.118^{b}	0.992		1.127	1.662	-0.136^{a}	1.115	-0.014^{a}	1.761	1.663	-0.129	0.995	0.004^{a}	0.745	1.659*
General Industrials															
Gaussian Distribution	-0.010	0.988		0.732	1.765	-0.054	1.100^{+}	-0.059^{a}	2.625^{c}	1.757	-0.046	0.930	0.093^{a}	2.251	1.755

Table 5.3: Estimated GARCH models															
Index	**GARCH-M**					**EGARCH-M**					**TARCH-M**				
	δ	α+β	γ	F-LM	SIC	δ	α+β	γ	F-LM	SIC	δ	α+β	γ	F-LM	SIC
Student -t Distribution	-0.032	0.985		1.232	1.704	-0.043	1.118[+]	-0.049[a]	3.307[b]	1.701	-0.048	0.942[+]	0.069[a]	2.652[b]	1.702
Generalised Error Distribution	-0.036	0.985		0.881	1.704	-0.048	1.114[+]	-0.054[a]	2.408[c]	1.700	-0.055	0.936	0.080[a]	2.171	1.700*
Electronic & Electrical Equipment															
Gaussian Distribution	-0.096	0.980		2.276	1.625	-0.191	1.100	-0.038[a]	0.044	1.620	-0.130[b]	0.954	0.052[a]	1.757	1.621
Student -t Distribution	-0.080	0.982		1.839	1.554	-0.146	1.104	-0.040[a]	0.446	1.548	-0.101[c]	0.950	0.062[a]	1.467	1.552
Generalised Error Distribution	-0.075	0.980		1.934	1.545	-0.135	1.100	-0.039[a]	0.262	1.540	-0.090[c]	0.949	0.060[a]	1.477	1.543*
Industrial Engineering															
Gaussian Distribution	-0.012	0.981		0.489	1.735	-0.069	1.209	-0.065[a]	0.358	1.727	-0.061	0.916	0.119[a]	0.388	1.725
Student -t Distribution	0.003	1.240		0.765	1.470	-0.008	1.384	-0.097[a]	0.465	1.461	-0.011	1.056	0.322[b]	0.816	1.468
Generalised Error Distribution	0.000	2.245		1.418	1.130	0.141	0.061	-0.086[a]	11.935	1.378*	0.001[a]	1.812	1.073[c]	6.926	1.378
Industrial Transport															
Gaussian Distribution	-0.020	0.966		1.564	1.735	-0.081	1.124	-0.054[a]	1.495	1.727	-0.062	0.925	0.081[a]	1.674	1.728
Student -t Distribution	0.027	0.982		0.165	1.628	-0.022	1.221	-0.059[a]	0.593	1.625	0.152	0.926	0.0875	1.685	1.695
Generalised Error Distribution	0.031	0.969		0.225	1.619	-0.012	1.195	-0.059[a]	0.953	1.617	0.007	0.920	0.093[a]	0.342	1.617*
Support Services															
Gaussian Distribution	-0.024	0.984		2.759	1.858	-0.046	1.107[+]	-0.048[a]	3.531[b]	1.855	-0.046	0.951	0.061[a]	2.296	1.854
Student -t Distribution	-0.010	0.992		0.285	1.809	-0.029	1.113[+]	-0.044[a]	3.749[b]	1.811	-0.058	0.965	0.045[a]	0.404	1.809
Generalised Error Distribution	-0.019	0.991		0.392	1.799	-0.031	1.110[+]	-0.046[a]	3.549[b]	1.800	-0.022	0.966	0.046[a]	0.223	1.798*
Oil and Gas															
Oil & Gas															
Gaussian Distribution	0.072	0.999[+]		12.765 [a]	2.163	0.069	1.122[+]	-0.024[a]	21.021[a]	2.167	0.054	0.984[+]	0.028[a]	10.299[a]	2.163
Student -t Distribution	0.050	1.002[+]		9.371[a]	2.107	0.046	1.132[+]	-0.024[a]	21.786[a]	2.107	0.043	0.987	0.030[b]	8.001	2.110*
Generalised Error Distribution	0.044	1.000[+]		10.052 [a]	2.109	0.046	1.128[+]	-0.023[a]	20.154[a]	2.111	0.038	0.985	0.028[a]	8.568	2.111
Oil & Gas Producers															
Gaussian Distribution	-0.022	0.978[+]		7.526[a]	2.716	-0.019	1.083	-0.020[a]	6.962	2.721	-0.043	0.986	0.022[a]	1.483	2.707
Student -t Distribution	-0.017	0.980[+]		9.104[a]	2.673	-0.009	1.091	-0.025[a]	7.086	2.673	-0.019	0.981	0.028[b]	1.205	2.672
Generalised Error Distribution	-0.007	0.976[+]		6.212[a]	2.658*	-0.004	1.087	-0.024[a]	5.436	2.660	-0.018	0.982	0.026[b]	0.812	2.657
Technology															
Technology															
Gaussian Distribution	-0.150[a]	0.995		0.145	2.353	-0.222	1.094	-0.032[a]	1.641	2.365	-0.172[a]	0.984	0.022[a]	0.127	2.352
Student -t Distribution	-0.075[c]	0.993		1.277	2.237	-0.108[a]	1.243	-0.035[b]	1.826	2.232	-0.091[b]	0.967	0.053[b]	1.552	2.237
Generalised Error Distribution	-0.023	0.986		1.563	2.234	-0.067	1.136	-0.032[a]	0.255	2.231	-0.036	0.961	0.050[b]	1.846	2.235*
Software Computer & Services															
Gaussian Distribution	-0.116[b]	0.992		0.029	2.510	-0.189[a]	1.110	-0.030[a]	1.249	2.490	-0.140[a]	0.980	0.024	0.029	2.498
Student -t Distribution	-0.078[c]	0.993		0.796	2.365	-0.109	1.262	-0.039[a]	0.777	2.359	-0.093[b]	0.961	0.066	0.933	2.366
Generalised Error Distribution	-0.018	0.981		0.923	2.362	-0.045	1.244	-0.036[b]	1.084	2.362	-0.026	0.951	0.065	1.084	2.362*
Telecommunications															
Telecommunications															
Gaussian Distribution	-0.023	0.994		1.025	2.467	-0.044	1.154[+]	-0.032[a]	3.030[b]	2.462	-0.038	0.976	0.033[a]	1.104	2.467
Student -t Distribution	-0.044	1.003		0.848	2.402	-0.054	1.189	-0.027[b]	1.876	2.397	-0.051	0.984	0.037[a]	0.701	2.403
Generalised Error Distribution	-0.039	0.997		1.445	2.393	-0.043	1.174	-0.031[b]	2.176	2.389	-0.042	0.978	0.038[b]	1.236	2.394*
Fixed Line Telecommunications															
Gaussian Distribution	0.013	0.974		0.761	2.693	-0.075	1.163	-0.034[a]	1.843	2.687	0.001	0.955	0.040[a]	1.028	2.693
Student -t Distribution	0.007	0.993		0.124	2.592	0.007	1.215	-0.014[a]	0.232	2.585	0.005	0.986	0.013	0.109	2.594
Generalised Error Distribution	0.002	0.983		0.181	2.565	0.024	1.191	-0.024[a]	0.483	2.558	0.001	0.969	0.027	0.117	2.567*
Mobile Telecommunications															
Gaussian Distribution	-0.043	0.990[+]		3.507 [b]	3.093	0.137	1.020	-0.093[a]	6.515	3.076	0.042	0.935	0.097[a]	2.853	3.086
Student -t Distribution	-0.139	0.988[+]		2.898[c]	3.074	0.054	1.032	-0.094[a]	4.974	3.066	-0.012	0.921	0.120[a]	1.474	3.071
Generalised Error Distribution	-0.128	0.973[+]		2.811[c]	3.065	0.029	1.027[+]	-0.094[a]	5.004[a]	3.055	-0.011	0.927	0.113[a]	1.875	3.054*
Benchmark															
All Share															
Gaussian Distribution	0.047	0.995[+]		3.167[b]	1.383	-0.009	1.162[+]	-0.072[a]	4.970[a]	1.381	0.001	0.949	0.084[a]	2.243	1.372
Student -t Distribution	0.036	0.994		2.012	1.337	-0.001	1.160[+]	-0.060[a]	7.900[a]	1.335	0.015	0.954	0.072[a]	2.091	1.332*
Generalised Error Distribution	0.031	0.994		2.121	1.344	-0.007	1.162[+]	-0.066[a]	3.036[b]	1.342	0.011	0.951	0.078[a]	2.076	1.337
Mid Cap															
Gaussian Distribution	-0.044	0.982		1.465	0.670	-0.136 [b]	1.204[+]	-0.073[a]	2.855[c]	0.669	-0.126[c]	0.925	0.103[a]	0.627	0.662
Student -t Distribution	-0.024	0.985[+]		3.925[b]	0.606	-0.085	1.168[+]	-0.978[a]	7.129[a]	0.607	-0.074	0.947[+]	0.063[a]	2.359[c]	0.605*
Generalised Error Distribution	-0.044	0.985[+]		2.817[c]	0.611	-0.108 [b]	1.178	-0.056[a]	5.117	0.651	-0.046	0.940	0.072[a]	1.368	0.606
Small Cap															
Gaussian Distribution	-0.159	0.978		0.537	0.120	-0.314[a]	1.235	-0.101[a]	0.631	0.101	-0.298[a]	0.882	0.173[a]	0.462	0.104
Student -t Distribution	-0.119	0.978		1.334	0.008	-0.233[a]	1.185	-0.053[a]	2.851	0.003	-0.195[a]	0.936	0.065[a]	0.937	0.007*
Generalised Error Distribution	-0.092	0.972		0.611	0.024	-0.233[a]	1.196	-0.068[a]	1.521	0.018	-0.187[a]	0.915	0.094[a]	0.332	0.022
Secondary Markets															

Table 5.3: Estimated GARCH models

Index	GARCH-M					EGARCH-M					TARCH-M				
	δ	α+β	γ	F-LM	SIC	δ	α+β	γ	F-LM	SIC	δ	α+β	γ	F-LM	SIC
ALT X															
Gaussian Distribution	-0.141	0.969		0.939	1.597	-0.181	1.222	-0.046[a]	1.244	1.593	-0.254[c]	0.919	0.088[a]	0.925	1.608
Student -t Distribution	0.087	0.952		0.865	1.531	-0.005	1.200	-0.035[a]	1.129	1.530	0.949[a]	0.918	0.097[a]	0.316	1.601
Generalised Error Distribution	0.039	0.955		0.862	1.526	0.019	1.217	-0.034[a]	1.134	1.529	0.018	0.924	0.044[a]	0.913	1.540*

Source: Author's own estimates

Notes:

[a,b,c] implies coefficient is significant at 1%, 5% and 10% respectively.

* next to the SIC coefficient represents the selected model

δ is the GARCH-M coefficient

α+β is the Condition for stationarity of the GARCH model

γ is the Coefficient of assymetry. Note this only applies to EGARCH-M and TARCH-M models

F-LM represents the test for ARCH effects

SIC represents the Schwarz information criterion

Table 5.4: TARCH-M Model under GED distribution				
Index	**δ**	**α+β**	**γ**	**F-LM**
Basic Materials				
Basic Materials	0.015	0.938	0.102 [a]	2.273
Chemicals	0.016	0.983	0.023 [a]	1.120
Forestry & Paper	0.001	0.958	0.079 [a]	1.880
Industrial Metals	0.001	1.009	0.018	0.118
General Mining	0.002	0.975	0.938 [a]	0.929
Mining	0.052	0.982	0.033 [a]	5.495[a]
Platinum & Precious Metals	0.108[b]	0.986	0.027	2.999[c]
Consumer Goods				
Consumer Goods	-0.011	0.949	0.092[a]	2.149
Automobile & Parts	0.002	0.476	0.273[a]	0.003
Beverages	-0.009	0.965	0.052[a]	1.863
Food Producers	-0.043	0.942	0.062[a]	5.142
Personal Goods	0.008	0.857	0.260[a]	0.054
Household Goods	0.031	0.884	0.160[b]	0.691
Consumer Services				
Consumer Services	-0.097[b]	0.956	0.064[a]	1.114
Media	-0.079	0.982	0.037[a]	0.931
Travel and Leisure	-0.004	0.004	0.025[a]	0.498
Food & Drug Retailers	0.003	0.978	0.015	0.429
General Retailers	-0.098[c]	0.966	0.042[a]	1.653
Financials				
Financials	-0.032	0.945	0.097[a]	2.141
Banks	0.015	0.938	0.102[a]	2.273
Non-life Insurance	-0.001	0.890	0.131[a]	2.202
Life Insurance	-0.042	0.969	0.050[a]	2.141
Real Estate	-0.029	0.991	0.019[b]	1.209
General Financials	-0.003	0.926	0.078[a]	0.138
Equity Investment Instrument	-0.090[c]	0.949	0.060[a]	1.477
Health Care				
Health Care	-0.056	0.978	0.028[b]	0.740
Health Care Equipment & Services	-0.002	0.964	0.048[c]	0.943
Pharmaceuticals & Biotechnology	0.000[a]	2.804	1.331	0.286
Industrials				
Industrials	-0.079	0.931	0.091[a]	1.286
Construction & Materials	-0.129[a]	0.995	0.004	0.745
General Industrials	-0.055	0.936	0.080[a]	2.171
Electronic & Electrical Equipment	-0.090[c]	0.949	0.060[a]	1.477
Industrials Engineering	0.001[a]	1.812	1.073[c]	6.926
Industrials Transport	0.007[a]	0.920	0.093[a]	0.340
Support Services	-0.022	0.966	0.046[a]	0.223
Oil and Gas				
Oil & Gas	0.038	0.985	0.028[a]	8.568
Oil & Gas Producers	-0.018	0.982	0.026[b]	0.812
Technology				
Technology	-0.036	0.961	0.050[b]	1.846
Software Computer & Services	-0.026	0.951	0.060[b]	1.084
Telecommunications				
Telecommunications	-0.042	0.978	0.038[b]	1.236
Fixed Line Telecommunications	0.001	0.969	0.027	0.117
Mobile Telecommunications	-0.011	0.927	0.113[a]	1.875
Benchmark				
All Share	0.011	0.951	0.078[a]	2.076
Mid Cap	-0.046	0.940	0.072[a]	1.368
Small Cap	-0.187[a]	0.915	0.094[a]	0.330
Secondary Markets				
ALT X	0.018	0.924	0.044	0.913

Source: Author's own estimates

Notes:

Table 5.5: Diagnostic Checks

	Raw series							TARCH-M- G.E.D						
Index	**Mean**	**Std.Dev**	**Skewness**	**Kurtosis**	**Jarque-Bera**	**LB(12)**	**LB^2(12)**	**Mean**	**Std.Dev**	**Skewness**	**Kurtosis**	**Jarque-Bera**	**LB(12)**	**LB^2(12)**
Basic Materials														
Basic Materials	0.017	0.768	-0.020	8.263	4242.369[a]	67.886[a]	2864.921[a]	-0.002	1.000	-0.070	4.964	593.535	17.741	26.928[b]
Chemicals	0.016	0.529	-0.040	7.706	3392.829[a]	93.168[a]	338.211[a]	0.018	1.000	0.009	6.247	1614.682	18.938	10.002
Forestry & Paper	-0.004	1.140	0.146	9.426	6338.809[a]	50.861[a]	426.552[a]	-0.008	0.983	-0.067	7.193	2694.899	57.271[a]	17.585
Industrial Metals	0.025	1.087	0.104	12.173	12894.430[a]	49.731[a]	350.451[a]	0.033	1.030	0.918	17.540	32888.970	54.029	5.8267
General Mining	0.015	1.120	0.398	7.320	2955.623[a]	49.749[a]	984.773[a]	0.013	0.995	0.343	6.227	1666.232	16.628	9.3587
Mining	0.024	0.823	-0.017	7.537	3153.184[a]	63.187[a]	2563.115[a]	-0.001	1.001	0.015	4.883	543.347	17.742	29.715[a]
Platinum & Precious Metals	0.032	0.998	-0.332	6.830	2314.704[a]	106.642[a]	1308.915[a]	-0.031	0.990	-0.267	6.801	2527.026	34.224[a]	1248.3[a]
Consumer Goods														
Consumer Goods	0.026	0.781	0.336	8.175	4170.637[a]	23.827[b]	521.021[a]	0.028	0.997	0.223	4.957	617.241	12.326	21.638[b]
Automobile & Parts	-0.020	1.372	-0.192	429.033	27800444.000[a]	483.882[a]	905.263[a]	-0.071	1.938	-20.808	717.794	78501432.000	16.011	0.045
Beverages	0.016	0.778	0.040	7.269	2792.709[a]	30.482[a]	788.766[a]	0.007	0.999	0.030	6.142	1512.595	9.7666	18.635
Food Producers	0.018	0.548	-0.579	14.581	20747.720[a]	40.174[a]	695.422[a]	0.013	1.004	0.005	5.777	1181.100	11.049	21.922[b]
Personal Goods	0.031	0.981	3.477	59.314	125295.900[a]	27.085[a]	156.277[a]	0.030	1.000	1.106	15.036	5821.887	12.914	2.798
Household Goods	-0.002	1.155	0.020	4.724	115.720[a]	54.525[a]	398.845[a]	-0.004	0.997	0.008	3.621	15.733	17.467	13.374
Consumer Services														
Consumer Services	0.014	0.513	-0.752	9.792	7412.333[a]	124.98[a]	991.223[a]	0.005	1.008	-0.521	6.508	2050.587	28.622[a]	9.661
Media	0.022	0.888	-0.525	9.657	6956.925[a]	75.833[a]	1037.214[a]	0.037	1.008	-0.147	9.592	7433.151	16.759	8.7367
Travel and Leisure	0.007	0.640	-0.253	8.529	4721.492[a]	88.877[a]	430.541[a]	0.016	1.001	0.213	7.478	3097.738	15.801	27.229[a]
Food & Drug Retailers	0.032	0.718	-0.146	12.631	14221.600[a]	21.113[b]	672.025[a]	0.053	0.979	-0.328	6.414	1851.226	16.954[a]	16.675
General Retailers	0.014	0.562	-0.392	6.706	2197.788[a]	202.86[a]	1082.716[a]	0.008	1.003	-0.266	5.176	768.543	53.797[a]	9.7553
Financials														
Financials	0.015	0.596	-0.428	10.000	7616.786[a]	85.993[a]	1266.423[a]	0.006	1.005	-0.180	5.431	924.642	13.341	11.059
Banks	0.021	0.785	-0.052	7.009	2463.041[a]	90.755[a]	1119.856[a]	0.008	1.002	0.023	5.313	819.586	14.617	11.802
Non-life Insurance	0.019	0.626	-0.059	10.814	9353.620[a]	25.121[a]	334.981[a]	0.046	0.997	0.131	7.564	3199.906	46.372[a]	10.864
Life Insurance	0.007	0.713	-0.261	8.387	4486.891[a]	42.326[a]	1091.425[a]	-0.002	1.002	-0.171	5.379	884.238	11.387	17.508
Real Estate	0.012	0.444	0.019	8.072	3939.813[a]	40.964[a]	768.491[a]	0.021	1.000	0.002	5.560	1003.307	26.732[a]	6.723
General Financials	0.018	0.730	-0.729	12.942	15464.370[a]	100.671[a]	1397.325[a]	0.021	0.998	-0.103	5.492	957.329	30.671[a]	8.419
Equity Investment Instrument	0.014	0.682	3.004	88.458	1124110.000[a]	74.275[a]	74.142[a]	0.030	0.998	0.161	7.699	3396.631	15.824	69.773[a]
Health Care														
Health Care	0.017	0.621	-0.289	9.691	6908.040[a]	42.751[a]	607.636[a]	0.012	1.003	-0.021	5.832	1228.332	7.1476	18.293
Health Care Equipment & Services	0.031	0.791	0.236	7.271	2828.572[a]	41.621[a]	449.131[a]	0.056	0.975	0.361	5.610	1122.847	17.249	10.044
Pharmaceuticals & Biotechnology	0.034	0.856	1.154	15.706	25543.140[a]	34.267[a]	49.6813[a]	0.003	0.069	-0.733	59.129	482738.800	22.245[b]	41.837[a]
Industrials														
Industrials	0.019	0.566	-0.578	10.453	8712.553[a]	35.181[a]	692.371[a]	0.005	1.004	-0.226	5.355	880.420	11.474	16.658
Construction & Materials	0.013	0.650	-0.153	8.704	4997.495[a]	109.471[a]	587.283[a]	0.033	1.008	0.139	6.893	2332.281	17.659	4.6533
General Industrials	0.023	0.637	-0.374	9.559	6674.509[a]	18.223[c]	608.825[a]	0.010	1.002	-0.177	5.442	931.923	10.569	22.145[b]
Electronic & Electrical Equipment	0.012	0.620	-0.422	8.442	4644.961[a]	82.881[a]	1464.514[a]	0.024	1.000	-0.117	5.240	776.671	21.775[b]	17.581
Industrials Engineering	0.010	0.674	-1.820	78.482	874697.500[a]	46.713[a]	587.3589[a]	0.003	0.100	-2.125	43.059	248483.900	17.595	24.59[b]
Industrials Transport	0.003	0.639	-0.626	9.554	6820.250[a]	48.315[a]	970.2861[a]	-0.001	1.002	-0.222	6.549	1959.082	17.132	10.341
Support Services	0.010	0.675	-0.285	7.192	2741.752[a]	22.919[b]	918.923[a]	0.005	0.997	-0.209	5.256	805.883	15.134	11.244
Oil and Gas														
Oil & Gas	0.023	0.832	0.033	7.530	3144.142[a]	50.888[a]	2311.191[a]	0.013	1.035	-0.015	6.805	2217.582	17.891	34.751[a]
Oil & Gas Producers	0.026	1.038	-0.038	6.802	2214.917[a]	55.235[a]	1078.338[a]	0.013	1.035	-0.015	6.796	2217.582	35.195[a]	1133.113[a]
Technology														
Technology	0.010	0.927	-0.685	12.356	13695.310[a]	74.333[a]	827.625[a]	0.026	1.014	0.524	13.947	18517.280	39.005[a]	7.997
Software Computer & Services	0.012	0.976	-0.555	11.724	11845.730[a]	68.679[a]	751.747[a]	0.030	1.014	0.452	14.571	20759.330	38.471[a]	6.582
Telecommunications														
Telecommunications	0.030	0.950	0.057	9.154	5803.355[a]	35.145[a]	754.347[a]	0.015	0.998	0.045	5.339	841.192	11.153	17.029
Fixed Line Telecommunications	0.020	1.028	-0.008	9.034	5577.457[a]	44.728[a]	563.616[a]	0.024	0.985	-0.006	6.225	1594.676	13.767	15.311
Mobile Telecommunications	0.032	1.194	0.328	5.666	293.459[a]	37.458[a]	198.941[a]	0.020	0.998	0.251	3.885	40.206	17.216	11.032
Benchmark														
All Share	0.019	0.568	-0.502	9.512	6649.647[a]	49.692[a]	1371.736[a]	-0.014	1.002	-0.296	5.003	667.798	18.136	13.429
Mid Cap	0.021	0.408	-1.153	13.013	16172.900[a]	223.421[a]	920.071[a]	0.012	1.008	-0.325	5.441	977.258	22.963[b]	6.728
Small Cap	0.018	0.313	-1.824	17.201	32928.850[a]	630.672[a]	942.031[a]	0.031	1.021	-0.818	7.693	3781.873	126.95[a]	6.9424
Secondary Markets														
ALT X	-0.015	0.573	-0.918	6.825	652.646[a]	37.279[a]	160.368[a]	-0.020	1.003	-0.582	5.990	372.751	37.592[a]	8.238

Source: Author's own estimates

Notes:

The critical value for the ADF test at 1% critical value is -2.565592 and the KPSS 1% critical value is 0.739000.

Thus [a] denotes rejection of a unit root/nonstationarity for both tests.

The lag order was determined by the SIC and the spectral estimation method is the Bartlett Kennel for ADF and KPSS respectively.

LB(12) and LB^2(12) are Ljung-Box statistics for 12 lags calculated for returns and squared returns respectively

Table 5.6: Trends in Volatility		
Index	**β_1**	**β_2**
Basic Materials		
Basic Materials	0.117[a]	0.000269[a]
Chemicals	0.334[a]	-0.000029[a]
Forestry & Paper	1.356[a]	0.000056[b]
Industrial Metals	0.803[a]	0.000215[a]
General Mining	1.072 [a]	0.000158[a]
Mining	0.130[a]	0.000309[a]
Platinum & Precious Metals	0.203 [a]	0.000453[a]
Consumer Goods		
Consumer Goods	0.658[a]	-0.000008
Automobile & Parts	-0.471	0.000868[a]
Beverages	0.634[a]	-0.000006[a]
Food Producers	0.387[a]	-0.000049[a]
Personal Goods	0.531[a]	0.000820[a]
Household Goods	0.656[a]	0.001599[a]
Consumer Services		
Consumer Services	0.236[a]	0.000017[a]
Media	0.755[a]	0.000016
Travel and Leisure	0.517[a]	-0.000064[a]
Food & Drug Retailers	0.707[a]	-0.000077[a]
General Retailers	0.233[a]	0.000043[a]
Financials		
Financials	0.303[a]	0.000038[a]
Banks	0.468[a]	0.000091[a]
Non-life Insurance	0.319[a]	0.000063[a]
Life Insurance	0.256[a]	0.000141[a]
Real Estate	0.173[a]	0.000017 [a]
General Financials	0.390[a]	0.000072[a]
Equity Investment Instrument	0.541[a]	-0.000050[a]
Health Care		
Health Care	0.412[a]	-0.000007
Health Care Equipment & Services	0.828[a]	-0.000078[a]
Pharmaceuticals & Biotechnology	0.709[a]	0.000023[a]
Industrials		
Industrials	0.349[a]	-0.000012[b]
Construction & Materials	0.329[a]	0.000043[a]
General Industrials	0.440[a]	-0.000012
Electronic & Electrical Equipment	0.343[a]	0.000022[a]
Industrials Engineering	0.505[a]	0.000001
Industrials Transport	0.351[a]	0.000042 [a]
Support Services	0.393[a]	0.000038[a]
Oil and Gas		
Oil & Gas	0.058[b]	0.000361[a]
Oil & Gas Producers	0.868[a]	0.000129[a]
Technology		
Technology	1.098[a]	-0.000103[a]
Software Computer & Services	1.254[a]	-0.000126[a]
Telecommunications		
Telecommunications	0.807[a]	0.000084[a]
Fixed Line Telecommunications	1.209[a]	-0.000073[a]
Mobile Telecommunications	0.777[a]	0.001419[a]
Benchmark		
All Share	0.185[a]	0.000082[a]
Mid Cap	0.177[a]	-0.000007[c]
Small Cap	0.118[a]	-0.000012
Secondary Markets		
ALT X	0.251[a]	0.000206[a]

Source: Author's own estimates

Notes:

[a,b,c] implies coefficient is significant at 1%, 5% and 10% respectively.

Table 5.7: Dummy variables estimation				
Index	**Trend**	**Dum1**	**Dum2**	**Dum3**
Basic Materials				
Basic Materials	0.00013[a]	0.453[a]	0.297[a]	2.002[a]
Chemicals	-0.00002[a]	0.383[a]	0.013	0.234[a]
Forestry & Paper	-0.00008[a]	2.056[a]	0.561[a]	3.328[a]
Industrial Metals	0.00008[a]	0.746[a]	1.901[a]	2.858[a]
General Mining	-0.00003[a]	1.108[a]	0.015	2.938[a]
Mining	0.00018[a]	0.544[a]	0.507[a]	1.971[a]
Platinum & Precious Metals	0.00033[a]	0.864[a]	0.082	2.360[a]
Consumer Goods				
Consumer Goods	0.00003[a]	0.658[a]	0.701[a]	0.217[a]
Automobile & Parts	0.00089[a]	0.502	-0.396	0.198
Beverages	0.00002[a]	1.030[a]	0.308[a]	0.609[a]
Food Producers	0.00003	0.788[a]	0.003	0.178[a]
Personal Goods	0.00049[a]	n/a	n/a	0.292[a]
Household Goods	0.00086[a]	n/a	n/a	0.648[a]
Consumer Services				
Consumer Services	0.00003[a]	0.513[a]	0.074[a]	0.263[a]
Media	0.00005[a]	1.204[a]	0.343[a]	0.707[a]
Travel and Leisure	-0.00003[a]	0.747[a]	0.365[a]	0.244[a]
Food & Drug Retailers	-0.00003[a]	0.760[a]	0.001	0.187[a]
General Retailers	0.00004[a]	0.301[a]	0.113[a]	0.329[a]
Financials				
Financials	0.00006[a]	0.916[a]	0.114[a]	0.511[a]
Banks	0.00011[a]	1.229[a]	0.220[a]	0.859[a]
Nonlife Insurance	0.00006[a]	0.580[a]	0.109[b]	0.498[a]
Life Insurance	0.00009[a]	0.624[a]	0.279[a]	0.977[a]
Real Estate	0.00003[a]	0.347[a]	0.129[a]	0.216[a]
General Financials	0.00008[a]	0.955[a]	0.132[c]	0.762[a]
Equity Investment Instrument	-0.00003[b]	1.272[a]	0.112[b]	0.944[a]
Health Care				
Health Care	0.00004[a]	0.832[a]	0.114[a]	0.207[a]
Health Care Equipment & Services	-0.00001	1.173[a]	-0.097[b]	0.219[a]
Pharmaceuticals & Biotechnology	0.01130[a]	122.758[a]	84.039[a]	124.686[a]
Industrials				
Industrials	0.00001[b]	0.625[a]	0.107[a]	0.287[a]
Construction & Materials	0.00002[a]	0.504[a]	-0.070[a]	0.751[a]
General Industrials	0.00002[b]	0.699[a]	0.162[a]	0.301[a]
Electronic & Electrical Equipment	0.00002	0.648[a]	-0.001	0.843[a]
Industrials Engineering	0.00079	70.330[a]	-5.104	188.713[a]
Industrials Transport	0.00003[a]	0.619[a]	0.125[a]	0.700[a]
Support Services	0.00005[a]	0.616[a]	0.188[a]	0.476[a]
Oil and Gas				
Oil & Gas	0.00022[a]	0.607[a]	0.453[a]	2.077[a]
Oil & Gas Producers	0.00013[a]	1.942[a]	0.499[a]	1.733[a]
Technology				
Technology	-0.00011[a]	0.841[a]	0.986[a]	0.892[a]
Software Computer & Services	-0.00013[a]	0.857[a]	1.067[a]	0.826[a]
Telecommunications				
Telecommunications	0.00008[a]	1.111[a]	0.132	1.009[a]
Fixed Line Telecommunications	-0.00005[a]	1.184[a]	0.283	0.681[a]
Mobile Telecommunications	0.00055[a]	n/a	n/a	0.760[a]
Benchmark				
All Share	0.00007[a]	0.598[a]	0.206[a]	0.694[a]
Mid Cap	0.00000[a]	0.360[a]	0.04	0.215[a]
Small Cap	0.00003	0.244[a]	0.042[a]	0.057[a]
Secondary Markets				
ALT X	-0.00039[a]	n/a	n/a	0.463[a]

Source: Author's own estimates

Notes:

[a,b,c] implies coefficient is significant at 1%, 5% and 10% respectively.

Dum1: Asian crisis (1997/10/27 to 1998/12/21)

Dum2: 9/11 attacks (2001/09/11 to 2002/03/13)

Dum3: Current financial crisis (2008/10/03 to present)

Table 5.8: South Africa's exports and export growth															
Year	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports	2750.5	3112	2997.4	3628.2	2585.3	3089.4	2959.4	2525.7	2819.271	2819.271	3178.506	4461.697	5521.397	6490.47	3001.19
Export growth	0.032	0.054	-0.016	0.083	-0.147	0.077	-0.019	-0.069	0.048	0.052	0.09	0.058	0.093	0.07	-0.335

Source: U.S. Census Bureau (2009).

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