THE IMPACT OF VOLATILITY ON THE PRICING EFFICIENCY OF THE SOUTH AFRICAN FUTURES EXCHANGE MARKET.

Thesis presented to the

DEPARTMENT OF ACCOUNTING

UNIVERSITY OF CAPE TOWN

In fulfillment of the requirements for the degree of

MASTER OF COMMERCE

By

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MAY 2001

Abstract.

Instability in financial markets has occupied much time in the financial and popular press over the past three years. Questions have been raised as to the structure and financial robustness of emerging market exchanges in the face of higher volatility and extreme capital flows. This study aims to see how the South African spot and futures markets have fared under these conditions. In order to establish whether the above-mentioned South African markets have absorbed the instability successfully a benchmark was needed. In this regard this study has chosen the pricing mechanism as a benchmark to establish the South African markets' resilience. The aim of the study is to determine how the pricing efficiency of the futures market (in relation to the spot market) has behaved during the emerging market crises and how it has reacted to changing volatility. In the event the pricing efficiency breaks down this would lead one to conclude that the markets were adversely affected by the crisis and in the event the pricing efficiency remained efficient and stable one would be able to conclude that the markets successfully negotiated the emerging market shocks.

The development of the futures market, underlying spot, volumes and price movements are analysed in the study over a 10-year period. This allows one to contrast structural differences in the market over the period and draw some conclusions as to how the market handled them. This also includes an examination of the regulatory framework.

The pricing efficiency is examined primarily by looking at the arbitrage gap between the fair value of the futures, as determined using the cash and carry pricing mechanism, and the actual traded values of the futures contracts. This has resulted in the need for certain assumptions to be drawn as to the actual fair cost of carrying a position (this would include interest rates and transaction costs). In response to this an application was developed, called the futures fair value calculator, which allows one to change the parameters and view the impact on the arbitrage gap. The variables chosen for the purpose of this study are believed to be market norms.

After building the fair value calculator and assessing the arbitrage gap the findings were that there are arbitrage opportunities, which in turn implies the market does display inefficiencies (the pricing mechanism breaks down). The incidence of these inefficiencies is shown to decrease as the futures market matures over the past 10 years. The inefficiencies are magnified with the emerging market shocks taking place, but are not necessarily found to be due to volatility. It is suggested that the inefficiencies come from other market influences with the primary possibility being isolated as the securities lending market.

The market volatility is determined by looking at two models, a traditional model and a GARCH (Generalised Auto-Regressive Conditional Heteroscedasticity) model. Each show there to be an increase in the general volatility levels between the period prior to the emerging markets crises occurring and post the emerging markets crises occurring. The GARCH model shows an approximate doubling of volatility levels over the two periods.

Both the volatility models are compared to the arbitrage gap and the study finds little or no relationship between volatility and the size of the arbitrage gap. This suggests that volatility either has little or no effect on the breaking down of the pricing efficiency. The GARCH-modeled volatility does exhibit a closer relationship between the volatility of the market and the size of the arbitrage gap, but the relationship is not close enough to be significant. This suggests that there is a weak relationship between volatility and market pricing efficiency. This relationship does not seem to be causal but rather that the increased volatility could highlight other market weaknesses that lead to the inefficiency.

The study concludes by highlighting a number of opportunities for further studies as well as a possible for financial innovation and product development in the area of ETF's (Exchange traded funds), basket trading and securities lending.

Acknowledgements.

Thanks must go to my supervisors: Professor Geoff Everingham and Professor Graham Barr. Their assistance, technical advice and support have been invaluable in the completion of this study.

From time to time various people aided me and I thank them accordingly, without their help I would have found it difficult to complete the study. They are:

Professor Mahamood Hassan for his help and advice when I was forming the research problem.

Mike Arnot for helping with my data processing and modelling, the study entailed a significant amount of statistical analysis and he helped me cope with the volume of analysis.

Nevan Reddy for his help with the volatility modelling. His quantitative skills helped me develop my approach to the problem of examining the effect of volatility on the arbitrage gap.

Sean Murray for his help in producing the Futures calculator. His programming skills allowed me to complete the futures calculator.

My family and friends for the moral support necessary to complete this study.

I certify that, except as noted above, this work is entirely my own and has not been submitted as a dissertation for a degree at any other university.

Julian Williams

15 May 2001

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Chapter 1: Introduction.

With the creation of the South African Futures Exchange (SAFEX) in 1988 (Lambrechts, 1990 : 1) futures trading has become an increasing feature of the South African Financial Markets. Turnover within SAFEX has grown since its inception. Coupled to this are the new influences that the South African Financial Markets have experienced. Since the democratisation of South Africa, there has been an increasing involvement of foreign participants in our financial markets. This foreign involvement has brought an increased demand for derivative products. This can best be seen when South African companies issued convertible debentures in Europe (Counihan & Malherbe, 1999 : 13), this led to foreign financial institutions wanting to borrow the shares of these South African companies to be able to lock in arbitrage profits, where the convertible bonds differed from their theoretical values. In this case the demand was not for derivative products, but it does illustrate the injection of more sophisticated trading strategies into the South African Markets.

The arbitrage opportunities created by the issue of the convertible bonds could also exist with the issuance of SAFEX futures. Like the bonds, the futures have a theoretical value (which will be discussed below – see chapter three) and when the actual value differs from this theoretical value, arbitrage opportunities are created.

This increased involvement of foreign institutions in South African financial markets leads to some interesting questions. Exactly how efficiently priced are SAFEX futures? How effective are SAFEX listed futures in facilitating effective arbitrage operations? What arbitrage opportunities exist between SAFEX futures and their underlying spots? To this end research has been performed on the efficiency of SAFEX futures, discussed in detail in chapter 6 but only between the years of 1989 and 1991. Since then South African Financial Markets have undergone significant changes relating not only to the increasing involvement of foreign participants, but also to the spot market. The Johannesburg Stock Exchange (JSE) has increased its liquidity by enacting numerous changes, which are collectively known as the JSE's "Big Bang" (JSE, 1999 : history.htm). The first change was to allow of brokers to transact in a dual capacity. Prior to this the brokers were only able to transact in an agency capacity. The relaxing of the regulations to let them hold stock has increased the liquidity in the JSE - the brokers could now supply the orders of their clients from their own pools of stocks. Secondly banks and foreigners were allowed to obtain membership or ownership of JSE brokers. The above changes occurred on 8 November 1995 (JSE, 1999 : history.htm).

Thirdly liquidity within the JSE increased further with the introduction of the JET (Johannesburg Equity Trading) System. This electronic trading system was implemented over a three-month period from 8 March 1996 to 7 June 1996, by which stage all of the JSE's listed securities were converted from the floor trading system (JSE, 1999: history.htm).

Collectively, all these changes led to a change in the number of deals on the JSE from 762 091 in 1995 to 3 655 200 in 1998 – a percentage change of 380%. These deals had a value of R 63 247 million in 1995 and R 319 334 million in 1998 – a percentage change of 405% (JSE 1998 : Market Profile 1). The above figures exclude arbitrage transactions. Since 1995 the increase in the number of arbitrage transactions has increased by 63% while the value of these deals has increased by 311% (JSE 1998 : Market Profile 1). See table 1.1 for more detail.

Table 1.1 - Turnover on the JSE Equities Market – 1995 to 1998.

Description	1998	1997	1996	1995
Excluding Arbitrage				
Value (R million)	319334	206542	117099	63247
Percentage change	55%	76%	85%	NA
Number of Deals	3655200	2343957	1440240	762091
Percentage change	56%	63%	89%	NA
Volume (Million)	34412	17850	8993	5148
Percentage change	93%	98%	75%	NA
Arbitrage				
Value (R million)	89118	67612	41474	21700
Percentage change	32%	63%	91%	NA
Number of Deals	96622	115387	100089	59128
Percentage change	-16%	15%	69%	NA
Volume (Million)	4256	3164	1798	1029
Percentage change	35%	76%	75%	NA
		(JSE 1998 : Market Profile 1)		

The above changes in the spot market, combined with the influx of the foreign financial institutions, leads one to conclude that the efficiency studies conducted in the early 1990's need to be updated.

Another factor that has affected the use of futures in South Africa has been the proliferation of local Investment Banks and financial services companies. In October 1999 there were a number of these institutions that did not exist in 1995 (See Appendix 1.1 for Investment Banks and Financial Services companies that did not exist on 1 January 1995). Investment Banks such as PSG Investment Bank and institutions such as Cadiz have contributed to the increased usage of derivative instruments. In its prospectus, Cadiz states, as part its business "the provision of …. Strategies to … clients in the bond, bond derivative and equity derivative markets" (Cadiz, 1999 : 17). This illustrates how local institutions are becoming more involved in sophisticated derivative transactions. In order for these derivatives to be used, some understanding needs to exist of how efficiently priced they are, if they are to be used for hedging purposes.

In addition to the above changes, the South African Markets have experienced turbulence in the past two years (beginning in October 1997) with the emergence of a series of market "crises". Together with an update on the efficiency of the South African Futures Market, this study will focus on the past two years and determine what impact this turbulence has had on SAFEX pricing efficiency.

1.1 Background.

Research has been undertaken on the pricing efficiency of South African Futures (Levett, 1991; Mitchell, 1989; Snell, 1990; Lambrechts, 1990). Lambrechts concluded that it was not possible to determine if the South African Futures Market is inefficient or not, in this case six tests were applied to determine the efficiency of the pricing of selected futures. Four for the six tests concluded the futures were efficiently priced and the other two concluded to the contrary. Mitchell (1989) found that selected futures he tested were efficient whereas others were not. Specifically, Mitchell tested whether E 168 (Eskom 168) futures were more efficient than BA (Bankers Acceptance) futures. Mitchell found that both markets exhibited inefficiencies. Mitchell also tested whether volumes affect pricing efficiency. He found that there is no link between volumes and pricing efficiency. Levett's (1991) findings were that the SAFEX futures were efficiently priced, although regression analysis did identify some inefficiencies (most of the time the futures were efficiently priced). Levett applied hedging strategies to determine how effectively hedging operations could be performed using SAFEX futures. He concluded that using numerous hedging methods, one could engage in some form of hedging using SAFEX futures, however, some hedging models had more success than others. Snell (1990) concluded that the futures he analysed were not efficiently priced. He did this by examining the futures market over the period 1987 to 1989 to see whether market performance had improved over the period.

This study aims to add to this body of research by examining the effects of market volatility on the efficiency of SAFEX futures as well as updating the efficiency studies undertaken in the late 1980's and early 1990's.

South Africa is now part of the global economy and the efficiency of our markets is of importance for us to remain an active part of that economy. If our derivatives markets are not adequately efficient, the capital flows into our markets could be hampered as hedging operations would lose their effectiveness and foreign investment could be lured away to more efficient markets. This highlights the importance of periodically updating our knowledge of the efficiency of our derivative markets.

Coupled to this is the volatility our market has experienced during the past two years. The "emerging market crises" which have been attributed to this, have been the subject of attention in the financial press and this study will quantify how the SAFEX futures have reacted to this. This is important to examine as it will give some insight into the resilience of the SAFEX futures to market shocks and the overall state of the South African markets during this period of market difficulty.

1.2 Definitions.

For a detailed list of definitions see Appendix 1.2.

1.3 The Research Problem.

One of the primary functions of a market is to promote price discovery (Collings, 1993 :30). This is because of the need of market participants to price risk correctly. The hedger needs to be able to hedge against future movements in the spot price and the speculator needs to accept the risk of this movement. The interaction of the buyer and the seller of this price risk should produce an agreed upon futures price. Once a price has been agreed upon it allows other buyers and sellers to see what a fair rate is for the risk that has been traded. This price that has been discovered will produce the basis for future trades. It is thus important that the price agreed upon can be regarded as rational and correct by the market participants.

Collings (1993) investigated the price discovery mechanism of the South African Futures Exchange in an attempt to explain the economic impact of an efficient financial futures market on the South African Economy. It is not the aim of this thesis to investigate the price discovery mechanism of the South African Futures Exchange, but rather to test the efficiency of the SAFEX listed futures, which will allow conclusions to be drawn to the state of SAFEX's price discovery mechanism.

The relationship between the spot and futures price is determined by the cost of carry model where the future is priced at the opportunity cost of holding the underlying spot instrument over the life of the futures contract. The robustness of this pricing mechanism will be examined by ascertaining how efficient it is within SAFEX.

Once the efficiency of the SAFEX listed futures has been established, the volatility experienced in world markets over the past few years will be examined with an aim to conclude how the pricing efficiency within SAFEX has reacted to this volatility. This should allow one to draw some conclusions on the state of SAFEX's pricing mechanism as well as the robustness of this mechanism during periods of changing volatility. In the event the pricing efficiency does not hold one should be able to determine the arbitrage opportunities within SAFEX.

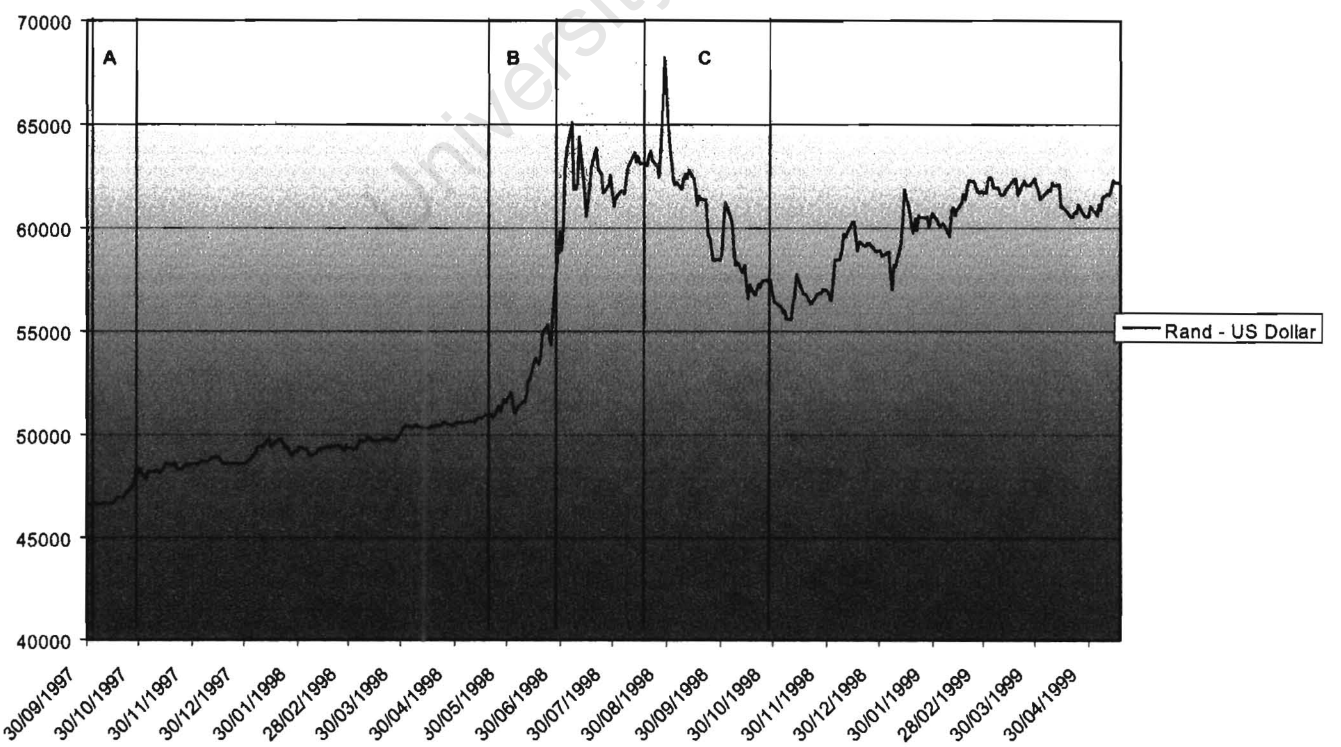
The research problem is thus: How does the pricing efficiency of SAFEX listed futures react to market volatility?

1.4 Justification for the Research.

During the "three crises" (the three crises being the Malaysian Crisis, the Russian Crisis and the Brazilian Crisis) experienced from October 1997 the emerging markets have been subject to large flows of foreign capital. These flows have been accused of destabilising the emerging markets with one of the most vociferous critics being the Malaysian Premier Mohammad Mahathir (Cavill, 1997 : 3). During this time the South African currency market experienced large movements in capital. This can be best observed in figure 1.1 which shows the Rand - United States Dollar exchange rate. There is an initial accelerated depreciation in the Rand against the dollar at the end of October 1997 (A). This is followed by another period of accelerated depreciation that occurs from June 1998 to early July 1998 (B). This is reversed from late August to early November 1998 (C).

Figure 1.1 - Rand vs US Dollar

30 September 1997 to 17 May 1999



Given these currency flows and market movements this research is an attempt to quantify how this affected the South African Futures Market. The efficiency of the Futures Market during times of crisis will allow market participants to determine the effectiveness of risk management strategies during these periods.

Due to the informational content of futures and spot markets (Lambrechts, 1990 : 4) market participants should react to the prices that are arrived at in the market. It is for this reason that these prices should be true and accurate. The trueness and fairness of futures market prices, under periods of market duress, also needs to hold in order for society to enjoy a social benefit from the existence of a futures market.

1.5 Purpose of the Study.

The actual futures prices will be tested against their theoretical counterparts to establish an "efficiency gap". This "efficiency gap" will then be compared to market volatility. The purpose of the study will thus be to determine the relationship between this "efficiency gap" and market volatility. The study will not be theoretical and actual data will be tested over a twelve-year period from 1987 to 1999. The testing involved in establishing the "efficiency gap" will be to take the cost of carry model which is based on arbitrage opportunities between the theoretical; and actual futures price and apply it to the data set to determine the theoretical futures price. The testing of the relationship between the "efficiency gap" and the market volatility will be done by comparing the output from different volatility models to the day-to-day size of the "efficiency gap". This should allow conclusions to be drawn as to the movement in the size of this "efficiency gap" relative to changes in volatility and whether any relationship exists between the two.

The above testing will allow for conclusions in the following areas:

a) Whether SAFEX listed futures have any relationship with their theoretically determined prices.

b) In the event of there being a difference between the theoretical and actual futures prices, the nature of this difference and its extent. This will allow for insight into the market's efficiency.

c) In the event of the "efficiency gap" existing, if there is any relationship between it and different volatility measures.

d) If there is a relationship, the aim will be to ascertain the nature and extent of this relationship.

1.6 Objectives of the Study.

The primary objective of this dissertation is to establish the effect of volatility on the pricing efficiency of SAFEX listed futures.

A secondary objective will be to quantify the impact of the recent market volatility on the efficiency of pricing of SAFEX listed Futures. This recent volatility was manifested in the form of the "Asian Crisis", the "Brazilian Crisis" and the "Russian Crisis"; it would be useful to determine exactly how these "crises" have affected the pricing efficiency within SAFEX, and consequently the stability within our markets.

1.7 Research Method.

The first step in the research of both the pricing efficiency and volatility was to conduct a literature review of works in these areas. In South Africa, numerous dissertations have been completed in the field of futures pricing efficiency. Each of these has been reviewed with a primary aim of investigating the pricing models used and the formulation of these models. The volatility research has been divided in two. The first area dealing with more traditional measures of volatility such as standard deviation and variance. The second area deals with the application of the general auto-regressional conditional heteroscedastic (GARCH) statistical model. The forecast volatility produced by the GARCH model will be tested against the "efficiency gap" in the same way as the traditional volatility measures will be tested.

Upon completion of this the next step will be to develop the efficiency pricing models that would be used in the testing of the actual futures prices. As stated above, the model was developed along the lines of the cost of carry model, making adjustments for taxes, interest on margin, dividends and other transaction costs. The research conducted by Hugo Lambrechts (1990) was heavily relied on in the formation of the efficiency models. The models were applied to the spot data to produce the theoretical futures prices. These were then compared with the actual prices and tested statistically for pricing efficiency.

Once efficiency had been determined the "efficiency gap" was determined between the theoretical and actual futures prices. This was done by simply subtracting the one from the other.

The following step was to calculate the volatility measures. This was done on a two-step basis. The traditional volatility measures were calculated first and then regressed against the efficiency gap to determine if there was a relationship between the two. This was then repeated for the GARCH measure, the actual measure was applied over the period and the results were regressed against the efficiency gap.

1.8 Overview and Structure of the dissertation.

The overview of the dissertation excludes the introductory chapter (chapter one).

1.8.1 A review of the South African Futures Market

Chapter 2 begins with the history of SAFEX and it's forebear being the market created by Rand Merchant Bank. This section describes what steps have been taken to encourage the growth of SAFEX and what growth subsequently has been enjoyed.

This leads into the segmenting of the periods under scrutiny into two periods, namely: April 1987 to end September 1997 and October 1997 to end October 1999. These periods are analysed and major events are put into perspective. It is important to note that this analysis is of the events that occurred during the two periods and not a data analysis. This is conducted later when the efficiency tests are undertaken. The focus of this analysis is the three crises that took place between October 1997 and October 1999. The reason for this is that this is the main justification for the research, that is, how the SAFEX reacted to these market shocks.

A discussion and description of these market shocks leads on to a brief discussion of volatility and what effect it has on markets. This is done for the reader to understand the context of the thesis, why volatility is being examined and why it is being researched together with market volatility.

As it is the market participants who drive the market, a brief description follows, of each of the types of market participants, their roles in the market and how they interact.

1.8.2 Futures – The Mechanics.

Chapter 3 describes the functioning of a futures contract and how profits and losses are made. The chapter begins with an analysis of the futures contract and a description of its main features. This leads on to the difference between a future and a forward and what needs to be in place in order for a forward to be called a future. Technical terms such as the basis and spreads are defined as well as how the mark to market process works. The chapter finishes with some application of futures trading (speculating or hedging) and some specific issues surrounding futures such a program trading.

1.8.3 Volatility – a Discussion.

Chapter 4 introduces the issues involved with market volatility. Possible causes are explored as well as how the market has reacted to this and chosen to protect itself against this phenomenon. One reply to volatility was the introduction of portfolio insurance. This has been credited with being one contributing factor to the 1987 "crash" and will be examined briefly. Other reasons cited for market volatility are futures close-outs and securities lending. These are also examined in detail in this chapter to determine if this is indeed the case, and why.

The chapter finishes off discussing measurement of this market phenomenon. The traditional methods of measuring volatility are examined and explained as well as the more innovative methods. This is done for the reader to understand their application in this thesis.

1.8.4 Literature Review of Efficiency Studies.

Chapter 5 produces exactly what its title suggests. The efficiency studies done around the world are examined separately to those produced in South Africa. The main reason for this is the (efficiency) model differences between South African studies and foreign works.

1.8.5 GARCH – an Explanation and Literature Review.

Chapter 6 explains what GARCH is. A literature review is also conducted of the development and use of this measurement from when it was first introduced in 1986. The aim of the literature review is to aid understanding of what this measure is trying to achieve and how it does this. This will lead to greater understanding of the findings of the thesis by the reader.

1.8.6 Empirical Testing of Market Efficiency – Closing rate data.

Chapter 7 is where the first actual modelling and testing begins. The efficiency of the market is tested in this chapter. In other studies (Lambrecht's 1990, Snell 1990) on South African futures market efficiency, closing rate prices have been used. This chapter uses similar methodologies. The value added by this chapter is the updating of this efficiency-based research. In South Africa, the last thesis dealing with this was produced in 1991 by Levett. The state of SAFEX's efficiency has not been measured since and this chapter rectifies this.

The approach taken is to divide the data into two parts and comment on each one separately. The first part deals with pre October 1997 and the second part deals with the market from October 1997 to October 1999. Comparisons will be drawn as to the differences in the efficiency of the pricing of the SAFEX-listed futures. The data is separately reviewed from a statistical perspective before actual testing begins. As part of the results the output from the application of the model is reconciled with the events occurring in the market.

1.8.9 Empirical Testing of Volatility – Traditional.

Chapter 8 provides the reader with two outcomes. The first is the actual state of the volatility of the South African equity and futures market over the past 10 years. Again, this data is divided in two and the two are compared. The second outcome is the actual comparison of this volatility with the market efficiency determined above. It is at this point that the efficiency gap is regressed against the traditional measures of volatility to determine if volatility has, indeed, an effect on the efficiency of the pricing on SAFEX listed futures.

As mentioned above, the traditional volatility measures include standard deviation and variance and exclude ARCH and any of its derivatives. What the reader should gain from the initial volatility investigation will be an assessment of the volatility of the South African markets during the crises. At this point conclusions will be able to be drawn as to the impact of volatility on the efficiency of the pricing of South African Futures.

1.8.10 Empirical Testing of Volatility – GARCH.

Chapter 9 sets out to achieve what is stated above, namely an alternative way of measuring volatility and forecast volatility and what relationships exist between this and the pricing efficiency of SAFEX-listed futures. As in the previous chapter the volatility measured will be compared with the "efficiency gap" between the actual and theoretical prices of SAFEX-listed futures. The aim of this will be to determine if a relationship exists and if one can conclude on how volatility affects the South African markets.

1.8.11 Implications of the findings and Conclusions.

Chapters 10 and 11 put into perspective the findings of the previous chapters. Further areas for research are identified and conclusions are drawn on the state of the South African Markets. These chapters will act as a "report card" on how South Africa reacted to the three crises over the past two years.

1.9 Limitations.

The main limitation is that the efficiency of the futures market is tested under conditions that do not truly reflect the actual market behavior (such as using closing rate data only and not intra day data) (Lambrechts, 1990 : 6). The danger of this is that the wrong conclusions could be drawn from the research. The main components that are not observed, through an ex post examination of the market, are the "estimation and adjustment of both transaction costs and risk" (Lambrechts, 1990 : 6). The transaction costs that are not observed are essentially embodied in the spread between the buy and sell prices of both the spot and the futures prices.

One of the assumptions made in assessing market efficiency is that any difference between the actual and theoretical futures price should be subject to arbitrage trading by market participants and thus should be reduced soon after it appears. A problem with this reasoning is the assumption that the arbitrageur is indeed able to take advantage of the opportunity that has presented itself. In practice the arbitrageur may be unable to take advantage of the opportunity due to liquidity constraints, the risk involved in taking the position, or other market constraints that may present themselves. This may lead to any results concerning the efficiency of the market to be flawed and incorrect conclusions being drawn. An attempt is made to reduce the risk of producing flawed research by testing intra-day data.

Lambrechts (1990:8) quotes Followill's (1986:169) assertions that if this is the case, and there are "unassumed market positions", this may be an indication of the market's sophistication rather than evidence of its inefficiency.

Chapter 2: A Review of the South African Futures Market.

2.1 A Brief History of SAFEX.

Rand Merchant Bank pioneered futures trading in South Africa with trading beginning in April 1987. The first contracts to be traded were on various equity indices and long bonds. There were five contracts launched in the first batch. Rand Merchant Bank undertook all the duties of the exchange that included being the market maker and the clearinghouse.

This initial market led to the establishment, in September 1988, of the South African Futures Exchange (SAFEX) and the SAFEX Clearing Company (Pty) Ltd (SAFCOM). Twenty-one banks and financial institutions (SAFEX, 1999:safexdep.htm) completed this formation of SAFEX. Included in the 21 institutions were the Johannesburg Stock Exchange and the South African Reserve Bank. Upon formation 80 "seats" were subscribed for at an initial price of R 25 000 each. An executive committee was elected to oversee the employment of the R 2 million start-up capital that had been raised by the sale of the "seats". In 1989, when the systems and infrastructure had been put in place, another 39 seats were issued at a price of R 35 000 each, thereby allowing other market participants to join. SAFCOM took over the operation of Rand Merchant Bank's futures 'market' in April 1990. Upon taking over the operations, futures were made available, by SAFEX, on equity indices, long bonds and money market products.

Up to this point SAFEX was not an officially licensed exchange. In August 1990 the Financial Markets Control Act was enacted (SAFEX, 1999:safexdep.htm) and SAFEX was officially licensed as a derivatives exchange. The official opening of the exchange took place on the 10 August 1990 by the Minister of Finance. At this point monthly volumes were approximately 60,000 contracts, with 10,000 open interest (SAFEX, 1999:safexdep.htm). The next development came in October 1991. The South African Reserve Bank gave permission for non-residents to participate in SAFEX.

The first time monthly volumes started to consistently exceed 100,000 open contracts was in June 1992. From this point volumes began to grow exponentially: monthly volumes exceed 200,000 by January 1993 and passed the one million mark in December 1993. Open interest grew at a similar pace: by December 1993 it was at 500,000 contracts and exceeded the 1 million mark in January 1997 (SAFEX, 1999:safexdep.htm).

There were a number of SAFEX implemented developments that aided this market growth. The first came in October 1992 with the launch of options-on-futures that were launched together with a portfolio-scanning- type margining system (SAFEX, 1999:safexdep.htm). The second was the introduction of a fully automated trading system that was launched in May 1996. The next development came in September 1997 in the form of individual equity options, which were introduced on the six largest JSE-listed equities. In February 1999 the next development materialised when the Individual Equity Options were replaced. In their place SAFEX introduced twelve Individual Equity Futures (IEF) and options on the futures. Six IEF's were listed (SAFEX, 1999:safexdep.htm) upon their general introduction.

Another development to take note of was the development of the Agricultural futures market. SAFEX launched this market in January 1995. The agricultural futures market developed in the same way as the financial futures market. In March 1998 options were introduced on agricultural products. The agricultural products suite was extended in February 1999 to include Sunflower Seeds and Cape Wheat futures. This thesis will not deal with the agricultural futures markets in South Africa; this has only been added for one to gain a complete understanding of the history of SAFEX.

2.2 Review of the Markets to October 1997 – Spot and Future.

A few months after the launch of the informal SAFEX market, the world markets were thrown into turmoil with the October 1987 crash. This affected the South African Equity and Futures Markets. This was followed by numerous other crises of different proportions, most notably was the Mexican Peso crisis and the U.S. Bond Market bear market, both of 1994. During each of these periods the markets experienced varying degrees of volatility. Each of these periods is examined in more detail below. The futures and spot markets are not analysed separately. The two markets are linked through a set relationship (see chapter 3) and thus react similarly to market events. In the event of this not being the case this will be noted.

The period reviewed is 1 April 1987 to 28 August 1997. The first period of note began on the 19 October 1987 when the world markets experienced a market "crash". The All Share Index experienced a high of 2804 on the 19th October, the following day the index closed down 11.7% or 328 points. This drop continued until 12th February 1988 when the index closed at 1517, 1287 points lower (45.9% down). This period is marked period A on figure 2.1 below. The period 1 April 1987 to 28 August 1997 has been chosen as the South African Futures Market was established in April 1987 and the emerging market crises "began" in late August 1997. The volatility over this period is analysed separately in chapter 10 below.

After the 1987 "crash" the markets recovered until the next dip, which occurred from August 1990 to February 1991. During this period the overall index dropped from a high of 3210 achieved on 14 August 1990 to a low of 2527 on 31 January 1991. The drop was 21.28% or 683 points. The reason for the drop was primarily due to the political turmoil within South Africa at the time. This period is marked B in figure 2.1 below.

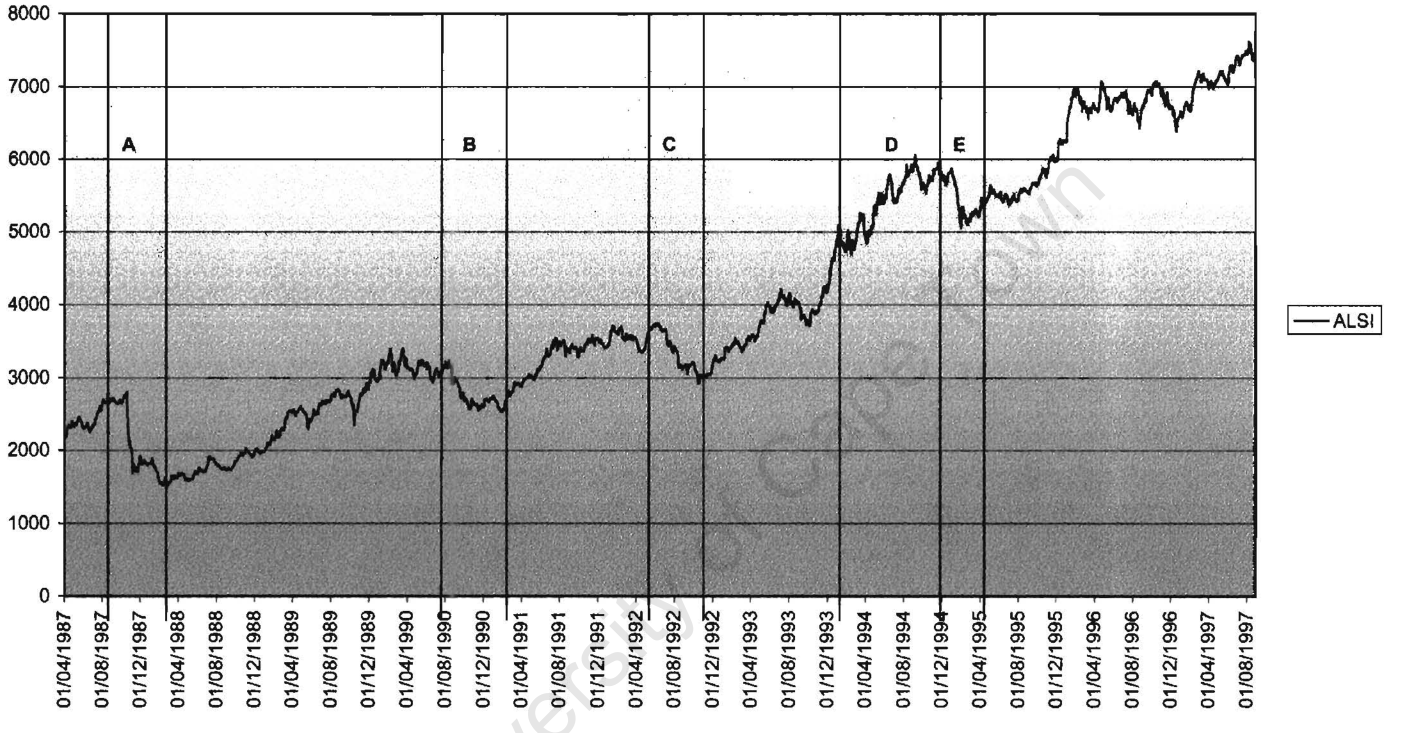
As political events were moving towards a liberalisation of the South African political environment, so the market rallied until June 1992 when the market again peaked at 3744 on the 4 June 1992. The overall index then dropped from this point to 2926 on the 15 October 1992 - a drop of 818 points or 21.85%. Again, this was primarily due to political shocks within South Africa. This period is marked C on the below figure 2.1.

A significant rally was then realised until November / December 1994. During this period the overall index rose from 2926 to a high of 6054 on the 7 September 1994 - an increase of 3128 points or 107%. This was due to the first democratic elections being held in South Africa and the re-entry of South Africa into the global financial markets. It is important to note that during this period two significant financial global events took place, namely: the Mexican "Peso" crisis and the United States bond bear market. Both of these events occurred in 1994 and are market by the period D on figure 2.1.

Even though South Africa had been accepted back into the global financial markets, one can see the effects of these two crises were minimal with the JSE Overall Index maintaining a bull trend over this period. In 1994 Alan Greenspan, chairman of the United States Federal Reserve implemented a number of interest rate increases as part of his economic policies. The first of these occurred on the 4 February 1994 with others following at varying intervals throughout the year. The effect of this was the Dow Jones Industrial Index dropped from a high of 4820 on the 3 February 1994 to a low of 4389 on the 5 April 1994, a drop of 431 points or 8.94%. During the same period the JSE dropped 1%. These interest rate increases culminated in U.S. bond market participants suffering significant losses. The most notable casualty was Orange County California, which has to apply for bankruptcy protection on 6 December 1994. The trend of South Africa not being effected by external markets is important to note as this changes during the August 1997 to August 1999 period.

The Mexican Peso crisis began with the assassination of Mexican presidential candidate Luis Donaldo Colosio on March 23, 1994 (Arner, 1999). This led to a loss of foreign exchange reserves as foreign investors pulled out of Mexico during the course of 1994. This culminated in the Mexican Stock Exchange dropping over the period end 1994 to 27 February 1995. The Mexican Bolsa index fell 39% in nominal terms this period (Arner, 1999). The JSE was initially not effected. Looking at period D in figure 2.1 below the JSE rallied during a period of turbulence in Mexico. The drop from late 1994 to 27 February 1995, however, had a direct impact on the JSE. This is represented by period E. During this time the JSE dropped from a high of 5942 on 17 November 1994 to a low of 5054 on 31 January 1995 - a drop of 888 points or 14.9%. This drop is due to what is due to what became known as the Tequila Effect (Arner, 1999). The Tequila Effect was the withdrawal of foreign investors from all emerging markets and corresponding drops in their stock exchanges. This illustrates that South Africa was still governed by the movements international markets. The Tequila Effect illustrates how South Africa could be affected by difficulty experienced in other emerging markets. For the remainder of the period until 28 August 1997 South Africa was in a bull market and there were no significant market events to report.

Figure 2.1 - JSE Overall Index: 1 April 1987 to 28 August 1997.



2.3 The Crises – The Markets from August 1997 to August 1999.

After the above period the JSE entered a period of turmoil. A number of market shocks were experienced, starting with the Eastern Crisis and following on with the Russian and Brazilian Crisis. These events and how they affected the South African market are the focus of this thesis. The volatility during this period is analysed separately in Chapter 10 below. This analysis has been performed to put dates to the shocks and market movements into context.

2.3.1 The Eastern Crisis

The Eastern Crisis was set off by the devaluation of the Thai Bhat in July of 1997 according to John Cavill (1997). After significant government intervention in the Eastern economies of Malaysia, Thailand, Indonesia and Hong Kong, the markets became less stable. This led to significant losses. On the 9 July 1997 the Singapore Straits Times index was at 2007,23, by 12 January 1998 it had dropped to 1073,47. A drop of 933,76 points or 46.5% of the market had occurred over a six-month period. Initially, until the 22 October 1997, the South African market did not react to this. From 28 August 1997 to 22 October 1997 the JSE rose from 7368 to 7413 - a rise of less than one percent. During the same period the Straits Times index fell from 1915,96 to 1731,68 - a drop of 10%.

This led to the drop as shown in figure 2.2 below (see area marked "a"). The JSE dropped from a high on 22 October of 7413 to a low of 5874 on the 28 October 2000 - a drop of 20.7%. The JSE continued to drop until the 12 January 1998 when it hit a temporary bottom of 5568. This was caused as the extent of the financial crisis in the East became known. Significant foreign borrowings led to the IMF having to put together "rescue" packages for the Eastern economies, an example of this is the US$ 57 Billion package the IMF put together for South Korea. (Baker, 1998).

South Africa was not as badly affected by the market shocks as the Eastern economies were. It was suggested by Forecaster Ecosa economist Helmo Preuss (1998), that one reason for this was that South Africa had already undergone a default type scenario in 1985, when the South African Banking system had to restructure the payment of its international debts.

The South African market rallied from the low of 12 January 1998 to a high of 8374 achieved on the 21 April 1998 (area marked b on figure 2.2 below). The increase was 2806 points or 50.4%. This rebound was explained by a general article in the Financial Mail (1998) to be due to South Africa's standards of transparency and accounting relative to other emerging markets. Another factor was the fact that shareholding structures were becoming concentrated and market liquidity was rising in South Africa. Mark Richardson (1998) offers another reason: Trevor Manual the South African Finance Minister was thought of highly in international financial circles.

During this period the South African Market became increasingly affected by the international markets as one can see by the October 1997 drop. This also introduced increased variability into the JSE. From 28 August 1997 to 21 April 1998 (a period of approximately 8 months) the JSE had dropped by 20% and then risen by 50%. This leads to the question of whether the efficiency of the South African market is maintained during these periods of stress and significant variability.

2.3.2 The Russian Crisis

The one feature of the Eastern Crisis is the devaluation of the currencies of the Tiger economies (Malaysia, Korea, Thailand, Indonesia). This put pressure on their trading partners. One of the concerns was that either

China or Japan would significantly devalue their currencies, thereby setting off another round of market collapses. Plender (1998) observes that Japan was subject to economic difficulty, but could not afford to devalue the Yen, because, in the event of this happening, China might see little incentive in maintaining a stable currency, thereby forcing the Asian Tigers into another round of devaluations.

One such victim of these eastern devaluations was Russia. Russia's economy was already in a state of instability prior to the Asian Crises. After the market turbulence had passed through Asia, Russia succumbed and faced a financial crisis in August 1998 (Peel, 1998). The initial crisis had occurred over May / June 1998 with the IMF putting together another "rescue" package of US$ 23 Billion in July 1998.

South Africa was affected by this default. The JSE reached a high of 8371 on 21 April 1998, only to be effected by the Russian Crisis and drop to a low of 4676 on 11 September 1998. This drop is represented by period C in figure 2.2 below. This drop of 3695 points, or 44.14% shows the increasing variability or volatility in the Johannesburg Stock Exchange. Over the period of a year the market had dropped 20%, risen 50% and then dropped another 44%. At this point one can observe that South Africa was now being directly affected by the movements in the international markets. South African institutions were also directly involved. Standard Bank was exposed to the Russian market and faced the prospect of writing off a significant investment. It was thus a combination of this direct impact on the South African economy and the general withdrawal from emerging markets by the international investment community that caused this drop in the JSE.

2.3.3 The Brazilian Crisis

After the Russian Crisis had been overcome the JSE recovered, rising from 4676 on 11 September 1998 to 6024 on the 6 November 1998 an increase of 28.8% (marked as period D in figure 2.2 below). After this the Brazilian market was becoming increasingly unstable. Reasons for the instability ranged from the increasing nervousness amongst the worlds investors regarding emerging market economies as well as structural economic deficiencies that the Brazilian Economy was dealing with.

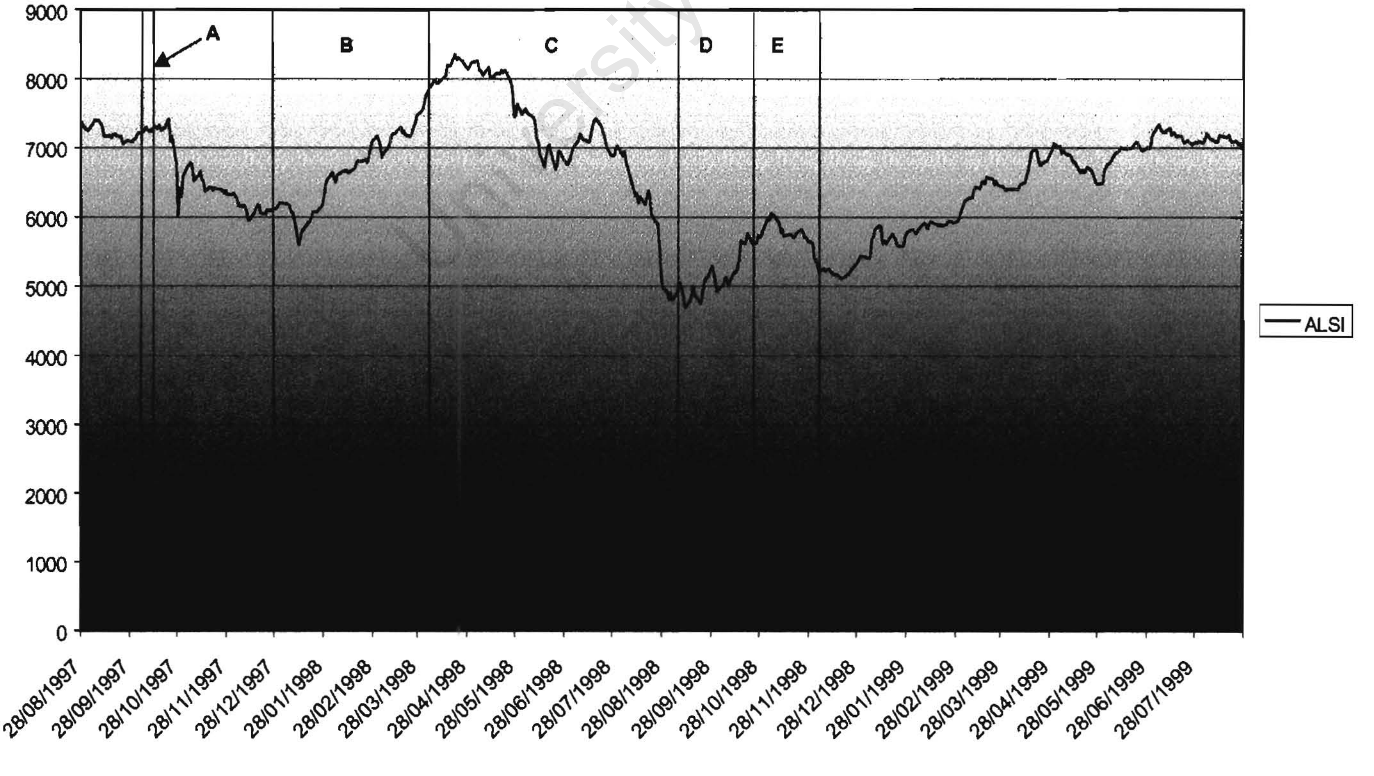
The Brazilian Crisis was, according to Bell (1999), precipitated by a management problem. Itamar Franco, the governor of the wealthy state of Minas Gerais, placed a moratorium on his state's debt repayments to the federal government. Coupled with this was the fact that the Brazilian Real was pegged, within a trading range, to the U.S. Dollar. With the global instability this peg was put under pressure by the currency market participants and the Brazilian short-term interest rates were forced up to 70%. This pressure led to the resignation of Gustavo Franco, the head of the Brazilian Central Bank. The currency was left to float and devalued by 20% against the U.S. Dollar. During January the Bovespa Index (the Brazilian Stock Exchange Index) dropped 30% and rebounded by 33% on the news of the devaluation and floatation of the currency.

The IMF came to Brazil's aid by providing a $41.5 Billion facility but this was not deemed to be enough to stem the crisis (Wood, 1999). Brazil responded by introducing an austerity package against a backdrop of a possible broadening of the debt moratorium (Bell, 1999).

In response to this the South African Reserve Bank raised short-term interest rates to avoid an extreme deterioration of the Rand against the South African trading partners. The prime interest rate rose from 18% to 25% over this period. The effect on the stock market can be seen on figure 2.2 below in the area marked E. During this period the JSE dropped from 6024 on the 6 November 1998 to 5085 on the 17 December 1998. The drop of 939 points (15.6%) was the last significant drop for the two-year period.

After the Brazilian Crisis the JSE experienced a recovery, rising over the next two years to 7023 on the 27 August 1999. This increase of 1938 points equated to a percentage increase of 38.11%. The JSE had experienced movements in this two-year period that were more extreme than what it had experienced in the preceding 10 years. During this two year period the JSE had initially dropped 20%, risen 50%, dropped another 44%, rebounded 29% , dropped a further 16% and then finally risen 38% - 6 significant reversals in the space of two years.

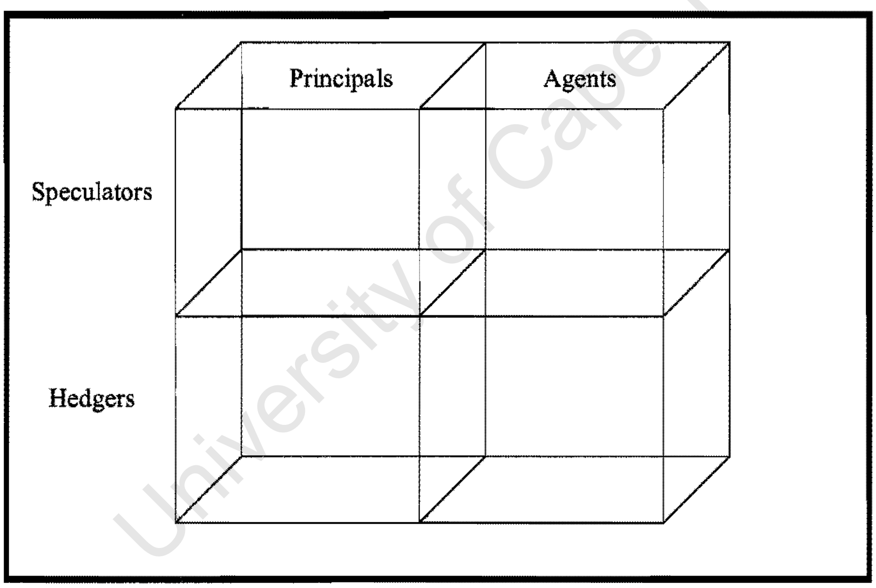
Figure 2.2 - JSE Overall Index: 28 August 1997 to 28 August 1999.



2.4 South African Futures Market Participants

As per Fourie, Falkena and Kok, participants in the futures markets can be divided into four main groups, namely: Hedgers, Arbitrageurs, Speculators and Investors. (Fourie, Falkena & Kok, 1992 : 216). Kolb (1997 : 21) and Lambrechts (1990 : 40 – 51) offer different a categorisation. In this case the participants are broadly seen to fit into a 2 dimensional matrix (See figure 2.1): those acting in an agency capacity and those acting in a principal capacity mapped on to those acting as speculators and those acting as hedgers. Examining these categories, new participants arise: Brokers (both floor brokers and introducing brokers), Futures Commission Merchants (FCM), Associated Persons (AP), Commodity Trading Advisors (CTA), Commodity Pool Operator (CPO) and Floor Traders. One could add to this list the role of strategy brokers, as they actually create and design positions using OTC (Over-the-counter) instruments and / or combination of listed instruments for a client to achieve a certain exposure or specific hedge.

Figure 2.3 – Broad Categories of Futures Market Participants.



2.4.1 Hedgers

A Hedger is an individual or entity that has an exposure to an instrument and wishes to diminish this exposure by entering into transactions which have an opposite effect to the initial exposure the instrument gives. This reduction of exposure can be done by the use of various derivatives, in this study, hedging using futures to reduce exposure to a risk is what will be focused on. Hedgers can take the form of financial institutions such as banks and asset management companies. Hedgers reduce their exposure to risk by passing it on to speculators who will accept this risk in the hope of making the commensurate profit. Hedging is given as the primary reason for the economic benefit embodied in the existence of futures markets. This allows commercial activities such as farming to continue with certainty. This benefit creates stability in these markets, by removing price related uncertainty and passing it on to those who are willing to accept it. During 1999 there has been a move to remove other risks such as weather related risks with the introduction of futures and options on the weather by the Chicago Mercantile exchange (Luce, 1999). Commodity or weather related futures will not be dealt with in this thesis, however.

The hedger's optimal decision is to decide on a combination of hedging and speculation (Lambrechts, 1990 : 48). This suggests that hedgers do not only perform hedging activities but can be involved in a combination of strategies. This is because the hedger is motivated by an effort to stabilize income by taking away price risk and simultaneously optimise expected profits.

2.4.2 Arbitrageurs

Arbitrageurs are market participants who engage in the market for risk free profit. In the case of the futures markets, arbitrageurs are participants who seek to exploit the differential between the theoretical price of a future and the actual price of a future. Arbitrageurs are responsible for maintaining the efficiency in the pricing of a futures market by taking advantage of the mispricing between the actual and theoretical futures prices. Arbitrageurs also facilitate the convergence of the futures price with the spot price as the future nears maturity.

2.4.3 Speculators

A speculator can be defined as "anyone who uses the futures market for capital gain only" (Fourie, Falkena & Kok, 1992 : 216). Speculators serve an important purpose in futures markets by supplying liquidity and, through being actively involved in the futures market, lead to more efficiently priced futures. The liquidity allows hedgers to have their trades absorbed into the market without undue disturbance in the current price of the future (Botha, 1988 : 4). Speculators are in turn divided into a number of categories depending on the length of time they hold a position and whether they are directly involved in the trading floor or not. The role of the speculator is a controversial one. Speculators have often been accused of destabilising markets, causing exaggerated movements in prices. Speculators, however, perform an important function of establishing and maintaining efficient markets (Lambrechts, 1990 : 49). Speculators are a significant part of the futures market; they risk their own capital to profit from price movements. They are also credited for lessening extreme price movements by their participation in the markets, that might otherwise occur (Lambrechts, 1990 : 50). During the market crises of the past two years, speculators have been blamed for some of the market shocks that have occurred, however, not all the blame can be placed on speculators. If a market is generally inefficiently priced, whether speculators get involved or not, it will have to regress towards its true value at some time.

2.4.3.1 Floor Traders.

Floor traders are speculators who, as the name suggest, operate from within the futures exchange. In the United States of America floor traders must be members of the futures exchange. The main difference between floor traders and other traders is the requirement to be a member of the exchange. This will enable the floor traders to avoid commission costs that traders who are not a member of an exchange would have to pay. This avoidance of commission costs will enable these traders to exploit smaller arbitrage opportunities.

2.4.3.2 Scalpers.

Scalpers are speculators on the floor of an exchange who sells contracts for their own account. (Lambrechts, 1990 : 42). Scalpers profit from small movements in the futures they trade in. They tend not to hold positions overnight, but can do so from time to time. Scalpers can operate as market makers and thus will offer to buy at the bid price and sell at the offer price. Scalpers attempt to profit from buying at slightly lower than the last price and selling slightly higher than the last bid price. This requires continuous bidding and offering. This supplies liquidity into the market. This focus on small movements in price makes the scalper indifferent to longer-term trends and confines the scalper to hold positions for short periods. Like floor traders scalpers will be members of the exchange and not pay commissions. This enables the scalpers to profit from the small movements in price. These small movements in price are known as ticks or minimum fluctuations.

2.4.3.3 Position Traders.

Position traders take a longer-term view of the market. They are thus concerned with trends that are exhibited by a future. Where a scalper will liquidate a trade before the day is out, a position trader will hold for numerous trading days. The decision to trade is usually based on some fundamental or technical view of the market. These traders also provide liquidity to the market for hedgers to perform their operations. Position traders can also be a member of an exchange, but do not have to be. The position traders, by avoiding the need to close out their positions before the day is over, avoid the close out costs (such as brokerage or commissions), but expose themselves to the risks involved in carrying a position overnight. Position traders can hold a future for periods of more than a day to a number of months.

2.4.3.4 Day Traders.

As the name suggests, day traders will enter and exit a trade during the same trading day. Similar to scalpers, they will look to unwind a position before the trading day closes, thereby avoid the risks involved with carrying a position overnight. Day traders aim at narrower spreads between bid and offer prices than the position traders, but not as narrow as the scalpers. The main aim here is for the trader to identify a mispricing of a futures contract at the beginning of the day, exploit this and close out the position by the end of the day at which time the mispricing has ceased to exist. Day traders can be both locals (members of the exchange), or off floor proprietary traders. A day trader differs from a scalper in that a day trader may profit or lose more from larger price changes than a scalper (Lambrechts, 1990 : 45).

2.4.3.5 Spreaders or Spread traders.

These traders would take positions across different contracts. Spread traders can either trade across different maturities of the same contract, or across the same maturity of similar contracts. They will do this be buying the one contract and selling the other, thereby covering themselves and limiting their exposure. These trades are a form of arbitrage. The spreader will thus be reducing the risks involved in speculating. Similar to the arbitrage traders, spread traders seek to profit where the price of a future has drifted from its theoretical value. The purpose of the trade is to anticipate the potential change in relative values between two contracts (Lambrechts, 1990 : 30). The fact that the contracts are similar or the same contract but with different maturities does not remove the risk involved in the spread trade and thus does not make it a perfect arbitrage trade, however, the similarity serves to reduce the risk substantially when compared with an outright open position. This leads to futures exchanges accepting lower margin requirements for spread type trades. The mechanics of a spread trade are explained in chapter 3.3.

2.4.4 Investors

Investors will take the longest positions of all the participants. The aim of the investor could best be described as follows: "Instead of purchasing assets in the cash market as an investment, investors may also establish synthetic cash positions in the futures market as an alternative investment form." (Fourie, Falkena & Kok, 1992 : 217).

An example of an investment type trade will be where the investor purchases an index future and shorts certain of the underlying shares in the index to establish a specific exposure to a selection of shares in the index.

2.4.5 Brokers

Brokers will execute trades or orders for customers and receive a fee for doing this. Brokers, when filling orders, may trade for their own accounts or act as agents. Brokers may also ask as traders and enter into proprietary trades that are not necessarily with their clients. Brokers have to be members of the exchange they are dealing on. In order to be able to trade they will also have to be a clearing member or have an agreement with a clearing member, for the clearing member to clear the broker's trades. Brokers will also engage in supplying their clients with advice. This advice will vary from broker to broker. A discount broker would limit the advice given to the client where a full service broker will not only advise the client on market conditions, but may also supply recommendations to the client. Brokers can be divided into numerous subsections, namely: Floor brokers, introducing brokers, associated persons and commodity trading advisors.

2.4.5.1 Floor brokers.

Floor brokers will execute orders for individuals who are not on the floor of the exchange. In the United States of America there are broker associations or broker groups of which floor brokers are members. These floor brokers will band together to fill orders for their customers (Kolb, 1997 : 39). These broker associations are not a feature of the South African Markets.

2.4.5.2 Introducing brokers.

These participants are again, a feature of the U.S. market. Introducing brokers accept orders but not the funds to support those orders. An introducing broker will find a carrying broker who will execute the trades. The introducing broker will find the client and engage the carrying broker to complete the trade. The commissions for such trades are then split between the introducing brokers and the carrying brokers.

2.4.5.3 Associated Persons.

This is a broad category that describes individuals who are involved in the solicitation of orders, customers, customer funds, or supervises the above activities (Kolb, 1997 : 40). This will thus include brokers as well as other participants who make up the futures industry.

2.4.5.4 Commodity Trading Advisors.

This is an American term for an individual who advises clients on how to trade. This will be done either directly or through publications. The advice will vary from individual trades, where opinions will be given on when to close out and whether a specific trade is advisable or not, to market opportunities. Thus the writer of a newsletter who advises that interest rates will be moving sharply in the near future and that interest rate futures should be entered into, would qualify as a commodity trading advisor.

2.4.5.5 Strategy Brokers

A strategy broker would essentially be a commodity trading advisor. However the strategy broker would be more actively involved in the advice given. A strategy broker offers synthetic strategies for commission. An example would be where a strategy broker approaches a fund manager and offers to hedge away a specific risk. The strategy broker will then proceed to construct a position through the use of both over the counter (OTC) and listed futures to hedge away the risk. This will then be sold to the fund manager. The strategy broker will then find a counter party to enter into the opposite side of the position, again taking a commission. This type of trade is called "back to back" where the broker creates the trade but is not a party to it. There is, however, nothing stopping the broker in becoming a principal in the transaction. These types of brokers serve an important purpose as they bring more participants into the market. In the case of the South African market these brokers are important as they bring into the market unsophisticated parties such as certain fund managers who would not, as a feature of their investment strategies, engage in the use of futures to hedge away risks. These strategy brokers supply the expertise that these parties may not have, by advising and building the strategies for them. SAFEX is still a young exchange, having being formed only in 1988. Strategy brokers perform an important role in its development by introducing more participants and thus liquidity to the exchange, ensuring its growth. This, in turn, will enable more contracts to be traded and prices to become more efficient. A strategy broker can be seen as an advanced form of Futures Commission Merchant (FCM).

2.4.6 Futures Commission Merchants

A futures commission merchant (FCM) is an individual or firm that accepts orders to trade futures for a commission. FCM's will use floor brokers to execute the trades they have been commissioned to undertake. Essentially the FCM intermediates between the clients and the traders. Lambrechts (1990 : 46) cites Kaufman in defining FCM's as "Individuals, associations, partnerships and corporations engaging in soliciting or in accepting orders for the purchase or sale of any commodity for future delivery (on and subject to the rules of any contract market) and registered with the CFTC". The CFTC is the Commodity Futures Trading Commission, which is an American federal regulatory body. FCM's must be a member of an exchange if they are to trade for their clients. If they are not a member of an exchange they will have to be affiliated with one to fill the orders they solicit.

FCM's clients are primarily principals who trade for their own account. FCM's thus take on the function of administering margin accounts and requirements, profit and loss monitoring, risk supervision, placing and executing orders, record keeping, accounting, generating trading research and strategy proposals and hedging strategies (Lambrechts, 1990 : 47).

2.4.7 Commodity Pool Operator

A commodity pool operator is an American term that describes an individual or entity that solicits funds to form a pool which will engage in futures trading activities (Kolb, 1997 : 40). This pool of funds is called a commodity pool. The individuals who contribute the funds gain a share in the pool and participate in the profits and losses made upon trading of the futures.

Chapter 3: Futures - The Mechanics

A futures contract, according to Blake (1990 : 158) is "an agreement between two counter parties that fixes the terms of an exchange that will take place between them at some future date". While this statement is correct there are numerous subtleties that one needs to be aware of. The most significant is the difference between the futures and the forward contract. The specifics of the futures contract are described below.

3.1 The Futures Contract.

Each futures contract has a number of characteristics, the first being that the future trades on an organised exchange. In the case of South Africa a future would have to be associated with SAFEX. A contract for future delivery of a good, which is not traded through SAFEX, could not be considered a future. The futures exchange cannot be the same as the foreign exchange market, which is a loosely organised market and has no physical location. A futures exchange should have membership in the form of membership seats. It should also have a fixed location and trading times. There does not necessarily need to be a trading pit. Since the advent of automated trading the need for this, to define an exchange, has been negated.

The second characteristic of a futures contract is that its terms must be standardised. Generally, the futures contract specifies the quantity and quality of the good that can be delivered to fulfill the futures contract. The contract also specifies the delivery date and the method of closing the contract, and the permissible minimum and maximum price fluctuations permitted in trading (Kolb, 1997 : 5). Finally the contract outlines the minimum price fluctuations or price tick size. This can be seen in the example of the All Share Index (ALSI) contract traded on SAFEX. The underlying instrument is the Johannesburg Stock Exchange Actuaries Top 40 Companies – All Share Index (ALSI40). The contract size is 10 Rands multiplied by the index level. The contract size refers to the price of the contract. An example would be where the future agreed upon value of the ALSI40 is 6000. The value of one contract would be 6000 multiplied by R 10 being sixty thousand Rands. The expiry dates and times for the ALSI40 futures contract are 16h00 on the 3rd Thursday of March, June, September and December or the previous business day in the event the day falls on a non-trading day such as a public holiday. The contract is quoted as the index level. SAFEX does not quote decimal points, only complete units. The initial margin (explained below) is revised periodically by the risk committee. Margins are reduced by SAFEX for spread positions. The minimum price movement is one index point (which would be ten Rands as each point is multiplied by 10 to ascertain the value involved). The expiry valuation method is the arithmetic average of the index taken every two minutes over the final two hours of trading on the expiry date as calculated by the JSE. The settlement method for the ALSI40 contract is cash settlement and the clearinghouse fees are R 1.00 per futures contract (SAFEX, 1999 : ifmdspecs.htm). The rest of the contracts are detailed in appendix 3.1.

A third feature of a futures contract is that a clearinghouse guarantees the obligations associated with it. In the cast of SAFEX listed futures the clearinghouse is SAFCOM. This guarantee ensures the market functions correctly and thus creates confidence in the market by the market participants. The clearinghouse manages to achieve this guarantee by being the counter party to every trade. In the case of a buyer of a futures contract the clearinghouse will be the seller. In the case of the seller of the futures contract the clearinghouse will be the buyer. The clearinghouse then protects itself by ensuring that the number of futures contacts sold equals the number of futures contracts purchased. In the case of adverse market movements, this matching will protect the clearinghouse. The clearinghouse does expose itself in the case of credit risk. As the clearinghouse guarantees each trade entered into, in the event of a party defaulting on a payment the clearinghouse will have to expose itself by still settling with the counter party. The clearinghouse mitigates this in two ways. The first is the mark-to-market process (described below) and the second is through the penalties it imposes on a member in the event of the member defaulting. The clearinghouse thus protects all market participants from credit risk and thus allows for the smooth functioning of the market. In the event the clearinghouse did not exist, each market participant would have to obtain credit approval from each other market participant in order for trade to be able to take place. This would significantly impede the growth and functioning of the market as certain participants would not be able to trade with others due to their unfavorable credit ratings. Thus in the South African case all trades on SAFEX must go through SAFCOM, where SAFCOM is the counter party to each trade.

A further feature of a futures contract is that trading of the contract requires margin payments and daily settlement. This is discussed below. Briefly, this entails the trader putting down a percentage of the value of the futures contract, at the commencement of the trade, as a deposit. This is to guard against the clearinghouse losing in the event of default of the trader. This margin as it is called is added to each day or subtracted from depending on the extent of the fluctuation of the profit or loss associated with the futures contract.

Futures contracts can also be closed easily. This feature is as a result of the standard form of the futures contract. Closing of a futures contract refers to the case where the trader decided to reverse the position entered into. An example would be where a trader has agreed to deliver R 1 million worth of Eskom Bonds to a counter party at a set price and at a set date in the future. If the trader wants to rid him or herself of this obligation it would be done by closing the futures contract. There are essentially three ways to close a futures contract. The first is where the futures contract is closed through delivery of the underlying instrument or cash settlement of the profits or losses accruing to the contract. Some futures contracts are written in such a way that actual delivery of the underlying instrument must take place on the expiry of the futures contract. This would normally be the case for the commodity based futures contract. Here, the exiting of the futures contract at expiry of the contract would be achieved by actually delivering the underlying good. With the development of the financial futures contract actual delivery became difficult or impractical (especially in the example of the index futures, where, if the contracts were not cash settled, the seller would have to deliver the index to the buyer on expiry). An alternative was developed – cash settlement. This can be best illustrated by means of an example: Suppose party A enters into a contract to purchase 100 De Beers shares at R180 one month from now. Suppose at the end of the period the actual price of De Beers is R 175. In this case the buyer in the futures contract has realized a loss. The share is R 5 cheaper in the market that what has been agreed to as per the futures contract. In the case where the contract was to be settled through actual delivery the buyer would have to purchase the R 180 share from the futures contract counter party and sell it into the market, thereby realising a R 5 loss. Where the contact is cash settled the buyer merely pays the seller R 5 and the contract's obligations are fulfilled – no actual delivery of the underlying instrument takes place. This type of contract is common for futures based on indices, as it is often impractical to deliver the underlying instruments in this case.

The second method of settling a futures contract involves the offsetting the original trade by the entering into of a reversing trade. Taking the above example and extending it: the buyer of the De Beers future could contract to sell one De Beers share for the same expiry date and for the same amount. This would have the effect of "immunising" the buyer from any movement in the De Beers share. It is important to note that the buyer must ensure that the terms of the two contracts are the same. If this is not the case the buyer has not managed to fully reverse the position entered into.

The third method of closing a futures contract is known as an exchange for physicals or ex-pit transaction. In this transaction two traders agree to simultaneous exchange of a cash commodity and futures contracts based on that cash commodity (Kolb, 1997 : 13). Adapting the above example, assume the buyer in the futures contract wants to actually acquire the De Beers share and the seller in the futures contract actually wants to sell a De Beers share that is in his or her possession. In this case the buyer agrees to actually buy the De Beers share and cancel the futures contract and pays the seller. The seller agrees to actually sell the De Beers share and cancel the futures contract and delivers the De Beers share to the buyer. The exchange is notified and adjusts its books to acknowledge that the buyer and the seller are out of the futures market.

The last feature of futures contracts is that they are regulated by identifiable agencies.

3.2 The Forward versus the Future.

Another type of instrument that resembles the future is the forward or forward agreement. The forward agreement is a future that does not comply with the above characteristics. An agreement between two parties to exchange a motor vehicle at a set price at a set date in the future would be an example of a forward. This contract would typically not be traded on an organised exchange. It would not be a standardised contract – it would commonly be tailored to meet the counter parties' needs. There would be no clearinghouse to guarantee the performance of the parties to the contract. It would be unlikely that there would be any margin payments and the contract would be difficult to exit without entering into new negotiations with the counter party. There would also be no identifiable agency or authority that would regulate the contract.

The best known forward market is the market for foreign exchange. All trades are done over a network of telephones and only through approved counter parties. The market participants have to assess the credit risk of each counter party before being able to trade with them, as there is no organisation to guarantee the performance of the counter party.

3.3 Futures Trading.

When buying a future there are a number of orders one can give to one's broker. These orders will depend on the reason for the trade and the urgency of the trade. Briefly, there are three basic types of orders, namely the market order, the limit order and the stop order. Once the order has been entered and the transaction executed the issue of how the trade is actually settled becomes an issue. Each of these issues and concepts are described below.

3.3.1 Market order.

An instruction is sent to the broker instructing him or her to execute the order at the current market price. This type of order is usually given where there is some urgency to conclude the trade. The broker is not allowed to use his or her discretion when executing this type of trade. (Lambrechts 1990: 13).

3.3.2 Limit Order.

In this case the client sends an instruction to the broker to buy or sell the futures within set parameters. The broker then has the discretion to execute the transaction under better terms than this. The parameters are usually related to either the time within which the transaction must be completed or a set price. In the case of a set price the buyer will determine a price above which the trade must not occur, and it is then up to the broker to conclude the trade at a level below the price set. The converse applies to the seller. Limit orders are also known as "limit-only" orders or "or better" orders (Lambrechts, 1990 : 13).

3.3.3 Stop Order.

Stop orders are designed to limit the possible loss faced by a market participant by setting predetermined prices that, if the future trades at that price, the broker must execute either a sale or a purchase depending on the type of stop order. Stop orders are also known as stop-loss orders. The stop loss traditionally refers to the case where the market participant holds a long position in a future and leaves an order with a broker that instructs the broker to sell in the event of the price of the future dropping to a set level. Practically the trade will only take place at the closest level to that of the stop loss.

3.3.4 Settlement

Traditionally, futures have been settled at the expiry of the futures contracts through physical delivery of the underlying instrument. This is because traditionally futures were used by farmers to hedge away price risk while their crops were still in the field. In SAFEX futures on specific shares and bonds are physically settled. The index, short-term interest rate and Rand Dollar futures are settled in cash and no physical delivery of the underlying takes place. According to Lambrechts (1990 : 35) physical settlement is important to ensure the convergence of cash and futures prices as the futures contract moves towards expiry. This is because if this convergence does not occur arbitrage opportunities present themselves between the spot and the future. This convergence is important because is provides the basis of pricing for futures contracts.

The main reason for cash settlement is to avoid the transaction costs involved in settlement and regulatory constraints (as is the case with the Rand Dollar future). In the event index based futures were to be physically settled, this would lead to the creation of share "baskets". These baskets would be made up of the shares that constitute the index. To construct this basket the market participant would be faced with costs such as brokerage and the spread on each share as well as the added cost associated with creating odd-lot orders.

One prerequisite for a cash settlement system to work correctly is the existence of an efficient underlying spot market. This is needed because the spot market will be used as a reference point for calculating the futures settlement price. The spot price should be "widely available and easily accessible, uniform and representative as an industry standard, immune to manipulation by any interested party and an accurate barometer of the value of the commodity or security" (Lambrechts 1990 : 35).

3.4 The Basis and Spreads.

The basis is a key concept in the understanding of futures prices. The basis is the difference between the current cash or spot price and the futures price. Thus the basis is the relationship between the current and future prices. A spread defines the relationship between futures of different maturities and different underlying instruments.

3.4.1 The Basis

The futures price normally used in the determination of the basis is the near future (the future next in line to reach expiration). This basis is prone to diminish over the life of the futures contract. The reason for this can be seen in the pricing of the futures contract, however, the basic logic behind it is that by the end of the life of the futures contract the price of the future and the spot price should be equal. The basis will thus be zero at this point. This is known as convergence. The basis is typically more stable than the actual future or spot prices. This is because the basis defines the relationship between the two, which is subject to arbitrage opportunities if it does not hold. For an example of how this arbitrage works see below. The stability of this relationship is also due to the fact that the spot and futures prices should both react to information affecting the market.

With the basis comes basis risk. If a market participant decided to hedge a position it is done on the understanding that the relationship between the spot and the future will follow a predicted route. One way to ensure this is to hold the hedged position to the maturity of the futures contract. It is known that the spot and future prices will be equal at this point. A problem arises where the hedger wishes to unwind the hedge before the futures contract has matured. In this case the hedger is being exposed to a possible unanticipated change in the basis. As stated above, any unanticipated changes in the basis should be removed through arbitrage, however there could be delays in the arbitrage taking place. In this case the hedger will not exit the hedge in the same position as when the hedge was entered into, and the hedger will have either have profited from the hedge or experienced a loss. The risk of this happening is known as basis risk. The main source of this change in the basis is the movement in interest rates. This is because they affect the pricing of the future. How this occurs is described below.

This basis risk has led to the creation of arbitrage traders who enter into positions that are free of price risk (as each trading position is hedged) and speculate over the movement in the basis.

3.4.2 Spreads

Like the basis, spreads are relationships that should hold between futures of different maturities and underlying instruments. In the first case an example would be the relationship between the futures contract for the delivery of a basket of Didata shares in March and a futures contract for the delivery of a basket of Didata shares in June. In the second case an example would be the relationship between the futures contract for the delivery of a basket of Didata shares on March and the futures contract for the delivery of a basket of Comparex shares in March (Didata and Comparex are both large Information Technology companies listed on the Johannesburg Stock Exchange.). It would be reasonable to expect the two shares to have a relationship due to the relative similarities between the companies.

The trader will profit by exploiting these relationships. This will be done by buying the one contract and simultaneously selling the other. Similar to basis trading, the aim will be to profit from changes in the relationships where the one contract changes relative to the other. As with the basis trading where the spot and the future will tend to move in the same direction, futures related by either the virtue of their underlying spot instrument or their maturities will also tend to move in the same direction. The profit is made in the extent of each move. Another benefit of engaging in spread trading is the margin requirements tend to be less. This is explained in more detail below (under section 3.6 Margin and Marking to Market).

An example of a spread trade would be as follows:

Table 3.1 - Example of a Spread Trade.

Position on 9 June 1998

Contract	Price of Contract (A)	Number of Contracts (B)	Contract size (C)	Contract Value (A*B*C)
December 1998 ALSI	6,340	1	R 10	R 63,400
September 1998 ALSI	6,197	-1	R 10	R -61,970

Note: +1 Contract = buy, -1 Contract = sell.

Position on 4 September 1998

Contract	Price of Contract (A)	Number of Contracts (B)	Contract size (C)	Contract Value (A*B*C)
December 1998 ALSI	4323	-1	R 10	R -43,230
September 1998 ALSI	4153	1	R 10	R 41,530

Net loss on December Contract:	R	-20,170
Net gain on September Contract:	R	20,440
Net gain / loss overall:	R	270

A spread trader enters into a partially hedged position on the 9 June 1998 by buying 1 December 1998 ALSI contract and selling 1 September 1998 ALSI contract. At this point the trader should be partially hedged – one would expect both the contracts to react to movements in the underlying All Share Top 40 Index. On the 4 September 1998 the arbitrage trader decided to exit the position. This is done by reversing the trades, so 1 September 1998 ALSI contract is purchased and 1 December 1998 contract is sold. Table 3.1 shows the figures for each trade.

When the position is unwound the December contract has yielded a loss of R 20 170 while the September contract has yielded a profit of R 20 440 leaving the trader with a net, spread-generated profit of R 270. Note also, that the prices used in the examples are the closing rates for each day. The above example does not include margin requirements and does not take taxation into account.

Where a spread is between two contracts that have similar underlying instruments such as the Comparex – Didata example above, this is known as an intermarket spread. Where the spread is based on different maturities, such as in the ALSI example above, this is known as an intramarket spread. As the spread trader is also a speculator, losses can also be made. In the case of a loss the spread would be negative.

The partially hedged nature of the spread trade lowers the risks involved with this type of trade. The profit or loss that will result from a spread position will be less than the profit or loss that may result from an outright long or short position in a future. This is because the price risk is substantially reduced in the spread position.

3.5 The Pricing of a Futures Contract.

The pricing of a futures contract is based on the ability to arbitrage between the spot price of an instrument and its future price. Essentially, this arbitrage is based around the alternative of holding the spot position, in which case the market participant will incur costs such as the opportunity cost of holding cash and other transaction costs, and the holding of the futures position.

The futures pricing model is known as the cost-of-carry model or carrying charge theory of futures prices. This cost of carrying a good until a future date is broken down into four compartments according to Kolb (1997: 69), namely: storage costs, insurance costs, transportation costs and financing costs. In the case of a commodity based futures contract the storage cost will be the cost of actually holding the good. For example, if one were to purchase gold one would have to incur costs to keep it in secure environment. Likewise, this purchasing of gold would have to be insured against theft. If the trader purchased wheat the insurance would have to extend to cover risks such as fire. The costs that need some explanation are the financing costs. The most significant finance cost is the opportunity cost of the cash that is invested in purchasing the spot instrument – interest. According to Kolb (1997: 70), the interest rate that market participants have to bear is the repo or repurchase rate (see definitions for definition of repo rate). Lambrechts (1990, 139) uses the NCD rate, but this thesis was completed before the introduction of an active repo market into South Africa.

Ignoring all charges, except for the financing charges, the cost-of-carry arbitrage model can be illustrated through the following example:

Suppose a trader was faced with the choice between purchasing a September 1998 South African Breweries future (SABQ) or 100 South African Breweries shares (SAB) on the 3 July 1998. The analysis is as follows:

Table 3.2 - Cost of Carry Arbitrage Example

Prices for the Analysis	
Spot price of SAB on the 3 July 1998:	6350 c
Futures price of SABQ on the 3 July 1998:	662.5 c
Transactions:	
03-Jul-98	**Cash Flow**
Borrow R 6350 for 1 year at 10%	R 6,350.00
Buy 100 SAB shares in the spot market for 6350c	R -6,350.00
Sell 1 SABQ September 1998 futures contract for 662.5c	R -
Total Cash Flow	R -
30-Sep-98	
Deliver the shares against the futures contract	R 6,625.00 *
Repay the loan capital	R -6,350.00
Repay the interest (R 6,350 * 10% * 89 days)	R -154.84
Total Cash flow	R 120.16

* Note each contract is multiplied by R 10

When the arbitrage position is entered into on the 3 July 1998 the arbitrageur enters the position by borrowing to buy the underlying South African Breweries shares. In this example the interest rate is assumed to be 10%. The prices taken for the example are also the closing prices of the respective share and future. In order to hedge the position entered into, a futures contract is sold. The futures purchased are thus sold forward for delivery on the 30 September 1998. If the position is held to maturity the trader will not suffer any basis risk and all price risk should have been hedged away.

At maturity of the futures contract the shares are delivered against the futures contract. The arbitrageur receives the agreed price for the shares and repays the loan and the interest from these proceeds. In this case the arbitrageur is left with a surplus. This should not be the case, as the trader has been in a riskless position for the duration of holding the transaction. This leads to the cost-of-carry equilibrium where:

$$F_{0,t} = S_0 (1 + C) \qquad (1)$$

Where:

$F_{0,t}$	=	The price of the future in time 0 for delivery time = t.
S_0	=	The price of the spot instrument at time 0.
C	=	The cost of carry expressed as a percentage.

In the same way as the relationship between the spot and futures price is governed by the cost-of-carry model, the relationship with futures contracts of different maturities is governed in a similar fashion. The formula for the forward cost-of-carry model is:

$$F_{0,d} = F_{0,n} (1 + C) \qquad \ldots\ldots\ldots\ldots\ldots d > n \qquad (2)$$

Where:

$F_{0,d}$	=	The price of the future in time 0 for delivery time = t.
$F_{0,n}$	=	The price of the future in time 0 for delivery time = n.
C	=	The cost of carry expressed as a percentage.

The above cost-of-carry model needs to be adjusted for market imperfections. These imperfections primarily take the form of transaction costs. These transaction costs can be both direct and indirect. Direct transaction costs would typically be brokerage. Indirect transaction costs would include unequal borrowing and lending rates, limitations to storage (of the underlying spot indeed needed to be stored) and margins and restrictions on short selling. The direct transaction costs do not only include brokerage, but can also take the form of the spread. In the market the buyer will attempt to buy at a price lower then the seller is willing to sell at. The gap between the closest buy and sell prices - the spread - is cost the trader will have to pay to either acquire or sell the instruments.

Direct transaction costs affect the cost-of-carry pricing model as follows:

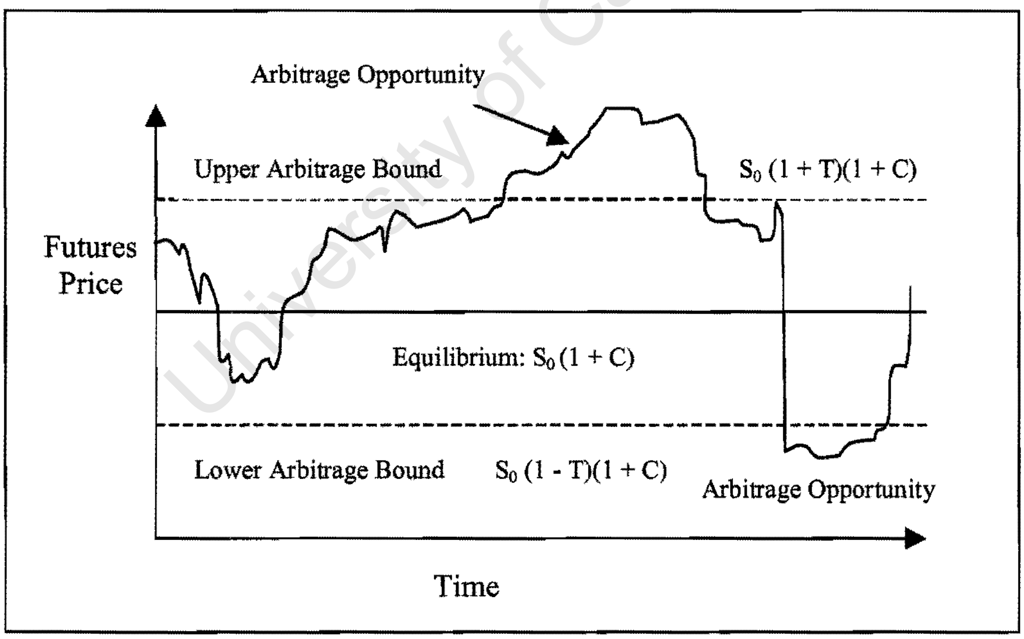
$$S_0(1 - T)(1 + C) \leq F_{0,t} \leq S_0(1 + T)(1 + C) \qquad (3)$$

Where:

$F_{0,t}$	=	The price of the future in time 0 for delivery time = t.
S_0	=	The price of the spot instrument at time 0.
C	=	The cost of carry expressed as a percentage.
T	=	The cost of executing the transaction.

This equation defines the no-arbitrage bounds of the future. These are the bounds within which the future may fluctuate without allowing market participants the opportunity to enter into the market and earn arbitrage profits by pushing the price back to its equilibrium. These bounds are illustrated below in figure 3.1:

Figure 3.1 - Arbitrage in an Environment with Transaction Costs.



(Source Kolb, 1997 : 81)

In typical markets the trader will only be able to borrow at one rate and lend at a different rate. The cost-of-carry model described above (1) does not allow for this, it assumes the trader can borrow and lend at the risk free rate. The impact of different rates is that the no-arbitrage bounds are widened. Unequal borrowing and lending rates impact on the cost-of-carry pricing model as follows:

$$S_0(1 - T)(1 + C_L) \leq F_{0,t} \leq S_0(1 + T)(1 + C_B) \qquad (3)$$

Where:

C_L	=	The lending rate,
C_B	=	The borrowing rate.

Most markets have some form of restrictions on short selling. These restrictions can be either regulatory or operational. In the case of regulatory the market authorities would dictate that short selling would, either not be allowed, or allowed under certain restrictive conditions. Operational restrictions would take the form of a shortage of loanable underlying instruments (or no market existing at all). To facilitate a short sale a trader needs to, in effect, borrow the underlying securities, sell them into the market and repurchase them at a future date for a lower price. (This is described in more detail below see 3.10). The cost-of-carry model described above (1) assumes that there are no restrictions on short selling. Short selling is needed to enable reverse cash-and-carry arbitrage and, in turn, keep the futures prices in equilibrium. The most common restriction regarding regulated short selling is the broker retains the proceeds of the short sale. The trader is thus only has use of the remaining funds. This restricts the trader's ability to execute reverse cost-of-carry arbitrage. The impact of the trader only being able to use a fraction of the proceeds of a short sale are demonstrated in the formula below:

$$S_0(1 - T)(1 + f C_L) \leq F_{0,t} \leq S_0(1 + T)(1 + C_B) \qquad (4)$$

Where:

f	=	the fraction of usable funds derived from the short sale.	$1 > f > 0$

The final restriction is embodied in any limitations to storage of the underlying instrument. This will primarily affect futures where the underlying instrument is a commodity. In the cost-of-carry arbitrage strategy, one needs to hold the underlying instrument until the strategy is closed out. It is for this reason that it is this leg of the futures pricing formula that is affected by storage costs. Storage limitations will be treated on a case-by-case basis when determining the ability to execute the cost-of-carry arbitrage strategy.

Another aspect of the cost of carry model is that it will allow the user to determine an implied repo rate. This is done by rearranging formula (1):

$$C = S_0 / F_{0,t} - 1 \qquad (5)$$

This will arise when one has the actual price of the future and the actual price of the spot. By feeding these variables into the cost-of-carry model one will be able to determine the interest rate that is implied through the differential in prices. This implied repo rate is compared to the actual repo rate. Where the actual repo rate is significantly higher or lower than the repo rate implied by the cost of carry model there is an opportunity for arbitrage to take place in the form of the cost-of-carry arbitrage or the reverse cost-of-carry arbitrage.

The model to price the futures contract has been outlined. It will be further adjusted in chapters below to take into account specific issues that occur in both the data and the South African environment. The day to day operations of the futures contract are governed by the margin requirements stated in the contract and the mechanism of marking to market.

3.6 Margin and Marking to Market.

To enter into a futures position a market participant needs to furnish the exchange with margin. This is a cash deposit that acts to guarantee the trader's ability to fulfill future commitments. The margin thus ensures the integrity of the futures market. The margin is essentially security or collateral against the futures position the market participant has entered into.

The margin deposits earn interest. The interest rate on the margin deposits is quoted daily and accrues to the trader over the period that the collateral is deposited. The margin requirements are decided by SAFCOM who the margins are deposited with and who pay the interest on the margin. This is the official margin, the brokers may require further margin from a client of they so wish. SAFCOM will change the margin requirements depending on the underlying condition in the markets. Margin requirements are an additional cost to market participants. This can be explained by the opportunity cost involved in allocating available cash to margin accounts. Market participants may have a use for cash that would yield a higher rate of return. By placing their cash resources in margin accounts they will not be able to earn more than the short-term risk free rate as this is what SAFCOM would invest the funds in. It is for this reason that the margin requirements are set as low as possible by SAFCOM - to reduce the cost of trading for the market participants.

Margin comes in three forms, namely: initial margin, maintenance margin and variation margin. Initial margin is the margin the trader initially advances to the broker (who will, in turn, forward it to SAFCOM) in order to be able to enter into the trade. Once the trade is entered into the trader will have to ensure the margin is maintained above a minimum level as the price of the future fluctuates. This level is known as the maintenance margin. In the event the margin falls below the maintenance margin level the trader will be called upon to make deposits into the margin account to raise the margin back to the maintenance level. These additional margin deposits are called variation margin. The effect of there always being margin in an account has the effect of having all the cash flows concerned with a trade having taken place before the trade is concluded. If the trader does not adhere to the margin call - the call to deposit more variation margin - the broker will be obligated to liquidate the trader's position at current market levels and recover any loss from the margin account and the personal assets of the trader.

In the setting of the margin levels, the exchange (in the case of South Africa, SAFCOM) take into consideration the trader's inter and intra market spreads (see above 3.4.2) as well as market conditions. Before looking at the setting of margin requirements one must understand the attitude of SAFEX to risk. This can best be summed up as "You stand good for your client" (SAFEX, 2000 iRiskMan.htm). This means that the broker must stand good for the losses of its clients and the clearing members must stand good for the losses of the other members who use them. It is for this reason one finds the brokers will be inclined to ask for additional margin over and above what SAFEX requires. SAFEX bears the ultimate risk, if a client, broker and clearing member were to default, SAFEX would have to stand good for the losses.

In setting margin requirements SAFEX uses the SPAN (Standard Portfolio Analysis of Risk) methodology introduced by the Chicago Mercantile Exchange in 1987. The premise SPAN is based upon is that one needs to consider an entire portfolio when setting margin requirements and not just the individual trades. This is because of the possibility of an inter or intra market spread existing within a portfolio. This reduces the risk profile of the portfolio due to the fact that certain trades may offset one another (hence the spread). Inter market cross-margining is a system that establishes the margin requirements by considering the spread positions that exist within a trader's portfolio across different exchanges. As there is only one futures market in South Africa this will not be applicable to the margin determination. Intra market cross-margining takes into account all the time series spreads, or spreads based on similar underlying instruments, into account. As part of a spread position one will sell the one contract and purchase the other, similar, contract. This reduces the final risk exposure and the margin is set lower accordingly. Intra market cross-margining can best be described by means of an example:

Suppose one has two contracts on the same underlying instrument that have been entered into - there is an agreement to purchase the September ALSI contract and a counter agreement to sell the December contract. One has a time series spread and the risk has been reduced as one is buying and selling the same instrument. While the two contracts are held the margin will be reduced by the effects of offsetting and the effects of spreading. A new parameter will be calculated - the Class Spread Margin Requirement (CSMR) - which will be the new margin arising on the spread position. In the case where a position contains options or a less straightforward mix of contracts, the calculation becomes more complicated. The principles remain the same, however, the capital needed to enter the positions is optimised by using the minimal amount of margin (SAFEX, 2000 iRiskMan.htm). A numerical depiction of the above example can be seen below:

Table 3.3 - Example of Margin Setting.

Contract	Number of Contracts	Initial Margin Per Contract	Class Spread Margin Requirement per contract	Total Margin
September	+1	R 3,500	R 1,000	
December	-1	R 4,000	R 1,000	
		R 500	R 2,000	R 2,500

Based upon a SAFEX example (SAFEX, 2000 iRiskMan.htm).

In the above example, because the September contract is purchased and the December contract sold the initial margins for each contract cancel each other out. This leaves a total initial margin requirement of R 500. It is for this reason that another level of margin is determined based on the total risk to the net position. This results in a total margin of R 2,500 that is paid upon entering the position.

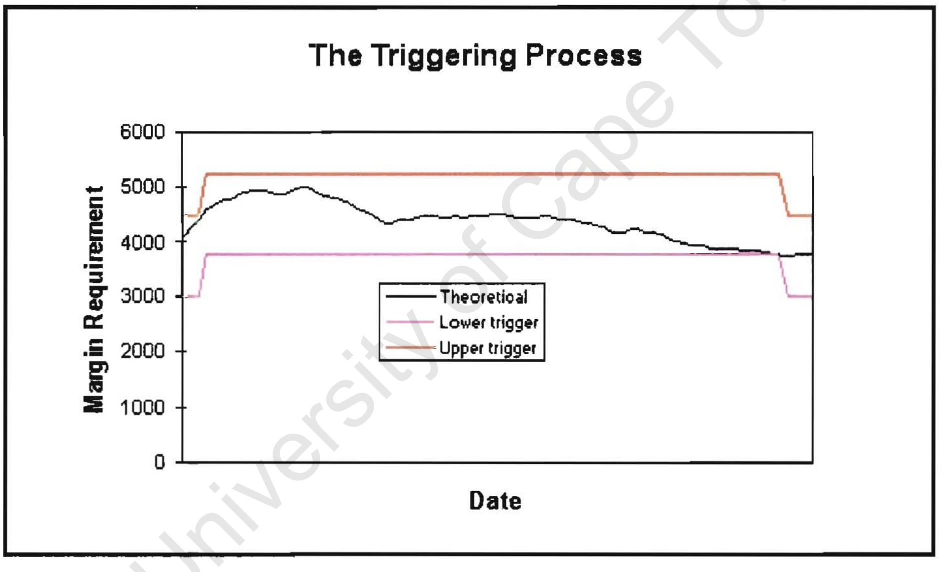
SPAN offers cross-margining between futures and options on futures by considering the entire portfolio in setting margin requirements (Kolb, 1997 : 35). The SPAN system considers 16 possible "what if" scenarios to determine the appropriate margin. The SPAN system computes how the value of a portfolio would change under each of the 16 different scenarios. (Kolb, 1997 : 35). The trader's portfolio is scanned at a number of points over a wide range of market moves. In a similar fashion to Value At Risk, the largest possible loss is computed over this range. The range is the anticipated market moves for the next trading day, which are calculated statistically. The exchange, once having identified the expected largest possible loss, sets the initial margin requirements equal to this. (See Appendix 3.2 for the 16 SPAN scenarios).

The body responsible for setting margins within the SAFEX / SAFCOM structure is the Risk Management Committee (RMCO). Each clearing member has a seat in RMCO as it is the clearing members that underwrite the exchange (SAFEX, 2000 iRiskMan.htm). Briefly, RMCO determines the "Risk Parameter". This is the number of standard deviations that is used to determine the possible worst-case loss and thus the margin requirements. Since it has been introduced, the standard deviations have been set at 3.5 (SAFEX, 2000 iRiskMan.htm). At a given volatility the prices between 3.5 standard deviations can be calculated. Once a scanning range is determined using the standard deviations the table in appendix 3.2 is used to determine maximum loss. 3.5 Standard deviations equates to a 99.95% confidence level. This means that the possible loss that will be determined will be the greatest statistically calculated loss to occur over 2000 trading days. This is biased towards normal trading conditions. In a period of uncertainty or market instability the margins may be set temporarily higher. This can be done using an "intra-day margin call".

This is where all positions are marked to market during the day and margin requirements are recalculated using different rates (SAFEX, 2000 iRiskMan.htm). These margin rates should thus change daily given the fact that market conditions are constantly changing. It is for this reason that the initial margin requirements are set using a "trigger" process.

The trigger process is where initial bandwidths are set around the calculated margin requirements. (See figure 3.2) In the below figure, the center line depicts the daily-calculated margin requirements. Margin requirements are actually set beyond a bandwidth around these lines that is shown using the lower and upper trigger lines. This results in the actual initial margin requirements only changing periodically and not on a daily basis. Once the trigger is breached this results in new margins being set.

Figure 3.2 - The triggering Process.



Source: SAFEX, 2000 iRiskMan.htm

From figure 3.2 one can see that the theoretical margin line (center) moves. This is primarily due to changes in volatility. It is for this reason that volatility needs to be calculated on a daily basis. SAFEX uses the greater of a long-term volatility and the overnight volatility to set margins. The long term period used is 750 days or three year volatility periods of daily historical closing prices. The overnight market volatility is derived, according to SAFEX, as follows "... from the implied volatilities of at-the-money options quoted on the futures, where these exist. Where options exist on more than one expiry month, a weighted linear regression is performed to allow for the term-structure of volatility in finding the overnight volatility. If options do not exist on a contract, the contract's own 30-day exponential historical volatility of the contract is used as a surrogate for the overnight market volatility...." (SAFEX, 2000 iRiskMan.htm). This will result in the authorities setting higher margin requirements during periods of higher volatility (assuming a trigger level is breached). Volatility is concentrated on when a portfolio contains options.

Current SAFEX margin requirements are listed below. They became effective on Friday, 19th May 2000, for settlement on Monday, 22nd May 2000.

Table 3.4 - SAFEX Margin Requirements.

	ALSI	FINI	INDI	RESI	RNDD
IMRs:					
Jun-00	6000	**4000**	8000	**8500**	**25000**
Sep-00	6000		8000		
Dec-00	6000				
Mar-01	6000		9000		
Mar-02	**7000**				
VSRs:	2.50	2.50	**3.00**	2.50	1.25
CSMRs:					
Jun-00	**700**	**500**	1000	**700**	2500
Sep-00	**700**		1000		
Dec-00	800				
Mar-01	800		**1000**		
Mar-02	800				

	R150	R153	R157	R162	JBAR
IMRs:					
Jun-00					2500
Jul-00					2500
Aug-00	25000	35000	35000	**17500**	2500
Sep-00					2500
Nov-00	25000	35000			
Dec-00					2500
Mar-01					2500
VSRs:	0.80	1.00	1.25	**0.60**	0.09
CSMRs:					
Jun-00					**600**
Jul-00					**600**
Aug-00	2000	2250	2500	1750	600
Sep-00					**600**
Nov-00	2000	2250			
Dec-00					**600**
Mar-01					**600**

	AGLQ	DDTQ	FSRQ	RCHQ	BOEQ	CPXQ	SABQ
IMRs: Jun-00	**4500**	**1200**	**100**	**1500**	100	**500**	**800**
VSRs:	4.00	**5.5**	4.00	3.50	4.00	5.00	3.50
CSMRs: Jun-00	**500**	**150**	25	**175**	25	75	**100**

(Source SAFEX, 2000)

IMR = Initial Margin Requirements.

VSR = Volatility Scanning Range.

CSMR = Class Spread Margin Requirement

Marking to market is the process whereby each day a trader's positions are recalculated using the current spot rates. This may result in variation margin being called for by the broker. As margin requirements are relatively small when compared to the underlying exposure inherent in the futures contract, small movements in the prices of the futures contracts or the underlying spot instruments can lead to margin requirements being breached. This would be when the margin held on account for the trader falls below the maintenance margin limits. The trader would transfer funds into the margin account to complete the mark to market process. The mark to market procedure occurs at the close of trade each day for the duration the trader holds the position.

As per Lambrechts (1990: 24) there are three steps involved in the marking to market process. The first step involves the calculation of the closing price of the futures contract. This is followed by the marking to market of open positions since the previous day. The final step comprises the mark to market of the transactions of the current day (Lambrechts 1990: 26).

In the calculation of the day's closing prices SAFCOM takes the closest bid and offer prices at the close of trading at 5:30 pm. The average is then calculated by adding the two together and dividing by two. The second step involves the following calculation:

$$A \times B \times C \qquad (6)$$

Where:

A = position,

B = change in closing price and

C = value factor. (Lambrechts 1990 : 26)

In this calculation the profit or loss is determined by multiplying the total change in market exposure by the value factor. The value factor is outlined in the contracts of each future. The value factor can also be known as the contract size. (See appendix 3.1 for SAFEX contract sizes).

Once this calculation has been completed the profit or loss on the trade for the current day is calculated:

$$D \times E \times C \qquad (7)$$

Where:

D = position,

E = change in prices (Lambrechts 1990 : 26).

The total mark to market amount is equal to the summation of the second and third steps.

3.7 Limits.

There are essentially two types of limits that a futures exchange can set, namely position limits or price limits. The reason for limits being set is to stop the market from destabilising past an unacceptable point. Each exchange will determine what this "unacceptable point" is. The effect of implementing the limits is to increase the time span over which new information is introduced into the market. The theory is that this will reduce excessive or wild speculation and keep the market orderly. An example would be when a market crash occurs. During this period there may be an excess of uncertainty within the market. This could cause the market to fluctuate wildly. When the limits are breached trading is suspended. This is supposed to allow the traders to digest the information surrounding the event (in this case a crash) and when the market next opens, reduce the heightened volatility.

A prolonged imposition of price limits, according to Lambrechts (1990:15), may result in the markets closing for long periods of time. This may result in significant losses for market participants as they are unable to close their positions and thereby stop their losses. It is for this reason that price limits may, if applied rigidly, become destructive and interfere with fundamental market forces. It is for this reason that an exchange is able to change price limits as trading conditions change. This variable price limit enables the market to follow the fundamentals affecting it, more closely.

Another factor to be aware of with regards to price limits is the competition between the different exchanges. One exchange may have stringent price limits that act to significantly reduce trading volatility during periods of instability. The breach of the price limits and the consequential suspension of trading may turn traders away from the exchange to conclude their deals and close their positions in other exchanges with less onerous price limits. In South Africa this is not really an issue as there is no direct competition for SAFEX. One must, however, be aware of this as the Chicago Board of Trade recently had a future listed on South African Rands, which illustrates how exchanges can take business away from one another.

In any futures research one must be aware of price limits being imposed and subsequent suspension of trade. This can lead to apparent arbitrage opportunities if the spot market remains open when the futures market closes. In reality there are no opportunities as one cannot take advantage of them because of the closure of the futures market. In the history of SAFEX there is no evidence of price limits being imposed.

Position limits center around the ability of an individual or group of market participants to control a financial instrument. Position limits are thus designed to guard against market participants attempting to corner the market. The position limit limits the trader's total allowable position. In the history of the markets there have been numerous attempts to corner the market. In 1979 - 1980 there was an attempt to corner the silver market. It was known as the Hunt Silver Manipulation (Kolb, 1997: 41). This was done by the traders attempting to purchase all the available silver as well as the silver futures contracts. This allows the traders to control the price and extract significant profits. The exchange will react to this by ordering the traders to sell a portion of their holdings. To prevent this, position limits are imposed. Position limits can be complex in their application as exchanges need to take into consideration how the positions are constructed. One could find a broker serving two different clients who are both taking large positions in a specific future, however, the positions may be taken for completely different reasons. Like price limits, there has been no evidence of an implementation of position limits within SAFEX.

3.8 Interest Rate Futures versus Equity Futures.

The above description of the futures contract is a generic one. This has to be adjusted for the specifics of the contracts. In the case of financial futures there are two distinct types - the interest rate and the equity future. In the case of each one the generic formula ((1) in section 3.5) needs to be adjusted for the change in the underlying instrument.

In the case of the equity futures there are two distinct types - the individual stock future and the stock index future. Each one results in similar adjustments to the generic cost of carry futures pricing formula. In the case of the equity future the complication that arises is the fact that dividends are received by the stockholder. In the case of the stock index futures the market participant will receive dividends on the underlying shares making up the index if the preference is to hold the index rather than the future. The holder of the stock index futures will not receive, or benefit from, dividends as the futures are linked to the price of the index that excludes dividends. When pricing equity futures one needs to take into account the dividends that will be received between the time the futures contract was purchased and when it either closes out or matures.

The receipt of the dividends lowers the cost of holding the stocks. In the cost of carry model the holder of the underlying shares incurs a cost for holding them. The largest cost (established in 3.5 above) is interest on the cash employed in the purchase of the shares. The receipt of dividends constitutes a return of this cash and should thus reduce the cost of carrying the shares. From this one can conclude that the cost of carrying an equity future needs to be adjusted by the value of the dividends received while holding the stocks. This results in the following formula:

$$F_{0,t} = S_0 (1 + C) - \sum_{i=1}^{N} D_i (1 + r_i) \qquad (8)$$

Where:

$F_{0,t}$ = The price of the equity future in time 0 for delivery time = t.

S_0 = The price of the underlying stock or index at time 0.

C = The cost of carry expressed as a percentage.

D_i = The i^{th} dividend.

r_i = The interest earned on carrying the i^{th} dividend from its time of receipt until the futures expiration at time t. (Kolb, 1997 : 231).

Again, as in the generic futures price determined in formula (1) above, this new formula must be subject to adjustments for market imperfections. The imperfections are applied to the above formula in the same manner as they have been in 3.5 above.

The interest rate future includes money market futures and bond, gilt and other interest paying instruments that have futures written on them. The principles are the same as in the case of the equity futures: the futures price needs to be adjusted by the interest that the holder of the underlying instrument receives over the time the positions are held for. When looking at interest rate futures it is important to note that in the South African case, at expiry of the future the underlying instrument has to be physically delivered. This differs from the foreign futures markets such as the Chicago Board of Trade where settlement is achieved using the cheapest to deliver bond and not one specific underlying bond. For this reason South African bond futures are easier to understand but are less flexible.

When pricing the interest rate future one has to be aware of the differences between the short term underlying instruments and the long-term instruments. On SAFEX there are two short-term futures contracts, namely the futures contract on Banker's Acceptances (BA's) and the futures contract on the Johannesburg inter-bank agreed rate (JIBAR) rate. There are currently four long term futures contracts all written on underlying South African Government Bonds, namely: R153, R150, R157 and R162. The reason for the pricing difference is that in the case of the long-term bonds one actually receives interest coupons whereas in the case of the short-term instruments they are purchased on a discount basis. This means that there are no interest cash flows, one simply pays less than the par value for the instrument when purchasing. Upon maturity of these instruments one receives the par value of the instrument. Even with this difference one still has to adjust the cost of carry model by the interest one receives when holding the underlying instruments. This results in the following formula:

$$F_{0,t} = S_0 (1 + C) - AI \qquad (9)$$

Where:

$F_{0,t}$	=	The price of the interest rate future in time 0 for delivery time = t.
S_0	=	The price of the underlying bond at time 0.
C	=	The cost of carry expressed as a percentage.
AI	=	The accrued interest from the underlying bond.

This equation is very similar to equation number (1). One has the same cost of carry relationship, but is adjusting it for the interest that is earned on the underlying bond. This equation will also be adjusted for the market imperfections as described in 3.5 above.

3.9 Portfolio Insurance, Program Trading and Securities Lending.

In this part of the chapter some of the concepts surrounding futures and the trading thereof are explained. Risk is managed through the use of portfolio insurance and program trading. Securities lending is used to facilitate the arbitrage which is necessary to ensure an efficiently priced futures market. Market volatility is often seen to be caused by these advanced strategies - this is not always the case.

3.9.1 Portfolio Insurance.

Portfolio insurance refers to a collection of techniques for managing the risk of an underlying portfolio (Kolb, 1997, 263). This will be achieved practically by attempting to set a floor on the value of a portfolio while managing to ensure that there is no ceiling in place. The basics of portfolio insurance involve the application of what is known as dynamic hedging. This is where one enters into futures positions in the opposite direction to one's current underlying exposure (i.e. implement a hedge) to reduce one's exposure to a loss. This is best understood by means of an example. Suppose one has a portfolio of equities with an initial value of R 1 million. One would decide what floor one would be comfortable with. In the example a floor of R 900 000 is assumed. As one is long of the underlying shares one would sell the shares forward to hedge the exposure. In this case we assume R 500 000 of the portfolio is sold forward. The portfolio is now 50% hedged. This has had the effect of reducing the exposure, while reducing the possible maximum payoff of the portfolio. Say the value of the underlying portfolio drops to R 990 000. To ensure the floor is kept, the portfolio would have to be further hedged. In this example another R 50 000 of the portfolio would be sold forward. This would have the effect of increasing the proportion of the portfolio that is hedged to 56%. If the portfolio dropped to R 980 000 it would have to be hedged further. Another R 45 000 of the underlying stock would be sold forward. This would have the effect of increasing the hedged portion of the portfolio to 61%.

As one can see the percentage of the portfolio is increased as its value nears the set floor. Upon reaching the floor the portfolio would be 100% hedged. This would restrict the portfolio to earning the risk free rate. As the value of the portfolio increases the hedges would be unwound. Hence the dynamic nature of the hedges. Portfolio insurance is thus the use of futures to reduce the underlying exposure of a portfolio to loss, while still allowing some exposure to gains.

3.9.2 Program Trading.

Program trading is also known as portfolio insurance. It also involves a dynamic trading strategy designed to reduce the losses a portfolio may be exposed to. Where, as the value of a portfolio drops, portfolio insurance described above advocates forward selling, program trading advocates selling off part of the portfolio itself.

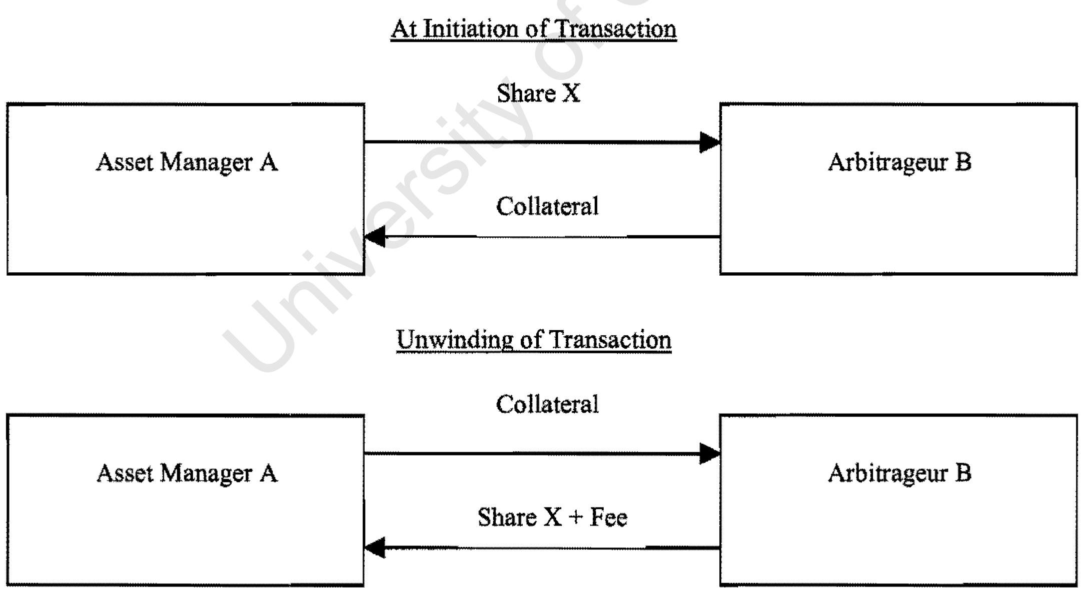
Program trading was partly blamed for the 1987 stock market "crash" according to Bernstein (1996 : 319). This was because as the values of the portfolios fell and positions were liquidated, so the general price level fell as well. This caused a spiral effect and result in prices dropping quickly as selling increased through the use of program trading. After the week of Monday 19, 1987, the portfolios "protected" by portfolio insurance were subject to losses similar to those who had not opted for portfolio insurance (Bernstein, 1996 : 320).

3.9.3 Securities Lending.

Securities Lending has also been accused of destabilising markets. Securities lending is a term that refers to the practice of a portfolio manager lending out underlying equities and bonds to facilitate arbitrage strategies. This can best be explained by means of an example:

Asset manager A has a long term holding in stock X. Arbitrageur B needs to borrow share X to complete a short strategy. Arbitrageur B enters into a transaction with asset manager A whereby Arbitrageur B borrows share X from the asset manager and sells it. The aim of the transaction for the arbitrageur will be to wait for the price of the share to drop, buy it back at as lower price and deliver it back to the asset manager in settlement of the loan. Asset manager A enters into the transaction to earn a lending fee - the asset manager will charge the arbitrageur a fee, which in South Africa, typically varies from 0.5% (50 basis points) to 2.5% (250 basis points) per year, of the initial value of the shares loaned out. It is important to note that there are no set guidelines as to what the fees should be - they are determined by market forces of supply and demand. See figure 3.3.

Figure 3.3 - Securities Lending Example.



As described before, part of the cash and carry arbitrage dictates that one must be able to short the underlying instrument. Practically this will be done by using a securities loan mechanism. If one was to enter a transaction involving the Sasol future listed on SAFEX and a reverse cash and carry arbitrage strategy was entered into, the Sasol share would have to be sold short at the inception of the transaction. This short sale would be hedged forward by means of a long futures contract on Sasol. In August 1999, the

Genesis report (Counihan, C & Malherbe, S, 1999) was issued which sought to investigate whether securities lending had a role to play in destabilising the South African markets. It was empirically proved that securities lending actually stabilised the South African market during periods of turbulence. As the main reason for securities loans being entered into is to facilitate arbitrage, this suggests that futures arbitrage is a stabilising influence on volatile markets.

3.10 Regulation in the Futures Market

The South African Futures Exchange (SAFEX) is governed by two sets of "rules". The first is the Financial Markets Control Act (Act No. 55 of 1989) as amended. The second is the rules of the South African Futures Exchange (SAFEX Rules) that came into operation on 1 July 1994 in terms of *Government Gazette* No. 15841 of 1 July 1994. The SAFEX rules will be dealt with under appendix 9.3.1 in the appendices below, while the Financial Markets Control Act will be dealt with under appendix 9.3.2 in the appendices below.

Chapter 4: Volatility – a Discussion.

The purpose of this thesis is not only to determine the pricing efficiency of SAFEX listed futures, but also to determine how this pricing efficiency reacts to market shocks. A proxy for market shocks is assumed to be an increase in volatility. The approach is to calculate the volatility and compare it against the significant market events during the period to determine if the shocks are identifiable through increases in volatility. Once the volatility has been determined it is compared to the change in the pricing efficiency in an attempt to identify any discernable patterns. According to Kolb (1997, 375) most of the debate surrounding volatility and futures has been around the possible volatility caused in underlying equity markets by the existence of financial futures. Some critics of index futures trading have sought to have the practice banned on the grounds that it increases volatility in the underlying markets. Consequently a number of studies were completed in this area. Their findings are discussed below. Whether financial futures increase market volatility or not would only affect a study covering a period before and after the introduction of futures trading. As this thesis covers a period starting with the introduction of futures trading, the issue of whether financial futures trading increases volatility is ignored as the focus is on the marginal or excess volatility.

4.1 What is Volatility?

The volatility of an instrument is the degree of variance in its price over a period of time. Increased volatility in a market increases the risk inherent in the market. This has implications for the pricing of the instruments listed on the markets. The cost of capital increases as one introduces more risk as investors need to be compensated for this risk. Increased volatility thus results in increased cost of capital and raises finance hurdle rates. This, in turn, can reduce the amount of finance available for businesses.

When measuring volatility one needs to be aware of the notion of excess volatility. In any market there will be a level of volatility experienced as prices fluctuate on a day-to-day basis. From time to time there may be periods where volatility increases due an event or string of events. This increased volatility is what is known as excess volatility. This chapter examines this excess volatility. The thesis compares these periods of excess volatility with the pricing efficiency of the futures contracts. Volatility can also be considered as being the annualised standard deviation of the natural logarithms of asset returns. This will be expressed mathematically in chapter 8.

For the purpose of measuring volatility in the context of this thesis one needs to be aware that there are two types of volatility - the volatility of the spot and futures market. The volatilites of these two markets are not necessarily the same. Theoretically they should by similar due to the arbitrage opportunities that would arise in the event they are not. If the spot market was, for example, more volatile than the futures market this would imply the prices in the spot market move more than the prices in the futures market. This would create situations where a spot price has moved and the related futures price has not. This would create the arbitrage opportunity as described in chapter three.

With regards spot market volatility, the term volatility describes the fluctuations in the price of a stock or other type of security. If the price of a stock is capable of large swings, the stock has a high volatility. The pricing of options contracts depends in part on volatility. A stock with high volatility, for example, commands higher prices in the options market than one with low volatility. Volatility is measured by an alpha factor; for example, a stock with a 1.4 alpha is regarded as one whose price will vary by 40% in a year. Also: a measure of the volatility of a security relative to an entire market, such as the Standard & Poor's 500 Index, is known as the security's beta or beta coefficient. (Hull, 1999 : 51).

Volatility is not necessarily a bad phenomenon. It does increase risk to market participants, but may increase trading opportunities. The risks that increase with the introduction of volatility are:

- Delayed trading information.
- Multiple prices.
- Inaccurate price quotes.
- Varied Price Executions.

4.1.1 Delayed trading information.

Increased volatility means that prices move faster than they normally would. For this to occur there would have to be an increased number of trades. During periods of increased volatility this increase in the number of trades can result in the delayed reporting of these trades. This delayed trading information would have an effect on any market participants' trading. Given participants will react to market information when making decisions, the delayed transmission of the market information will impair the ability to make decisions and thus increase the risk involved in trading. This risk related directly to the reporting of each trade put through by the market participant to the market participant. If the market participant puts a buy order through, hoping to make a profit from a small price increase, in a volatile market, the participant needs to know if and when the original buy order is executed. The longer it takes to notify the participant that the order has been filled the increased risk that the participant will not be able to exit the trade as planned. Thus, any delay in the reporting of any trade to a market participant will result in increased risk in a volatile market.

4.1.2 Multiple Prices.

This risk is related to the above one. This can best be described by means of an example. A market's volatility increased and a trader put through an order to sell 1000 ABCs at 100 cents in response to market report of a buy order of 2000 ABCs at 100 cents. On the order reaching the market the price had moved and the trader had only managed to fulfill part of the order at 100 cents, or alternatively, 50 ABCs were sold at 100 and 50 were sold at 90. This example shows the delay in the order reaching the market resulting in multiple prices being matched. In a volatile market, the increased number of orders could make any delay in transmitting a price to the market costly. This would increase the operational risk involved in trading.

4.1.3 Inaccurate Price Quotes.

This is similar to the first risk. In this case the risk is not that the trader is informed late of any orders the trader put through. This is simply the risk inherent in the delay of the transmission of market information during periods of volatility. This is because it impairs the decision making ability of the market participants and exposes them to the possibility of making incorrect trading decisions.

4.1.4 Varied Price Executions

This risk is similar in nature to 4.1.2 above. In 4.1.2, due to time delays in a volatile market orders risk being filled at multiple prices. In this case, again due to the volatility, the orders can be filled at a totally different price to what was expected. The trader will put in a market or "at best" order based on information that indicates prices at a certain level. Due to the delay in getting the order to market, by the time the order is executed the prices might change. As the order is a market order, the floor broker will be authorised to execute the trade at the market price that, due to the delay, might have changed. This risk of varied price execution impacts on the trader's expectations by introducing uncertainty into the decision making process. This, in turn, increases the risk involved in trading.

4.2 Possible Causes - The introduction of Futures Trading.

In answer to the question "Has stock market volatility increased with the introduction of financial futures?" Kolb (1997, 107) outlines the findings of twenty studies in this area. Working (1960) tested this hypothesis against the onion market. The findings were that the introduction of futures trading actually reduced the volatility of the underlying spot market. This was retested in 1963 by Gray. The results of this test were the same as in the Working's study - the introduction of futures trading actually reduced the volatility in the underlying spot onion market.

The focus of these studies remained on the commodity markets: Powers (1970) studied the effects of the introduction of futures trading on the cattle and pork market. Like the previous studies the conclusion was that the introduction of futures stabilised the underlying spot market. Taylor and Leuthold (1974) applied the above study to live cattle prices. The results were the same - the introduction of futures trading resulted in more stable prices after futures trading began.

Froewiss (1978) was the first to examine the effect of the introduction of financial futures trading on the underlying spot market. The study was conducted on the mortgage bond market after the introduction of mortgage interest rate futures. The results of this study was that the introduction of futures trading did not increase the price volatility in the mortgage bond market. This study was repeated in 1981 by Figlewski. The results in this case differed: the introduction of futures trading resulted in an increase in the volatility of the underlying mortgage bond market. A further study was completed on the impact of the introduction of futures trading on the mortgage bond market. The study was completed by Moriarty and Tossini (1985). This time the findings were that futures trading did not increase the volatility in the mortgage bond market. It must be noted that all these studies were completed on the United States mortgage bond market.

The last of the non-index futures studies reviewed by Kolb (1997 : 109) was completed by Antoniou and Foster (1992) who looked at the impact of futures trading on the Brent crude oil market. The findings were that the persistence of volatility in the underlying Brent crude oil market declined after futures trading commenced.

Index futures were first examined for their impact on volatility in 1987 by Santoni. The results of this study revealed that there was no significant increase in daily or weekly volatility of the Standard and Poors (S&P) index after futures trading on the S&P index was introduced. This study was backed up by Edwards in 1988 who reproduced the Santoni study and came to the same conclusion. The Edwards study was extended to include intraday data. Harris (1989) formed two groups, an S&P 500 group and a group of non-S&P 500 stocks to simulate S&P 500 stocks. The groups had the same volatility before S&P 500 futures commenced trading. After the futures have begun trading the S&P 500 stocks were slightly more volatile. This thesis thus supported the hypothesis that the introduction of index futures trading increases the volatility of the underlying spot market.

Lockwood and Linn (1990) found evidence to support the above view that volatility increases with the introduction of index futures trading. Their study was extended to include hourly returns on the Dow Jones indices and found that volatility increased after index futures commenced trading. Maberly, Allen and Gilbert's study (1989) found that volatility increases with the introduction of index futures trading particularly in bull markets. This view was refuted by the study conducted by Becketti and Roberts (1990) who found that there is little relationship between volatility in the stock market and the existence or volume of index futures trading.

Brorsen (1991) increased the scope of the study to include examining the effects of the deregulation of the charging of broker's commission. The study did look at the introduction of index futures trading and concluded that volatility did increase largely due to "reduced market frictions" (Kolb, 1997 : 382). Again, in 1991, Gerety and Mulherin found to the contrary. The Gerety and Mulherin study found that there was no systematic increase in volatility after the introduction of stock index futures. Bessembinder and Seguin (1992) recorder similar results in their study that examined whether volatility patterns in the stock market are related to volume in the futures market. They found there to be no relation between volumes in the stock futures market and the volatility of the underlying spot market.

The final two studies suggested an increase in volatility. Kamara, Miller and Siegel (1992) found that stock market volatility increased after stock futures trading commenced, but were unable to conclude as to what caused this. Jegadeesh and Subrahmanyam (1993) examined the bid-ask spread on the New York Stock exchange both before and after the introduction of stock futures trading. They found that, after the introduction of stock futures trading, the bid-ask spread increased which the authors suggest was due to trading volumes being attracted to the futures market.

The above studies show different results. The evidence suggests that the introduction of futures trading does not increase market volatility in all the markets with the exception of the stock market, the findings are not irrefutable. However, the weight of the evidence suggests that the introduction of futures trading to these markets does not effect a market adversely. In some cases these markets became more stable than they were prior to the introduction of futures trading. In the case of equity futures the studies are less conclusive. Some of the studies concluded that the introduction of stock or index futures trading resulted in an increase in volatility while others refuted this. Kolb (1997 : 389) concludes that the introduction of futures trading do not appear to result in increased volatility. His reasons for this are that there could be other reasons for any increases in volatility such as inflation or deficits. He does concede, however, that it is possible that the introduction of stock futures trading did result in an increase in volatility.

The studies were performed by calculating the volatility of the spot market before the futures were introduced and comparing it to the volatility of the spot market after futures trading had begun. This excludes studies such as Jegadeesh and Subrahmanyam (1993) who used a different methodology when looking at bid-ask spreads.

4.3 Possible Causes - Index Arbitrage.

The aim of this thesis is to examine the effects of volatility on index arbitrage opportunities. Kolb (1997 : 380). However, studies have been performed to examine if index arbitrage causes volatility. If index arbitrage causes volatility, this will impact on the study as a circular argument would ensue: index arbitrage causes volatility which in turn causes index arbitrage, which in turn causes volatility etceteras.

As described in chapter three, index arbitrage involves traders identifying opportunities where the price of an index future is different from its theoretical one calculated using the cost of carry model. In the event this is the case, traders will enter into the market and take advantage of the opportunity, thereby increasing trading volume. According to Kolb (1997 : 378) the positions are typically held to maturity (expiration of the futures contract) where they will be unwound as the futures price converges on the spot price. To avoid settlement procedures some traders will unwind their position once the discrepancy has been removed by entering into reverse trades, thereby removing the need to hold the position to maturity.

Critics of index arbitrage fear that as futures approach maturity, the desire to avoid settlement procedures will result in traders unwinding positions with increasing regularity as maturity approaches Kolb (1997 : 379). This would result in significant increases in trading volumes and volatility of the underlying prices. This, according to the same critics, will disrupt trading and push away investors who are averse to volatility. Kolb (1997 : 379) points out that this would only be the case if there was an order imbalance. If there were similar numbers of cost of carry position holders and reverse cost of carry position holders looking to unwind their positions, (and thus a balance in the orders) the trades would be filled without much effect on the market. One would thus not see an increase in volatility.

Index arbitrage only effects market volatility if two prerequisites are in place. Firstly, as the futures approach expiry the volatility could increase. Secondly, this would only be possible if there was some form of order imbalance between cost of carry and reverse cost of carry positions held by the market participants. The first part is examined below in 4.5. The effect of order imbalances were examined by the Brady Report (United States) which was a report commissioned in response to the October 1987 "Crash". The results of this report suggested that there was an order imbalance that resulted in increased volatility. However, the recommendations of the Brady report implied that the order imbalance was caused by increased volatility in the market. This was corroborated by a study completed by Bume, Mackinlay and Terker (1989 : 830) who found that S&P stocks fell 7% further than non S&P stocks. However, by the middle of the following day this has been rectifies and the difference had been mostly eliminated. The Bume, Mackinlay and Terker (1989 : 830) study also found a positive correlation between order imbalances and the fall in the stock prices, suggesting that index arbitrage destabilised the market.

Both the recommendations of the Brady report and the Bume, Mackinlay and Terker (1989) study pointed to the fact that index arbitrage only adds to the volatility in a market once the market has already become unstable through increased volatility. The further finding is that this does not remain the case as the index arbitrage also returns the stocks to the general market level.

One should expect the above to occur. In the case of a market that becomes more volatile, index arbitrage will have to take place to keep futures prices in line with the stock prices. This will introduce more trades into the market. This introduction of more trades could impact on the level of the stock prices. However, in this case where index arbitrage forces the prices out of equilibrium would induce index arbitrage in the opposite direction to return to the equilibrium where no arbitrage could take place. This would precipitate the conclusion that index arbitrage may increase volatility in times of increased volatility, but only temporarily.

The aim of this thesis is to examine the effects of excess volatility on the pricing efficiency of the futures prices. This will be done by examining the possible arbitrage opportunities that are created by the introduction of excess volatility. The above suggests that one should anticipate seeing two distinct stages in the arbitrage opportunities. The first stage should show one direction being predominant (for example cost of carry) and a second stage should show the opposite form of arbitrage being predominant (reverse cost of carry).

4.4 Portfolio Insurance.

The reason for the Brady report being commissioned was that critics of index arbitrage trading felt that, index arbitrage combined with portfolio insurance led to a destabilising spiral. The theory of this destabilising spiral is known as Cascade Theory (Kolb, 1997 : 385). Cascade Theory can best be explained by means of an example:

Portfolio insurers would look to reduce equity exposure as the markets begin to drop (for the dynamics of portfolio insurance see 3.9.1). This would be done by selling futures. This increased selling could result in the futures prices dropping below their theoretical values. When a future drops below its theoretical value the arbitrage strategy to apply is the reverse cost of carry strategy. This results in the index arbitrageurs buying futures and selling the underlying stocks in accordance with the arbitrage strategy. This results in the underlying stock prices being depressed further which, in turn causes portfolio insurers to sell more of their portfolio forward depressing futures prices further, encouraging index arbitrageurs to enter the market. In combination, the arbitrageurs and the portfolio insurers drive down both future and spot prices. This is Cascade Theory.

The above example shows how portfolio insurance can combine with index arbitrage to force markets downward. The regulatory authorities have taken steps to ensure this does not occur. The lead in this has come from the United States in the form of the Brady report recommendations. The main recommendation is the implementation of circuit breakers (Kolb, 1997 :387). Circuit breakers are halts in trading during periods of volatility. The effect of this is to "decouple" the stock market and the stock futures, allowing time to stop the circular pattern of the Cascade Theory. An example of circuit breakers are price limits. SAFEX has never implemented price limits but has the power to do so. This is because circuit breakers are controversial and their value unknown (Kolb, 1997 : 387).

Portfolio insurance when looked at in isolation can also be seen as a possible contributor to volatility in markets. This is through order imbalances. These order imbalances could affect stock prices as described above in 4.3. The order imbalances would arise through the portfolio insurance trades being executed in the same direction of the market. In the case where the market is falling, in terms of portfolio insurance, a forward sale has to take place that is in the same direction of the market. When the market is rising portfolio insurance dictates that purchases have to be made which are in the same direction of the market. When the trades are in the same direction of the market there is the possibility for order imbalances to result. As portfolio insurance is on the same direction of the market there is a tendency for portfolio insurance to contribute to the existing "momentum" of the market (Kolb, 1997 :379) and the result and volatility.

4.5 Futures Close Out.

There are two arguments that support the view that as the expiration date of a futures contract approaches, so the volatility of the futures price should increase. The first argument looks at the period up to maturity, while the second focuses on the volatility on the expiry day and, more specifically, the final trading session.

4.5.1 Period up to Maturity.

The original proponent of this theory was Samuelson (1965 : 41 - 49) who argued that the volatility of futures prices should increase as the contract approaches maturity. The Samuelson Hypothesis (as it has become to been known) assumes that competitive prices within a market keep the prices of the futures equal to the expected spot price at the contract's termination. This results in what is known as a "Martingale" which is a price process in which the expected value of the next price equals the current price, so the expected price change is zero (Kolb, 1997 : 108). Applying this to the term of a futures contract one can conclude that the futures price equals the expected spot price.

This links into volatility as follows: Little information is known about the future price of the spot instrument at the commencement of the life of the future. As the futures contract approaches maturity, more becomes known about the possible value of the future spot price. The closer to the expiry date the contract is, there is more introduction of information regarding the possible future value of the spot price. This increased introduction of information results in more movements in the expected price of the spot as the information is absorbed. As the futures prices follow a Martingale, they move as the expected value of the future spot price changes, which results in increased volatility in the futures market. Using commodities to illustrate the point, Kolb (1997 : 109) gives the following example:

Table 4.1 - Example of the Samuelson Hypothesis.

"Little is known about a corn harvest a full year before harvest time. As harvest approaches, the market gets a much better idea of the ultimate price that corn will command. For a futures contract expiring near the harvest, Samuelson's model implies that the futures price should be more volatile as the harvest approaches"

Source: Kolb (1997: 109)

Below are six studies that examine the evidence of the Samuelson Hypothesis in the commodities markets. Rutledge (1976) looked at the hypothesis in relation to wheat, soybean oil, silver and cocoa futures. The results were that the hypothesis was rejected in the first two cases but accepted in the case of silver and cocoa futures. Rutledge, thus did not prove for or against the Samuelson Hypothesis. Grauer (1977) looked for evidence of the hypothesis working on 10 different commodities. No support was found for the hypothesis.

In 1979, Dusak-Miller performed the same tests and found support for the Samuelson Hypothesis in live beef futures. This was further confirmed by the study performed by Castelino and Francis (1982) who found support for the hypothesis in wheat, corn and soybean complex futures. Anderson's study (1985) also supported the Samuelson Hypothesis but found evidence of other factors effecting volatility (Kolb, 1997 : 109). The above studies, combined with the results of the Milonas study (1986), which found support for the hypothesis in 10 out of 11 commodities tested, suggest that the Samuelson Hypothesis is correct. The bulk of the evidence supports its existence. Each of the above studies found there to be a type of seasonal volatility. The Samuelson Hypothesis supports this seasonal volatility; the seasons are linked to the maturity of the futures contracts.

Kolb (1997 : 110) comments that there could be other kinds of seasonal volatility. One of these mentioned (in the case of commodities) is the harvesting season influence. A study completed by Anderson and

Danthine (1983) concluded that a possible effect on the seasonal nature of volatility in futures prices could be the supply and demand for information concerning the underlying spot commodity or instrument. Another issue is the possibility of autocorrelation in the volatilities measured - if volatility is high in one month there is a possibility that it will be high in the following month. A final suggestion for other sources of seasonal volatility is given by Kolb (1997 : 110): the day of the week effect. This is where volatility appears to be higher on Mondays than on other days of the week.

4.5.2 Volatility on Expiry Day.

In 4.3 above, mention was made of market volatility increasing as futures approached their maturity or close out. This would illustrate futures contributing to periodic increases in volatility. Santoni (1987) observed what was termed a "jump" volatility. This jump volatility is the occasional extreme jump in prices. The existence of jump volatility does not necessarily mean that market prices have moved to a higher level of volatility, just that there are periods of heightened volatility. Santoni (1987) examined the effects of the introduction of index futures trading and only noticed jump volatility. He concluded that there was no evidence of increased normal market volatility.

When a market experiences order imbalances one should anticipate some degree of jump volatility. This would be intensified by an unwinding of an index arbitrage program that could possibly add to the order imbalance. This possible emergence of jump volatility as a futures contract approaches expiry has lead to a number of studies examined below. Part of these studies looked at what is known as the triple witching hour. This is when index futures, options on stock indices and options on the stock indices' futures expire. This simultaneous expiry has led to the term "the triple witching hour" as there is a heightened fear of excess or jump volatility. In the South African derivatives market the focus is more on the futures close out as this is where the market liquidity is the greatest. Most of the studies below find that there is increased volatility on these close out days, compared with other days. The jump volatility is concentrated in the last hour of trading. This is due to the method in which the final settlement price is determined. On SAFEX, the equity index futures' settlement prices are determined as follows: an arithmetic average of the index is taken every 2 minutes, over the final two hours of trading on expiry date, as calculated by the JSE (see appendix 3.1). On the Chicago Board of Trade the settlement price is determined in a similar manner. As the settlement price is determined over the last trading session, as the session draws to a close, so traders, not wanting to settle, will reverse their positions. This will result in increased trading volumes and possible order imbalance.

Stoll and Whaley (1986) produced the first study in this area of expiration day volatility. The study was done using minute-by-minute price data. The mean and standard deviation of returns were computed over the day. The study found that the standard deviation was higher when futures expired than when they did not. This was particularly prevalent in the last hour of trading. This was not the case when the S&P 100 option expired while the future did not. In this case the study found that the volatility was not significantly higher than on days on which nothing expired (Kolb, 1997 : 381). Another finding of the Stoll and Whaley study was that stock prices tended to fall on these expiry dates and rise again in the first thirty minutes of trade on the day following a futures contract expiry day. Both the price effect and the volatility effect were statistically significant.

Stoll and Whaley (1987) repeated their study in 1987 that resulted in the same conclusions, that expiration day volatility is greater than other trading days. Again it was found that this was particularly prevalent on the last hour of trade on the expiration day. Santoni's study (1987) also examined the expiration day effect on market volatility. This study, however, found expiration day volatility not to be higher than other trading days. This suggests some degree of uncertainty as to whether expiration day volatility is indeed higher than other trading days. The below studies provide overwhelming support for the Stoll and Whaley findings that the volatility on expiration day does increase suggesting that one should conclude this to be the case.

Edwards (1988) completed two studies during 1988 which both came to the same conclusions that expiration day volatility is greater than other trading days. This was supported by Feinstein and Goetzmann (1988) who came to the same conclusion when they studied expiration day volatility. Stoll and Whaley (1990) repeated their previous two studies in 1990. This time they noticed higher stock volume on expiration days, but similar price behavior for all stocks, whether represented by futures trading or not (Kolb, 1997 : 383). This seems to support the Santoni (1987) finding, but Stoll and Whaley (1991) repeated the study in 1991 and found that the change in the expiration day reduced trading activity and price volatility at expiration, which implies that there was increased volatility at expiration.

The Hancock (1991) study supported the view that volatility increased on expiration, however, the findings were slightly different. Hancock found that for the last fifteen minutes of trading, volatility is higher on expiration days, but that volatility is not higher at the close of trading than earlier in the trading day (Kolb, 1997 : 383). The study completed by Herbst and Maberly (1991) was similar to the 1991 Stoll and Whaley study. The study examined changes to the expiration procedures where Stoll and Whaley (1991) examined changes to the expiration date. The Herbst and Maberly (1991) study found that changes in the expiration procedures significantly reduced the volatility on expiration day (Kolb, 1997 : 383). This implies that there was excess volatility during the expiration day prior to the change in the expiration procedures.

From the above studies one can conclude that futures close out leads to momentary increases in volatility. There is evidence to support the Samuelson Hypothesis as well as the jump volatility theory. In this thesis care will have to be taken to build in the effects of futures close out on volatility. The thesis examines the effects of increased volatility on the pricing efficiency of futures prices. As volatility is caused by futures close out it would be of value to isolate these periods when drawing conclusions on futures pricing efficiency. By isolating the futures close out period one can identify the effects of seasonal excess market volatility (coming from futures close-outs) and external market shocks such as the emerging markets' crises.

4.6 Securities Lending.

There is a concern voiced by various market commentators, that securities lending increases market volatility and forces prices downwards. A notable proponent of this view is Donald Gordon, ex head of Liberty Life (Temkin, 1999) who argued that securities lending and arbitrage trading resulted in the Liberty Life stock price being depressed since the 1994 issue of Liberty Life convertible bonds in the European bond markets. As described in chapter three, securities lending facilitates arbitrage between the spot and futures prices. In response to these criticisms a report was commissioned by the Financial Services Board in January 1999 to investigate the securities lending industry in South Africa and whether the practice of securities lending should be curtailed or banned completely. The report is known as the Genesis Report and was completed by Counihan and Malherbe (1999). The scope of the report was three-fold. Firstly, the history, extent, composition and trend in securities lending facilitated by South African intermediaries was presented and analysed. The second perspective considered the role of securities lending in the relationship between futures and underlying markets, and in particular whether the arbitrage facilitated by securities lending is a stabilising or destabilising force. Thirdly, the risks faced by each participant in a securities loan were considered (Counihan and Malherbe, 1999 : 10).

Given the concerns that had been voiced over securities lending and the practice of short selling, this report would have implications for the pricing efficiency of South Africa futures as a restriction in the lending of securities would have reduced the ability of the futures / spot arbitrage mechanism to operate. The investigation surrounding the second point is thus pertinent to this thesis. The nature of the concerns voiced over securities lending is that it leads to a "vicious circle" (Counihan and Malherbe, 1999 : 33) that drives down prices artificially, the rationale being that securities lending results in increased market volatility. This in turn opens up arbitrage opportunities between the spot and futures market as the spot and futures prices diverge. This arbitrage is driven by securities lending, which, in turn, increases the short selling activity and thus artificially drives prices down further - hence the "vicious circle".

Counihan and Malherbe (1999 : 33) examined the correlation between securities lending and market volatility as, according to them, one should expect to find a close correlation between securities lending and market volatility for the above to be true. This examination was done on using a two-pronged approach. Firstly, the market participants were approached to comment on the relationship between market volatility and securities lending. The second part of the approach involved the correlation of volatility and securities lending activity.

The results of the examination showed that securities lending does not increase volatility and in certain cases securities lending actually reduces market volatility. The discussions with the market participants revealed that in times of extreme volatility arbitrage activity actually declines, this was suggested to be due to an increased operational risk. This would be because in periods of heightened volatility one would need to make more margin calls, putting pressure on this administrative capabilities of market participants. This, in turn, increases the operational risk as margin calls could be missed or take to long to conclude. This increase in operational risk would result in the market participant withdrawing from the securities lending market and thus the dampening effect.

The second part of the study where securities lending activity and volatility was correlated also concluded that securities lending does not contribute to excess volatility that a market might experience. In the study, the volatility of the ALSI40 was used as a proxy for the volatility of all spot equity prices. Other variables such as market activity were computed using trading volume. The results of the test not only confirmed that securities lending does not contribute to increased market volatility but, over certain periods, it was seen to have a negative correlation with the increased levels of market volatility suggesting that securities lending has the ability to dampen market volatility.

Further results were that the futures price leads the spot price with a lead of up to 40 minutes being recorded. This was found to be true even during crisis periods. No "vicious spiral" effect on prices was noted throughout the period tested which was June 1996 to December 1998. This included the emerging market crises. Convergence was noted between the spot and futures prices, which was found to come from arbitrage. The last significant finding was that lending for bear sales purposes dampened high levels of volatility.

The methodology employed in the second part of the study was to take daily data from June 1996 to the end of 1998, comprising of spot prices, number of contracts traded, trading volume in the futures and spot markets and the open position in futures and shares. The open position in shares was computed by looking at open securities loans. This was then followed by calculating volatility estimates. This was done using a statistical procedure called the Gauss-Seidel procedure that is an iterative process which stabilises the volatility measures which allow one to determine which variable determines the volatility. The final equation describing the volatility estimate was:

$$\hat{\sigma}_t = \alpha + \sum_{i=1}^{4} \lambda_i d_i + \sum_{k=1}^{n} \delta_k \hat{\sigma}_{t-k} + \sum_{j=1}^{n} \omega_m X_{t,m} + v_t \qquad (10)$$

Where σ denotes the estimated volatility in the spot market, d_i the day of the week effects and X_t a vector of the volume measures and dummies for the crisis period (Counihan and Malherbe, 1999 : 34). It was found that all the volume measures were highly correlated with each other so it was irrelevant which one was used for the study. The volatility on the ALSI40 spot was constructed by taking the average standard deviation on the ALSI spot market over a Monday to Friday trading period (Counihan and Malherbe, 1999 : 34). Three different volatility measures were then calculated:

a) The volume of the total lending market.

b) The volume of ALSI40 scrip lending market.

c) The volume of bear sales on the ALSI40 scrip lending market.

The test was then performed to see if there was a statistically significant link between the three volume measures and the volatility measure that was constructed. The results of the above test were as follows:

In the case of a) above, there was no evidence of a statistically significant link between volatility on the ALSI40 and the total volume of scrip lending. In the case of b) above, there was no evidence of a statistically significant link between volatility on the ALSI40 and the volume of ALSI40 scrip lending. In the case of c) above, there was some evidence of a statistically significant link between volatility on the ALSI40 and the volume of ALSI40 bear scrip lending. This was, however, sensitive to the sample period chosen. Where the weeks starting the 20 October 1998 and 27 October 1998 are *included* in estimation, the first difference of the volume of bear scrip lending proves to be insignificant, suggesting that no link is present between volatility and volume of bear scrip lending. However, if the weeks starting the 20 October 1998 and 27 October 1998 were *excluded* from estimation, the first difference of the volume of bear scrip lending proves to be significant, suggesting that a link between volatility and volume of bear scrip lending is present. More important than the finding of statistical significance, however, is the implication that rising volumes of bear scrip lending leads to *falling* volatility on the ALSI40 (Counihan and Malherbe, 1999 : 46).

The findings conclude that scrip lending provides "an important link between spot and futures markets" (Counihan and Malherbe, 1999 : 45). Without it, liquidity on both SAFEX and the JSE would drop and prices between the two exchanges would become uncoordinated. This would lead to institutional managers not being able to manage their exposures professionally. This results in the conclusion that given these benefits and the absence of any negative effects, securities lending ought not to be curtailed in SA. Counihan and Malherbe also note that in the event the practice of securities lending was to become curtailed, lending would still continue off shore that the South African authorities would be unable to control. This would lessen the effect of an on shore ban and possibly push the local practice off shore.

4.7 Measurement Issues.

For the purposes of this thesis, the measurement of volatility will be divided into two distinct parts. The one part will involve the measurement of volatility using auto-regressive conditional heteroscedastic techniques (ARCH). These techniques will be grouped under the section ARCH below. The rest of the measurement techniques used for the purpose of this thesis will be examined under the section "traditional" below. The difficulty in measuring volatility is that it does not tend to be constant. In some periods it is high, and in other periods it may be low, for the purposes of this thesis, what needs to be measured is the change in volatility so that this can be correlated with the change in the pricing efficiency. In determining the change in this volatility one needs to determine the trend in the volatility. The ARCH section below (5.7.2) will not be as detailed as the "traditional" section. This is because chapter 7 is dedicated to the ARCH model.

4.7.1 Traditional

Volatility is traditionally measured as standard deviation. The standard deviation is the square root of the variance that is calculated first when determining volatility. Standard deviation can be defined as:

$$\sigma = \sqrt{\sum_{J=1}^{N} P_J (R_J - R_E)^2} \qquad (11)$$

Where:

P_j = is the probability of the j'th outcome

$(R_j - R_e)^2$= the deviation squared of the jth outcome from the expected return.

The problem with this model is that it does not derive the standard deviation entirely from the data presented. The probability of the j'th outcome is determined using regression type analysis and personal judgment. An alternative to the above is the equation is to determine volatility by first calculating a historic, standardised volatility, and using this measure to determine variance and standard deviation. The historic, standardised volatility measure is determined next. The first step in this second formula is to determine the log normal percentage movements in the share price:

$$u_i = \ln\left(\frac{P_i^s}{P_{i-1}^s}\right) \qquad (12)$$

Where:

P^s = the current price of the security.

u_i = The continuously compounded return during day i (between the end of day i - 1 and the end of day i).

The next step is to determine the unbiased estimate of the variance per day (σ_n^2) using the most recent m observations. The formula for this is (Hull, 1999 : 369):

$$\sigma_n^2 = \frac{1}{m-1}\sum_{i=1}^{m}\left(u_{n-i} - \bar{u}\right)^2 \qquad (13)$$

Where:

m = The most recent m observations.

$\bar{u}$ = The mean of u_i

The mean, $\bar{u}$ above, is calculated as follows:

$$\bar{u} = \frac{1}{m}\sum_{i=1}^{m} u_{n-i} \qquad (14)$$

To determine the standard deviation one must determine the root of the variance. This will give the instantaneous standard deviation (volatility). This can be demonstrated by the means of an example:

Table 4.2 - Example of the Calculation of "Traditional" Volatility.

The grid below shows an analysis of the price movements of a fictional security. The first column in the table records the date the observation was made. The second column shows the price of the security S_i at the end of day *i*. The third column shows the proportional change in the price of the security between the end of day *i* - 1 and the end of day *i*. The fourth column shows the natural log of the proportional change calculated in column three. This is described by the equation $u_i = \ln(S_i / S_{i-1})$. The fifth column calculates the variance of the log normal proportional change for day *i* from the mean of the log normal proportional changes over the previous *m* days. This is described by the following equation $v_i = u_i - \bar{u}$ where v_i is the variance. The variance is squared in the sixth column. All the squared variances are added together and the mean is found. This is the log normal variance of the share price over the past *m* days. The variance is then rooted to produce the volatility or standard deviation.

"Traditional" volatility calculation for security *S*					
1	2	3	4	5	6
Day	S_i	ΔS_i	$u_i = \ln(S_i / S_{i-1})$	$v_i = u_i - \bar{u}$	$(v_i = u_i - \bar{u})^2$
0	20				
1	20.125	1.006250	0.006231	0.001465	0.000002146344
2	19.875	0.987578	(0.012500)	(0.017266)	0.000298103421
3	20	1.006289	0.006270	0.001504	0.000002262329
4	20.5	1.025000	0.024693	0.019927	0.000397089458
5	20.25	0.987805	(0.012270)	(0.017036)	0.000290211721
6	20.875	1.030864	0.030397	0.025632	0.000656997794
7	20.875	1.000000	0.000000	(0.004766)	0.000022710076
8	20.875	1.000000	0.000000	(0.004766)	0.000022710076
9	20.75	0.994012	(0.006006)	(0.010772)	0.000116025924
10	20.75	1.000000	0.000000	(0.004766)	0.000022710076
11	21	1.012048	0.011976	0.007211	0.000051993936
12	21.125	1.005952	0.005935	0.001169	0.000001367091
13	20.875	0.988166	(0.011905)	(0.016670)	0.000277902619
14	20.875	1.000000	0.000000	(0.004766)	0.000022710076
15	21.25	1.017964	0.017805	0.013039	0.000170018537
16	21.375	1.005882	0.005865	0.001100	0.000001209143
17	21.375	1.000000	0.000000	(0.004766)	0.000022710076
18	21.25	0.994152	(0.005865)	(0.010631)	0.000113010261
19	21.75	1.023529	0.023257	0.018491	0.000341930142
20	22	1.011494	0.011429	0.006663	0.000044398059
Total			0.095310		0.002878217159
Mean			0.004766		
Variance					0.000151485114
Std Dev.					0.012307928893

The variance per day, $\sigma_n^2 = \frac{1}{m-1}\sum_{i=1}^{m}\left(u_{n-i} - \bar{u}\right)^2$ is thus 0.000151485114 and the volatility is 0.012307928893 or 0.12% per day.

The volatility calculated in the example above can be expressed as both annual and daily rates. The above volatility is the volatility per day. The formula for the annual volatility is $s = \sigma_A \sqrt{\tau}$, where τ is the length of the time interval in years and σ_A is the annual volatility. In the above case one would set the length of time to be equal to the number of trading days. As per Hull (1999 :242) the period τ should be set to be the annual number of trading days and not the calendar days as using the trading days gives more accurate answers. To annualise the volatility in the above example: $0.0123 \times \sqrt{252} = 0.195$. The annual volatility is thus 19.5% per annum. In this case the number of trading days used was 252. The standard error of the estimate is $0.195 / \sqrt{2 \times 20} = 0.031$ or 3.1% per annum. The standard error of the estimate is defined as follows: $\sigma_A / \sqrt{2n}$.

Formula (13) can be simplified in the following ways (Hull, 1999 : 369):

1. u_i is defined as the proportional change in the market variable between the end of day i - 1 and the end of day i so that:

$$u_i = \frac{s_i - s_{i-1}}{s_{i-1}} \tag{15}$$

2. $\bar{u}$ is assumed to be zero.
3. m - 1 is replaced by m.

The effect of the above changes is to change formula 13 to become:

$$\sigma_n^2 = \frac{1}{m} \sum_{i=1}^{m} u_{n-i}^2 \tag{16}$$

For the purposes of this thesis the traditional method will be defined as formula number 13 above. The simplifications that are made above are used in the determination of volatility using ARCH. The reasons for the above simplifications are as follows:

1. According to Hull (1999, 369) this assumption has little effect on estimates of variance because the expected change in a variable one day is very small when compared with the standard deviation of changes.

2. Replacing m - 1 with m moves the estimate from being an unbiased estimate of the variance to a maximum likelihood estimate. A maximum likelihood estimate is explained in chapter 7 below.

The one characteristic of the above formulas 12 to 16 is that all the data is treated equally. In calculating the volatility for a particular day it would be reasonable to assume that more recent events in the market have more effect on the current price movements than events that occurred longer ago. The above formulas assign the same weighting to all the data that is processed to calculate current volatility, a logical step would be to weight the data in some way to take into account this relative importance of more recent data. Hull (1999 :369) suggests the following modifications to equation 16 above to take into account this time-related phenomenon:

$$\sigma_n^2 = \sum_{i=1}^{m} \alpha_i u_{n-i}^2 \qquad (17)$$

Where:

α_i = the amount of weight given to the observation i days ago. $\alpha > 0$

The differences between this formula and formula 16 above are:

1. $\frac{1}{m}$ has been removed. This is because the weighting of each data point has negated the need to find an average of all the data points.
2. α_i has been added to take the place of the average.

The weights given to each individual data point must sum to one. The older observations will have less weight assigned to them such that $\alpha_i < \alpha_j$ when i > j so that:

$$\sum_{i=1}^{m} \alpha_i = 1 \qquad (18)$$

Source: Hull, 1999 : 370.

Further to the assigning of weightings to individual data points, one should take into consideration long-term volatility levels. As stated earlier in the chapter, there exists a certain, natural level of volatility of prices within individual markets. This should be taken into account in the weighting of the observations. Hull (1999 : 370) suggests it should be done as follows:

$$\sigma_n^2 = \gamma V + \sum_{i=1}^{m} \alpha_i u_{n-i}^2 \qquad (19)$$

Where:

γ	=	the weight assigned to the long run volatility.
V	=	the long run volatility of the prices within the individual market.

Note: the individual weights and the weight assigned to the long run volatility should sum to one. This can be expressed as follows:

$$\gamma + \sum_{i=1}^{m} \alpha_i = 1 \qquad (20)$$

Equation 19 above is known as the ARCH (Autoregressive Conditional Heteroscedasticity) model and was first suggested by Engle (1982 : 1000). The essence of this measure is that the older the observations are the less weight they are given as well as the long-run average variance needs to be taken into account when estimating volatility. Hull simplifies equation 19 to the following:

$$\sigma_n^2 = \omega + \sum_{i=1}^{m} \alpha_i u_{n-i}^2 \qquad (21)$$

Where:

ω = γV

This is discussed below in section 4.7.2. The benefits of using the traditional method to measure the volatility of the spot and futures prices are that it is easy to understand and implement. The actual results of using this measure are presented in chapter 10 below. The reasons for using the ARCH model is that it applies a weighting to the different observations, according to their position in the time series which takes into account the effects of time on the data.

According to Hull (1999, 374) variance exhibits what is known as mean reversion. This is when the variance moves back to its long run moving average after experiencing short term fluctuations. ARCH takes into account long-term variance and thus makes some allowance for this phenomenon of mean reversion. This is another reason for one using the ARCH model to determine the volatility of the share or futures prices. A discussion of the ARCH model can be found in the appendices (See Appendix 9.4)

4.8 Reactions to Volatility.

As can be seen earlier in this chapter, increases in volatility or any new innovations that are seen to be increasing volatility have been greeted with negative reactions. An example of this is index arbitrage and securities lending; both were seen as possibly contributing to increased volatility and both were subject to officially commissioned investigations. In the event they were seen to be increasing volatility levels one may have seen measures to curb their operation. In the cash of index arbitrage, the Brady report was the investigation into its impact on volatility. Index arbitrage was seen to lead to some increase in volatility and resulted in the Brady report recommending the implementation of circuit breakers. In the case of securities lending the South African Financial Services Board commissioned the Genesis report that concluded that securities lending was not to blame for increased market volatility. In Malaysia, the practice of securities lending was curbed after the Asian Crisis as securities lending was seen to be increasing market volatility and contributing to market volatility.

The question one should ask is "why the negative reaction towards volatility?" The answer to this could be found in examining the role of the market regulators. Market regulators want to see the market functioning properly. This will be when price discovery occurs efficiently and unhindered. When there is increased market volatility, certain market participants are driven out of the market. This is because of the increase in cost of capital as explained earlier in the chapter. With certain market participants being driven out of the market, price discovers will be negatively effected as not all parties will be bidding and offering for the quoted securities. This will result in a biased price discovery mechanism, which attracts the attention of the regulators.

From a market participant's point of view, an increase in general levels of volatility and jump volatility result in the market possibly reacting differently to the manner in which it normally does. This would be because of the withdrawal of certain market participants. With the market changing during periods of heightened volatility, one could postulate that this should lead to new market opportunities arising. This thesis examines whether any opportunities arise through the incorrect pricing of futures when market volatility increases.

Chapter 5: Literature Review on Efficiency Studies.

The studies that were reviewed included other efficiency type studies, such as studies of the foreign exchange market. This was done to get a better understanding of the methodology employed. In the case of South African studies, the scope was increased to include any studies that had anything to do with the futures market. The efficiency study that had the most impact on efficiency investigation in this thesis was the Lambrecht's (1990) study. Accordingly it will be afforded more discussion below.

5.1 South African Efficiency Studies.

Eleven South African studies were reviewed. On these, four were directly related to the study of efficiency. The efficiency studies were all grouped around the launch of SAFEX. This thesis will update the findings of these theses with regards to the efficiency of the pricing of SAFEX futures. The remainder of the studies looked at other aspects of the futures market. Table 5.1 below summarises the findings of the studies:

Table 5.1 - Summary of the Findings of the South African Studies of the Futures Market.

Author (s) and date.	Findings.
H.A. Lambrechts. 1990	Efficiency of the futures market was tested and the results were inconclusive. Some of the tests showed the pricing structure to be efficient while some of them found the pricing structure to be inefficient.
C.R. Mitchell, 1989	The efficiency of the BA and E168 futures contracts was tested. Each was seen to be inefficiently priced with both exhibiting arbitrage opportunity.
P. Levett, 1991	The efficiency of stock index futures was tested. They were found to be inefficient but, after the construction of arbitrage bounds, the arbitrage opportunities were seen to be limited.
A.T. Snell, 1990	The INDI, ALSI and GLDI contracts were examined and found to be inefficiently priced over the period 22 June 1987 to 18 December 1989. This resulted in effective hedging procedures being difficult to implement.
B. A. C. Collings 1993	SAFEX was found to inefficient due to a lack of

	market liquidity. It was concluded that the efficiency would not improve as trading volumes had peaked.
J.P. van der Spuy (1989)	Looking at the corporate management of interest rate risk, it was noted that there was significant potential for new market participants as many corporates did not use futures to hedge against interest rate risk.
M.W. Arnold (1988)	Liquidity was identified as the main prerequisite for a successful futures market. This would also ensure the market was efficient.
D. Botha (1988)	The most appropriate futures to hedge against interest rate risk would be either notional bond futures or futures based on the underlying bond.
P.L. Fourie (1991)	There are arbitrage opportunities in the underlying spot market due to mispricings. This, however, is difficult to take advantage of due to a lack of liquidity in the underlying spot markets.
C. de J. Correia (1990)	After testing the efficiency of the South African Foreign Exchange market, it was noted that the market was efficient until the debt crisis of 1985. The methodology used in testing for efficiency was similar to the other studies above.
C . Counihan & S . Malherbe (1999)	As part of an investigation into the securities lending industry the arbitrage opportunities in the futures market are examined. This study finds the futures to be efficiently priced through the mechanism of arbitrage.
A. Swart (1998)	The liquidity and volatility of the underlying spot market was examined to see what effect index futures trading had on them. He found that index futures trading increased both volatility and liquidity on the underlying spot market.

5.1.1. H.A. Lambrechts (1990).

This study entitled "Market Efficiency and Price Determination of South African Financial Futures Contracts" looked at the pricing efficiency of the Eskom Long Bond futures contract (the E168), the All Share Index futures contract (the ALSI), the Industrial Share Index futures contract (the INDI) and the All Gold Index futures contract (the GLDI). Along with looking at the pricing efficiency of these futures contracts, Lambrechts studied risk management using these financial futures. This part of the study centered around the use of the above futures contract in the process of hedging. With regards the use of futures in the hedging of risk, Lambrechts concludes that there are many different methods one can employ in the use of futures to hedge risk. The method used depends on whether the potential hedgers wish to hedge completely and the reason for the hedge being put in place. Two of the main issues arising out of Lambrechts' investigation into hedging are the calculation of the hedge ratio and the different methods that can be used to do this, as well as the exposure to basis risk when hedges are put in place. Lambrechts states that hedging could be seen as the exchange of price risk for basis risk. (See definitions in chapter 1 for an explanation of basis risk).

The thesis closes off with Lambrechts discussing the tax and accounting implications of trading in financial futures contracts. With regards to the tax aspects, he examines the taxation of futures trading in other countries and compares it to the taxation of financial futures trading in South Africa. In this regard, he concludes that South African tax can benefit from the lessons learnt in other countries, notably the United States of America. The approach must be to develop a unified approach to taxing the trade in futures contracts and not, as in the case of the United States, a multi-pronged approach, where different interest groups lobby for their input into the tax law. Lambrechts suggests that a similar approach is taken towards the development of accounting rules. Since the thesis was completed both issues have been resolved. In the case of the taxation of the trade and hedging using futures contracts, the South African Revenue Services have produced a clear method of determining the tax liability. In the case of the accounting rules to be applied to the trade in and hedging using futures contracts, the solution has largely been provided by the international accounting community through the form of the International Accounting Statements. The South African authorities (SAICA - The South African Institute of Chartered Accountants) have adopted a harmonisation process whereby the South African accounting rules are to be "harmonised" with international standards. The international statements have a clear method of accounting for both speculating in and hedging using futures contracts.

With regards to the actual determination of the pricing efficiency of the futures contracts, Lambrechts first defined the formula to be used in determining the theoretical value of the futures contract. The formula he used was:

$$FP(t,T) = CP(t)\left\{e^{r(T-t)}(1-d/r)+d/r\right\} \qquad (30)$$

Where:

FP	=	The price of the futures contract with maturity date T time t.
CP	=	The spot price at time t.
d	=	The dividend yield.
r	=	The risk free annual effective risk free rate.
e	=	The continuously compounding rate.

The next step was to determine the theoretical futures price. Once that had been done, four tests were performed. Firstly, the correlation between the theoretical futures price and the actual futures price was calculated, to see if there is a statistically significant relationship between the two. The second test examined the differences between the theoretical and actual futures prices. The difference was tested to see if it was statistically significant. The third test focused on the ability of the futures market to reflect all currently available information. This test was performed by examining the Durbin-Watson model for evidence of residual correlation. The last test looked at arbitrage opportunities between theoretical and actual futures prices. The hypothesis was that there are no arbitrage opportunities that are available over extended periods of time.

The methodology used in the first test was to calculate the squared Pearson correlation coefficients between the theoretical and actual futures prices at a 95% level of significance. The second hypothesis, was tested by analysing the differences between the actual and theoretical futures prices. The methodology used for the testing of the third hypothesis is described above. The last hypothesis was tested using a regression type method. The daily returns on the three index stock futures contracts were regressed against an index of cash returns. Similar tests were performed on the E168 future.

The results were as follows: In the case of hypothesis number one, the three to six month futures contracts exhibited statistically significant correlations between the theoretical and actual futures prices. This suggested that over these contract periods the futures prices were efficiently priced. In the case of the contracts longer than 6 months, high correlations were found between the theoretical and actual futures prices. It was concluded that these contracts were also efficiently priced. This was found to be the case for both the index and bond futures contracts.

In the case of hypothesis number two, the differences between the theoretical futures price and the mid-market actual futures prices and the spot market prices were examined from the 1 July 1987 to 15 June 1989. The differences were found to be significant for most of the period examined which pointed to the conclusion that the stock index and bond futures market were inefficient. The testing of the third hypothesis revealed the stock index futures market to be an inefficient market. The futures' adjusted rates of return were regressed against returns on the underlying spot index. The Durbin-Watson method was used to examine the presence of residual correlation over the period. The residuals were found to be uncorrelated suggesting inefficiency in both the index and bond futures market.

The last hypothesis involved the examining of the arbitrage opportunities. If the pricing mechanism was efficient there should be no evidence of any arbitrage opportunities. In the case of each contract examined no systematic excess returns were exhibited through implementing an arbitrage strategy. This implies that the stock index and bond futures market was priced efficiently over the periods under review.

The final conclusion drawn on the efficiency of the futures pricing mechanism was that the results were inconclusive. Lambrechts suggests a number of reasons for this. The two main reasons were that the statistical tools used were possibly not sensitive enough and that, even though there were statistically significant differences between the theoretical and actual futures prices, the differences might not have been large enough to allow for profitable exploitation through arbitrage.

5.1.2 C.R. Mitchell (1989).

This study examined the efficiency of the Banker's acceptance (BA) and E168 futures contracts. The method used was similar to that of Lambrechts (note, however, that as this study was completed before the Lambrechts study, the methodology was not taken from Lambrechts) the efficiency was tested by examining the relationship between the actual and theoretical futures prices.

In the determination of the fair futures prices certain transaction costs were taken into account. The costs taken into account were an approximate purchasing cost, an approximate bid / offer spread and any clearing house costs. In the case of the BA future the term structure of interest rates for the BA rate had to be estimated. This was done using NCD rates as a proxy. The reason for the estimation was that only the short-term BA rate was freely quoted.

There were differences noted between the two contracts besides the differences in pricing standards (the BA rate is quoted on a discount basis whereas the E168 rate is quoted on a yield to maturity basis). The E168 futures contract traded approximately twenty times more heavily than the BA futures contract. This led Mitchell to also examine the effects of volume on the pricing efficiency of the contracts. One problem noted by Mitchell in the analysis was the determination of the mark - to - market prices. Theoretically the mid point of the bid offer spread should have been used when determining the mark - to - market prices, however, as these were not available the closing prices were used.

The results of the investigation into the pricing efficiency of the BA futures contract were:

1. In the case of the difference between the actual return and the synthesised return on the future, the earlier stages of the contract's life exhibited significant differentials.
2. The differentials were in excess of the transaction costs bands around the theoretical futures price, which in turn meant
3. In the early stages of the BA futures contract there was significant opportunity for arbitrage profit due to pricing inefficiencies and ultimately
4. The BA futures contract was inefficiently priced for most of the contract's life.
5. This was also found in the case where the returns were annualised.
6. The contracts were priced inefficiently by being overpriced for most of the contract's life.

The results of the investigation into the pricing efficiency of the E168 futures contract were:

1. The contracts exhibited a mispricing in the earlier parts of their lives (the different contracts examined were contracts of different maturities).
2. The mispricings were, at times, more than the trading costs which in turn meant
3. Arbitrage opportunities exhibited themselves from time to time.
4. The mispricings were when the value of the E168 futures were significantly less than the bond.
5. The E168 contract was more efficiently priced than the BA futures contract as inefficiencies occurred less often than in the case of the BA futures contract.

Mitchell further drew conclusions on the effect of volume of trades on the pricing efficiency of the E168 and BA futures contracts. He concluded that futures trading volumes do not necessarily effect the pricing efficiency of the two contracts. In the case of the BA futures contracts, it was found that the futures became more efficient while their trading volumes were declining. It was also found that the well-traded E168 contract was sometimes inefficiently priced. These findings were further supported by the differential between the volumes being traded in the BA and E168 futures contracts. Mitchell argued that if volume was to have a positive effect on the pricing efficiency of the futures contracts, one should notice the E168 being significantly more efficient than the BA contract due to the fact that there are twenty times more E168 contracts being traded than BA contracts. Even though the E168 contract was found to be slightly more efficient than the BA contract, the difference in efficiency was not seen to be related to the difference in volumes being traded.

5.1.3 P. Levett (1991).

This thesis examined the hedging effectiveness and efficiency of the share index futures market in South Africa. The focus of the thesis is on the hedging, the various hedging methods and its effectiveness. However, part of the thesis looks at the pricing efficiency of the futures contracts. The methodology is the same as in the previous two studies: a futures fair value formula is established and the theoretical value of the futures contract, based on the interest rates and the spot price. This theoretical value is than compared with the actual value and conclusions are drawn.

Levett takes into account the different lending and borrowing rates as well as transaction costs. This allows him to establish the no-arbitrage bands around the theoretical futures price. In the study Levett also focuses on the effects of dividends on the pricing of index futures and notes the difficulty in determining the dividend effect on index futures. In the case of single stock futures the dividends are relatively easy to determine, whereas in the case of stock index futures there are more dividends that occur at different times. This makes the process more arduous as the dividends have to be tracked. The All Share Index, All Gold Index and Industrial Indexes are examined and their dividend payments are tracked over the period under examination that is April 1987 to December 1989. The conclusion was to use actual dividends rather than the dividend yield as a surrogate for the actual dividend payments. This conclusion was reached after assessing the resultant difference in the futures prices after using actual dividends and dividend yield. The results of the assessment of these differences were as follows:

1. The estimation error of the GLDI and INDI futures contract were found to be greater than the ALSI futures contract.
2. This was due to the smoother distribution of dividend payments on the ASLI shares.
3. The materiality of the estimation error depends on the arbitrage bounds.
4. The differences in the GLDI and INDI futures contracts due to the using of the dividend yield were nearly 20 basis points, which, in the case of an arbitrage type model, is large in relation to the average cost of carry calculated.

The methodology was to first determine the futures price using the cost of carry pricing mechanism. The theoretical prices were then regressed against the actual prices, to see if there was a statistically significant difference. Part two of the methodology was to determine if there were any arbitrage opportunities that arose from the mispricings of the futures contracts.

The regression was done using price changes and not actual price levels; the theoretical futures price changes were regressed against the actual futures price changes. If the slope of the regression line is significantly different from one, then this signifies that there is not an equal relationship between the actual futures price and the theoretical futures price. The results of the regression revealed the following:

1. Pricing of the futures contracts is sub optimal in 6 out of the thirty-three contracts tested over the three index futures contracts.
2. Thirteen out of thirty three contracts exhibited statistically significant negative serial correlation. There is thus a bias in the correlation residuals.
3. There is a substantial amount of unexplained variance between the index and the futures price after examining the r^2 test owing to the introduction of basis risk.

Even though there was statistically different actual futures prices when compared with actual futures prices one can only execute profitable arbitrage if the differences are large enough to be exploited, or outside of the arbitrage bounds. Levett, constructs arbitrage bounds, taking into account both transaction costs and SAFEX contract fees. The transaction costs are the bid / offer spread on the futures contract, the brokerage on the buying or selling of the underlying spot and related taxes. Building in the arbitrage bounds the following results were noted:

1. In the case of the GLDI index, there were a number of arbitrage opportunities, but there were not many cases of this.
2. There were significant arbitrage opportunities in the INDI and ALSI index. This was because the limitations in shorting the index and thus the ability to execute reverse cost of carry arbitrage.
3. The bounds were revised to take into account limitations in shorting the underlying shares. Once this was taken into account the arbitrage opportunities in 2 above were mostly removed.
4. Even though there was little opportunity for arbitrage there was still significant variability in the actual futures price around the theoretical futures price that introduces increased basis risk and increases the risk hedger have to absorb.

5.1.4 A.T. Snell (1990)

Snell looked at the efficiency of the South African Share Index futures market and its impact on ex post hedging. The thesis was similar to the above study by Levett in that it looks at the pricing efficiency of futures contracts and how this effects the ability and cost of hedging. The first step was to determine the pricing efficiency. This was done by determining the theoretical futures price as was done above. The first step was to define the formula for the theoretical futures price. As part of this the treatment of dividends within the model had to be dealt with. Snell chose to use actual dividends after examining the dividends that were paid out on the All Share portfolio from 29 June 1987 to 15 December 1987.

The cost of carry interest rate that was used was the BA rate. This was assumed to be a proxy for the short-term risk free rate. The interest rates were expressed as continuously compounded rates. As part of the efficiency measurement, Snell looked at the implied dividend yield estimation error as an efficiency measure. This was done using the following formula:

$$DY' = \exp(R_t r_t) - F_t' / C_t \tag{31}$$

Where:

DY'	=	The implied market dividend yield.
F_t'	=	The market price of the futures contract at time t.
C_t	=	The value of the index portfolio at time t.
R_t	=	The risk free rate expressed on a continuous basis.
r_t	=	The time to contract expiration.

The above argument is fairly simplistic in that it assumes that the dividend yield estimation error is the only source of market inefficiency.

As the period reviewed covered the 1987 "October Crash", the evidence of the pricing efficiency tests impact on this study. It was found that during the 1987 crash the pricing mechanism broke down for various reasons, the most significant being that, due to system failures from higher than usual trading volumes being put through, trading congestion caused the prices to move out of equilibrium. Snell thus concludes that pricing efficiency was not prevalent during the October 1987 crisis.

As for the rest of the period under review it was found that, large and frequent violations of the cost of carry model were noted. These violations persisted in a one direction and tended to persevere over time before reversing back in the direction of fair pricing. The contracts tended to be undervalued most of the time. This was contrary to the findings in the GLDI contract which was found to be the opposite - overpriced. Snell also noted evidence of statistically significant autocorrelations in the mispricing variable. A further finding was that the mispricing tended to deteriorate from 1987 to 1989 which was concluded to be due to restrictions on short / bear sales as the mispricing was due to the fact that the futures contracts were under priced. The pricing inefficiencies were also assumed to arise out of the fact that the spot and futures markets were illiquid which did not allow for the taking advantage of the arbitrage opportunities that arose.

The effects of these findings on the ability to hedge effectively, was that it was seldom advantageous from a risk / return point of view to use a risk-minimising hedging strategy, due to the inefficiencies in the pricing of the futures contracts. Furthermore, it was found that implementing a traditional hedge, where one enters into a futures position that is exactly opposite to the spot market position, would lead to a suboptimal hedge where the portfolio return variability would not necessarily be minimised. The contracts examined by Snell in his study were, the ALSI contract, the INDI contract and the GLDI contract.

5.1.5 B.A.C. Collings (1993)

Collings looked at the economic impact of an efficient financial futures market on the South African economy. Part of the thesis dealt with the need for an efficient financial futures market. The focus of the thesis was not to look at the actual calculation of the efficiency but rather what the implications were for the need to have one.

Collings concluded that the financial futures market was not contributing towards price discovery as, due to few market users, the market was inefficient. Furthermore, he reasoned that the lack of market participants resulted in sub-optimum information levels and therefore a breakdown in the price forecasting function of the futures market. He went on further to say that, in this situation the financial futures market is unlikely to provide reliable additional information to participants in derivative markets and this will lead to the futures market failing to communicate reliable, improved information about future spot prices on a specific asset.

Collings, did, however support the need for an efficient futures market. The need was divided into three parts, namely the need to hedge and shift risk, the need for greater market efficiency in the spot markets and the need for price discovery. A futures market was also seen to support increased capital formation and new product development, which will, in turn, increase liquidity in the spot markets.

Collings noted that volatility in the futures markets destabilise the underlying spot markets. He presented the view that futures markets have the ability to protect spot markets from the detrimental impact of volatility-increasing speculation by allowing this type of speculation to take place in the futures market and not the spot market. This view is questionable, as it implies that futures prices are not linked with spot prices and are free to wander in different directions to the spot prices. If this was the case the market pricing mechanism would be inefficient as futures prices are linked to spot prices by the cost of carry model. This inefficiency in the futures market would reduce their economic value to society as stated above.

Collings' main reason for the lack of efficiency in SAFEX is due to a lack of market liquidity. He predicts that the trading volumes within SAFEX will not rise too far beyond 1993 levels and result in the market remaining inefficient. Both the volumes and the efficiency are examined later in this thesis, which will allow for some conclusion on the accuracy of Collings' predictions.

5.1.6 J.P. van der Spuy (1989)

The focus of this study was on the management of corporate interest rate risk. This included the management of interest rate risk using futures. In order for the futures to be successful in the management of interest rate risk they would have to be efficiently priced. The study did not look at the actual pricing efficiency of futures, but more at the need to be able to use futures in the management of interest rate risk.

Van der Spuy noted that there was little sign of active interest rate risk management by non-banking institutions. Furthermore, he noted, there existed opportunity for these institutions to become involved in the practice, thereby increasing the market participants. This increase in market participants would increase market liquidity and aid the market in becoming more efficiently priced.

The main reason for the lack of non-banking organisations using futures to effectively hedge against interest rate risk was concluded to be due primarily to a lack of understanding of how to hedge using futures. Other reasons included a lack of systems that are able to support futures trading and hedging and a limited knowledge of the nature of long-term markets. In the case of the corporates reviewed by Van der Spuy, all were limited in their knowledge of the long-term markets and their potential benefits to the organisation.

5.1.7 M.W. Arnold (1988)

In looking at the criteria for a successful financial futures market, Arnold noted that there would be a need for the futures market to be efficient. In looking at the other prerequisites for a successful financial futures market the following items were identified:

1. A competitive spot market whereby many buyers and sellers determine a market related price, the volatility of which exposes the holder of the commodity to price risk.
2. Sufficient market liquidity for hedgers to enter and leave the market without undue influence on the state of the market.
3. The underlying spot market must be capable of being graded against the standard qualities as per the contract specification.

4. Sufficient supplies of the spot instrument must be capable of being made available should there be a sudden demand for its delivery.
5. A willingness of institutions, corporations and other members of the financial community to participate in futures trading.
6. The volatility in the price of the underlying spot instruments must attract speculative participation.
7. The size of potential loss should an adverse event occur must encourage participants to hedge all, or at least part of the risk.

When this study was undertaken there was no formal futures market in South Africa. Since then the SAFEX market has been functioning. Broadly speaking, one should be able to find evidence of the above prerequisites being met by SAFEX.

At the time, Arnold sent a questionnaire out to a selection of potential market participants, whereby the respondents were required to rank the above prerequisites, along with others involving trading costs and the make up of the exchange, on a scale of 1 to 10 in importance. The following five elements were seen as being the most important:

1. An exchange should have an independent clearing house.
2. Some form of protection should be provided to investors by the financial futures exchange.
3. The exchange should play an active role in educating potential participants to the benefits of futures trading.
4. The contracts traded must be based on heavily traded financial instruments to promote liquidity.
5. The size of the contracts traded must be tailored for the desired target market.

Of the above, numbers one and two are provided in the structure of SAFEX and its related legislation. The remaining items point towards an interest in creating liquidity. The education would allow for more participants and therefore liquidity. The fourth point points directly towards a need to promote liquidity. With regards the last point, the creation of "market friendly" contract sizes would ensure no participants are restricted from being able to trade, which in turn, would promote liquidity. The focus therefore, of the market participants is the creation of liquidity as the most important prerequisite for a successful futures market.

5.1.8 D. Botha (1988)

Botha looked at the construction of hedging instruments for fixed-interest futures markets. The study was completed in July 1988, before SAFEX had formally begun and the findings of the thesis, as to what would be the most appropriate form of a fixed interest derivative, can be compared with the actual instruments that were subsequently designed.

The study does not analyse the pricing efficiency due to a lack of formal futures trading. It does however construct the theoretical futures prices to determine the effectiveness of using futures as hedging tools. The model used to determine the futures price was the cost of carry model. The carry rate used in the exercise was the call rate and transaction costs were not taken into account. The model used was thus a simple version of the cost-of-carry model.

Three theoretical spot portfolios were constructed for the purposes of determining the hedging effectiveness and were modeled on typical holdings of a bank, an insurance company and a pension fund. The portfolios were constructed of only three different assets of different terms: short term, a medium term and long term. The findings of the study were as follows:

1. The price index futures were relatively poor at hedging the portfolios, which led to the conclusion that
2. (Interest rate) Price index futures were possibly not the best types of instruments to be used in hedging transactions.
3. The futures that were most successful in hedging against price movement were the notional bond future and the bond future based directly on the underlying bond.

With regards point two, it was conceded that the limitations on the research may render this conclusion inappropriate. Comparing the findings of the study to the futures that are traded on SAFEX, one can see by looking at part 2 of appendix 3.1, the futures are based on the underlying bonds which suggests that the findings of the study were correct. This study is however limited in its discussion on which instruments should or should not be listed on SAFEX and to conclude whether Botha was correct or not based on subsequent findings would require further investigation.

5.1.9 P.L. Fourie (1991)

This study was also an investigation into interest rate futures. The title of the thesis "An investigation into fixed interest derivative instruments and their applicability to risk management" reiterates the importance of the use of futures in hedging transactions. As the title of the thesis suggests, Fourie looked at other derivative instruments and their role in risk management. The focus of this review was on the conclusions drawn on the applicability of futures in risk management.

Fourie examined the cost-of-carry model and the arbitrage opportunities available in the futures market. It was noted that there were frequent mispricings in the futures market and this was due to the market reacting to information at different speeds. Fourie also made the point that futures arbitrage is not always riskless as the arbitrage trader may face uncertain carry costs, this would primarily be due to movements in the basis due to fluctuations in the short term (carry) interest rates. The E168 bond was also noted to lack in liquidity that resulted in wide spreads that made arbitrage unprofitable, even though there were arbitrage opportunities available to be exploited.

A further point of the study was to examine the cost-of-carry model as to whether it is appropriate as a model for pricing futures. The results of the investigation was that the model was appropriate for long dated futures contracts, but not for short-term contracts (carry's) that did not take into account the short term compounding effect.

Fourie concluded that there was little use of derivatives in risk management by fund managers, primarily because of a lack of education amongst fund managers. This was further compounded by the lack of liquidity in the derivative markets, which was, in turn effected by the lack of institutional fund manager participants. It was noted, however, that the lack of knowledge amongst fund managers and pension fund trustees was being addressed and that liquidity should improve over time.

5.1.10 C. de J. Correia (1990)

Correia's work was the only local study to be reviewed that concentrated on the currency market. The reason the thesis was studied was to look at the methodology employed. The nature of the arbitrage pricing structure is different from the cost of carry model in that it is in essence a swap. There are, however a number of similarities. The covered interest arbitrage transaction essentially involves an arbitrageur borrowing foreign currency offshore, to deposit in South African securities, the firm will simultaneously buy the foreign currency forward. To determine the arbitrage opportunity Correia had to establish the pricing equation. The pricing equation is based on the covered interest rate parity theorem (CIPT). Mathematically the CIPT can be described as follows:

$$\frac{S-F}{S}=\frac{i-i^f}{i+1} \qquad (32)$$

Where:

x	=	initial amount stated in Rands.
i	=	domestic interest rate.
i^f	=	foreign interest rate.
S	=	spot exchange rate (indirect quotation).
F	=	forward exchange rate (indirect quotation).

Let:	Q	=	$(S-F)/S$	=	Forward Currency Premium
	I	=	$(i-i^f)/(i+1)$	=	Interest differential

Once the variables had been described, Correia plotted the forward currency premium against the interest differential for the period August 1983 to February 1988. The forward currency premium and the interest differential were closely related over the period up to the currency turmoil of the late 1980's where the difference between them widened.

The Forward currency premium and the interest differential were then regressed against one another. In performing the regression a degree of autocorrelation was noticed and removed. The results were similar to the analysis of the differential between the forward currency premium and the interest differential above.

Correia concluded that the opportunity for arbitrage was limited during the period August 1983 to February 1988, implying that the Rand was correctly priced over the period. This pricing efficiency, however, was deviated from during the sub period August 1985 to February 1988 more than in the first sub period (August 1983 to August 1985). This was due to political turmoil and structural changes in the trading environment.

5.1.11 C. Counihan & S. Malherbe (1999)

As part of the investigation into the practice of securities lending in South Africa, Counihan & Malherbe looked at the arbitrage transaction and the pricing efficiency of SAFEX futures. In determining the pricing efficiency the first step in the approach was to establish the cost of carry formula.

In determining the cost of carry the dividend issue was solved using the ALSI dividend yield. Transaction costs were introduced in the equation and were set at 1.5%. The question of whether the futures were efficiently priced was answered by testing for the existence of three possibilities, namely:

1. The futures are efficiently priced and become so by the action of the cost of carry and reverse cost of carry arbitrage.
2. The futures are priced through the arbitrage mechanism, but in times of market shock this in turn feeds back into the spot market, which is in turn, brought into the futures market through the arbitrage relationship. This would cause the markets to destabilise.
3. There is no arbitrage and no feedback between the futures and the spot prices, in which case the futures are inefficiently priced.

The above three propositions were examined by looking at the "co integrating vector". In the first case where the prices become more efficient as arbitrage is undertaken, the authors argue that there should be a convergence between the futures and spot prices. To measure this convergence between the two prices a co integrating vector is examined. In the second case, where the futures prices are determined by the movement in the spot prices, which in turn effect the spot prices once more, the authors argue that there should be evidence of two co integrating vectors. In the third proposition, there will be no co integrating vectors.

The authors then went on to estimate the following:

$$\ln S_t = \ln F_t + \ln COC_t + u_t \qquad (33)$$

Where:

$\ln S$ = the natural log of the spot price.
$\ln F$ = the natural log of the futures price and
$\ln COC$ = the natural log of the cost of carry term which is defined as:

$$\ln COC_t = \ln(i - d + t)_t \qquad (34)$$

Where:

i = the risk free interest rate on government bonds.

d = the dividend yield on shares.

t = the transaction costs.

The three propositions were tested for over the period June 1996 to December 1998. The period was broken up into sub periods over when the emerging market crises were October 1997, May-June 1998 and August 1998. In every case only one co integrating relationship was noticed and which was determined by the cost-of-carry equation.

From this the authors could conclude that arbitrage takes place in South Africa, and leads to the convergence of prices. There is no evidence of a feedback relationship from the JSE to the futures market in terms of which a downward spiral in prices might be precipitated.

5.1.12 A. Swart (1998)

The purpose of this study was to look at the impact of share index futures on the volatility and liquidity of the stocks on the underlying spot market. Swart noted that in previous research the answer to the above question was conflicting. Some studies had noted an increase in volatility and hence a destabilising effect while others noted an increase in liquidity and a reduction in volatility.

Swart studied the period 1990 to 1997 (similar range to this study) and investigated the relationship between the volume and the value of index futures trading for the three main share indices and their underlying spot assets on the Johannesburg Stock exchange.

It was found that volatility did increase for the All Gold and Industrial Indices while the relationship was not significant for the All Share index. Swart concluded that the results supported the view that index trading increases the volatility in the underlying assets.

With regards the liquidity of the underlying stocks regression tests were performed using the volume of the trade in the underlying constituents as a measure of the liquidity of the underlying assets. Swart found significant relationships between the volume and value of the futures trades for all three indices. He then applied a further liquidity test: the liquidity ratio and found that there was no significant relationship between the liquidity of the underlying assets and the level of futures trading.

He did conclude that the liquidity levels did increase as index futures trading increased, thereby supporting the hypothesis that index futures trading adds liquidity to the underlying spot markets.

5.2 Other world - wide efficiency studies.

Four international studies were reviewed with regards to futures pricing efficiency. There was a possibility to review more studies, but it was felt that this exhaustive approach would only achieve marginal benefits.

The quality of the Lambrechts, Mitchell, Snell and Levett studies meant that the need to look at international studies for guidance would be negated. The four studies that were looked at covered a broad spectrum of efficiency studies. This was done to allow for focus on the methodology that was used in the measurement of efficiency. Table 5.2 summarises the findings below:

Table 5.2 - Summary of the Findings of International Studies of the Futures Market.

Author (s) and date.	Findings.
D.A. Glassman, 1980	In studying the foreign exchange markets of various currencies, Glassman noted the markets were efficient where there was no structural impediment such as central bank intervention. Glassman also noted the existence of Heteroscedasticity when examining volatility.
R.J. Hodrick, 1987	Hoderick examines a number of studies of efficiency in the foreign exchange futures market. The conclusion is that the studies provide different results. The methodologies of the different studies differ and the approach to determine an efficient price and regress the actual prices against this is not solely used.
B.A. Goss, 1992	In this study a number of papers concerning the efficiency of the futures market are reviewed. The majority of the papers investigate a Fama type efficiency of the futures market. One of these studies is examined to see if it takes pricing efficiency into account. The second of the papers investigated looks at the pricing of interest rate futures and concluded the cost of carry pricing equation does not take into account the peculiarities of the bond futures contract.
A. Wong, 1986	The United States Treasury Bill futures market's pricing efficiency was examined. The methodology used was to look at the volatility of the market and determine if the market was "too" volatile to be efficient. Wong concluded that the Treasury Bill

	futures market is efficient.

5.2.1 D.A. Glassman (1980)

The Glassman study examined the same market as the Correia study - the futures markets in foreign exchange. The Glassman study, however, looked at different foreign exchange markets. The Glassman study differed further from the Correia study in that it examined the effects of volatility on the foreign exchange market.

The market efficiency was tested by regressing a forecast error against elements of information on which the forecast is based. This is similar to the cost of carry model. In the case of the cost of carry model, the "information" would be the interest rate and other carry costs. The analysis of efficiency was conducted using two basic approaches - a single and multimarket approach. Glassman analysed the foreign exchange market over the 1972 to 1978 period and found there to be evidence of heteroscedasticity in the results of the tests. To correct for this a procedure of weighted least squares was used. The conclusion was that foreign exchange futures markets were efficient over the period in the case of the single market and inefficient in the case of certain multimarkets. The most notable was the relationship between the Swiss Franc and the German Mark. It was suggested, however, that this could possibly be due to structural factors such as central bank intervention in the currency market. Glassman further concluded that the existence of daily price limits does not account for market inefficiencies. The existence of efficiency in the market leads Glassman to conclude that past values of variables in the information set are no help in forecasting future values if information is efficiently processed.

With regards to the analysis of variance, Glassman noted evidence of a change in variance over the different quarters of the year and the days of the week.

5.2.2 R.J. Hodrick (1987)

Hodrick also examined the foreign exchange markets and their efficiency. The study is a review of the empirical studies of foreign exchange futures market efficiency rather than an actual testing of the hypotheses.

The first section of the study was devoted to the analysis of asset pricing theory. It was noted that it is relatively easy to develop a rational expectations equilibrium model that allow for time-variation in expected returns on assets and each of the studies reviewed had done so in the approach to determine the pricing efficiency.

There were two approaches most noted in the determination of efficiency. The first model examined the time series properties and distributions of exchange rates. The second approach was to consider the hypothesis that the forward rate is an unbiased predictor of the future spot rate. Hodrick confirmed that fact that exchange rates do not simply follow a random walk in an efficient market. Currencies are related to each other by set relationships such as inflation and interest rates. This relationship is sometimes difficult to note, however, due to the volatility in some exchange rates.

The relationship between forward prices and future spot prices was also examined. This was done by looking at whether futures prices on a given day are unbiased predictors of the futures prices on the following day. The conclusion was that this is not the case. It was noted further in this regard that the forecast horizon of the futures prices evolve continually since the maturity date of the contracts is fixed. Hodrick also noted that the role of learning in determining interest rates, exchange rates and stock prices needs to be taken into account as well as the influence of government policies on asset prices.

Finally, Hoderick notes that some of the studies claim the foreign exchange future market to be inefficient due to a bias existing in the market. He argues that some of the methodologies used to prove this are not sound and that, even though there is some evidence of bias in the foreign exchange futures market, the market does exhibit some efficiency. Consequently the conclusion is that it is difficult to prove whether the market is efficient or not.

The studies Hoderick reviews have numerous approaches to the determination of efficiency. The approach is not only to determine the efficient price and regress that actual price against this. The models attempt to build in expectations and risk premiums.

5.2.3 B.A. Goss (1992)

Goss examines rational expectancy and efficiency in futures markets. The study comprises a set of papers by other authors. The studies are not confined to one futures market and include studies on different underlying spot instruments, ranging from currency markets to commodity markets and interest rate futures. It must be noted that the various studies do not necessarily determine a futures market to be efficient by looking at the pricing relationship between it and the spot market. The approaches tend to look at the ability to earn excess profits following a trading strategy and the future market's ability to absorb information timeously. In examining these two approaches one should still note the effect on the spot market. If the futures market absorbs new information quickly, this should be transferred into the spot market quickly or there is opportunity for arbitrage. For this reason the studies will have bearing on this thesis - even though a different approach is followed, the authors will still have to look at the relationship between the spot and futures market. As the studies are broad and do not specifically focus on the pricing efficiency of the futures market only two studies will be examined, namely the studies done by Taylor and Yau, Savanayana and Scheeweis.

The efficiency of the Yen futures market at the Chicago Mercantile Exchange is examined by Taylor. The author argues that efficiency should be defined as "if the risk adjusted returns, net of all costs, from the best trading rule is not more than the comparable figure when assets are traded infrequently". The focus of this study is very much on a Fama type of efficiency and not specifically pricing efficiency. To test the efficiency of the currency market Taylor applies a trend following trading strategy based on time series models. The results are that the market is inefficient and that excess profits can be made trading Yen currency futures. Taylor does not investigate the effect of profiting from this trading strategy on the spot market.

Yau, Savanayana and Schneeweis examine alternative performance models in interest rate futures. In determining whether the pricing of interest rate futures are efficient or not one needs to determine the return of the future. The authors suggest that this is often done on an ad hoc basis. This combined with the peculiarities of bond futures, more specifically the cheapest to deliver bond issue, result in the pricing / return calculation become very important. In analysing the pricing issues for interest rate futures the authors conclude that a number of issues are not taken into account correctly, they are:

1. Timing: cost of carry. This is where the short may deliver the bonds at any time during the delivery month. The short is thus able to benefit from pricing movements.
2. Timing: wild card. This allows the short trader to select any time on delivery day to settle the contract. The short thus can benefit from price movements on delivery day.
3. Switching. This is where there is an option as the type of bond that can be accepted in the settlement of the futures contract.

The argument is that each of these contract peculiarities have some form of value and this should be taken into account when pricing the futures contract under the cost of carry model. The authors conclude that the most appropriate return formulation is determined in part by the loss function of the individual agent who elects to use the futures as part of an asset risk management strategy.

5.2.4 A. Wong (1986)

Wong's study, entitled "Futures-Forward price differences and efficiency in the Treasury Bill Futures Market" looks at two issues. First, it examines the ability of two models to explain the differences between futures and implicit forward prices in the thirteen week Treasury Bill market. Second, the study determined the efficiency of the thirteen-week Treasury Bill futures market using volatility and regression tests. The volatility tests use variance bounds to examine whether futures prices are excessively volatile for the market to be efficient. The regression tests investigate whether futures prices are unbiased predictors of future spot prices.

The period covered by the tests was March 1976 to December 1984. The two models in the first test were developed by Cox, Ingersoll and Ross. The first model involved determination of whether changes in futures-forward price differences are related to changes in local covariances between Treasury Bill futures and spot prices. The second model was similar in that it built in the spot price into the analysis on the covariances. In the second test, the market efficiency was tested by examining the volatility of the futures. This involved the comparison of the mean variances on both sides of two inequality equations. The slope of the coefficients produced during the regression tests, were then examined to determine if they were statistically different from zero.

It was found that the Cox, Ingersoll and Ross models are not able to explain the Treasury Bill futures-forward price differences. The volatility study enabled Wong to conclude that the Treasury Bill futures market is efficient. There was evidence of autocorrelation existing in the nine-month futures contract tested. Wong suggests that this could be due to a missing variable related to information costs or default risk.

Chapter 6: ARCH – an Explanation and Literature Review.

The ARCH acronym is used to denote all ARCH type models. This chapter will examine the GARCH (1,1) model as well as the basic ARCH model. The explanation of the ARCH model can be seen in chapter five. This chapter will deal with some of the more advanced issues that need explaining and will examine the literature in the development of ARCH and GARCH (1,1) models. The last section of the chapter will deal with the application of the ARCH, GARCH (1,1) and basic volatility measurement models. In this section both South African and international studies will be reviewed.

6.1 ARCH & GARCH (1,1) - Explanation of Advanced Issues and terminology.

In chapter 5 the modelling of volatility was developed from a basic model, which does not take into account the long run, and time weighting of volatility to the ARCH model that takes these factors into account. The ARCH model was further developed into the GARCH (1,1) model where the long run and time-weighted volatility was adjusted to take into account the exponential decay of the weighting of the volatility observations over time. The chapter finished with a brief analysis of which model is the most appropriate in measuring volatility.

Chapter 5 did not deal with the estimation of the GARCH (1,1) parameters and the constant variance. Chapter 5 also dealt with the development of the model but did not explain the use of the terminology (Auto-Regressive and Conditional Heteroscedasticity). This section of chapter 7 will cover these areas.

6.1.1 Maximum Likelihood Methods

The approach applied to the estimation of the parameters is called the maximum likelihood method. It revolves around the maximization of the chance of an observation occurring. Hull (1999, 374) explains this by means of an example. Suppose that a selection of 10 stocks is sampled at random on a specific day. In looking at the stocks, one will be able to determine three possible price movements, namely: increase, decrease and no movement. Assume that during the day the price of one of the stocks decreased. Based on this data, if one had to estimate the future proportion of stocks with price declines, the most informed answer would have to be 10% based on the information available. Using the maximum likelihood method, one first looks at the probability of the decline in the price for one of the shares. If one defines the proportion of shares with a price decline as p, the probability that the remaining nine stocks do not decline is $p(1-p)^9$. The best estimate of p is when the probability of it occurring is at its highest. This is accomplished by maximising p. To maximise p the expression needs to be differentiated with respect to p and setting the result to nil. The result of this is $p = 0.1$. This shows what the maximum likelihood of p is, which is the same as the original estimate.

6.1.2 *Application of Maximum Likelihood Method.*

The first application of this methodology is in determining a figure for constant variance. The problem is in the estimating of a constant variance from m observations when the underlying distribution is normal and the variance is assumed to be constant (Hull, 1999 : 374). Hull (1999, 374) follows the above example and first determines the probability equation for a given variance observation:

$$P_{U_I} = \frac{1}{\sqrt{2\pi v}} \exp\left(\frac{-u_i^2}{2v}\right) \qquad (35)$$

Where:

u_i = The ith observation.

P_{u_i} = The probability density for the ith observation, u_i.

v = The variance of the probability density function P_{u_i}.

The observations are assumed to be u_1, u_2, ...u_m and the mean of the underlying distribution is zero. This equation (35) only takes into account an individual observation. To equate it to the example in 7.1.1 above it would be p. This single probability density function now needs to take into account the other observations. This is provided in the following formula:

$$P_m = \prod_{i=1}^{m} \left[\frac{1}{\sqrt{2\pi v}} \exp\left(\frac{-u_i^2}{2v}\right)\right] \qquad (36)$$

Where:

P_m = The probability density of the m observations occurring in order as observed.

Now that the probability density function has been described for all the observations, the next step, in accordance with the maximum likelihood method is to maximise the right hand side of the equation. The best estimate of v that maximises this expression needs to be determined. Maximising an expression is equivalent to maximising the logarithm of the expression. Taking the logarithms of equation 36 and ignoring constant multiplicative factors, the following expression results:

$$\sum_{i=1}^{m}\left[-\ln(v)-\frac{u_i^2}{v}\right] \tag{37}$$

Or

$$-m\ln(v)-\sum_{i=1}^{m}\frac{u_i^2}{v} \tag{38}$$

(Hull, 1999 : 375)

The above two formulas (37 & 38) are the maximising equations. These now need to be maximised. This is done by differentiating them (after setting them to zero):

$$\frac{1}{m}\sum_{i=1}^{m}u_i^2 \tag{39}$$

The function of the maximum likelihood estimate of v is thus equation 39. This is the estimate of the *constant* variance on day i over a period of m observations. One can thus see how the maximum likelihood method can be used to estimate variance. Now this must be applied to GARCH (1,1) to a) estimate the most likely GARCH (1,1) figure (defined as σ_i^2) which will then allow for b) the α, β and ω parameters to be estimated. The α, β and ω variables would have then been estimated using a maximum likelihood methodology. In applying the above to the GARCH (1,1) model the constant variance v must be expressed as a fluctuating variance v_i. The fluctuating variance is described by the GARCH (1,1) formula and so, $v_i = \sigma_i^2$ .We then substitute v with vi in the maximising expression and the following results:

$$\sum_{i=1}^{m}\left[-\ln v_i-\frac{u_i^2}{v_i}\right] \tag{40}$$

An iterative search is then performed to find the parameters in the model that maximise the expression in equation 40 above. This is known as estimating the parameters in a volatility-updating scheme. Hull (1999, 376) produces an example of this use of the volatility-updating scheme to determine the parameters; the example is reproduced in table 6.1 below.

Table 6.1 - Estimating of GARCH (1,1) parameters using a Volatility Updating Scheme.

The grid below shows an analysis of the Japanese Yen exchange rate between January 6 1988 and August 15 1997. The numbers in the table are based on trial estimates of three GARCH (1,1) parameters: ω, α and β. The first column in the table records the date the observation was made. The second column assigns a number to the date. The third column shows the exchange rate S_i at the end of day i. The fourth column shows the proportional change in the exchange rate between the end of day i - 1 and the end of day i. This is $u_i = (S_i - S_{i-1})/S_{i-1}$. The fifth column shows the estimate of the variance rate, $v_i = \sigma_i^2$ for day i made at the end of day i - 1. On day three the process is started by setting the variance rate equal to u_2^2. On subsequent days equation 28 (the GARCH (1,1) equation) is used. The sixth column calculates the likelihood measure $-\ln(v_i) - u_i^2/v_i$. The values in the fifth and sixth columns are based on trial estimates of ω, α and β. The aim is to choose the values of the parameters that maximise the sum of the values in the sixth column (thereby achieving the maximum of the maximisation formula).

GARCH (1,1) Estimation for Japanese Yen.

1	2	3	4	5	6
Date	***Day i***	S_i	u_i	$u_i = \sigma_i^2$	$-\ln(v_i) - u_i^2/v_i$
06-Jan-88	1	0.007728			
07-Jan-88	2	0.007779	0.006599		
08-Jan-88	3	0.007746	-0.004242	0.00004355	9.6283
11-Jan-88	4	0.007816	0.009037	0.00004198	8.1329
12-Jan-88	5	0.007837	0.002687	0.00004455	9.8568
13-Jan-88	6	0.007924	0.011101	0.00004220	7.1529
...	...	...	...	...	...
...	...	...	...	...	...
13-Aug-97	2421	0.008643	0.003374	0.00007626	9.3321
14-Aug-97	2422	0.008493	-0.017309	0.00007092	5.3294
15-Aug-97	2423	0.008495	0.000144	0.00008417	9.3824
Total (Max)					22,063.5763

In determining the values of of ω, α and β which maximise the total of column six an iterative procedure must be used. Hull recommends a special purpose algorithm, such as the Levenberg-Marquardt method, should be used to do this. In this example the optimal values of the parameters are:

$$\omega = 0.00000176$$
$$\alpha = 0.0626$$
$$\beta = 0.8976$$

Once the parameters have been determined, one is able to calculate the long-term variance *V*. In the above example *V* is:

$$\frac{\omega}{1-\alpha-\beta} = \frac{0.00000176}{0.0398} = 0.00004422$$

The long-term volatility is then: $\sqrt{0.00004422}$ or 0.665% per day.

To conclude, column five is the GARCH (1,1) output (taking into account the estimated parameters) while column six is the mechanism that is used to determine the GARCH (1,1) parameters, while relying on the output of column five. The solution to this problem is achieved by using an iterative procedure.

Source: Hull (1999:376)

From the above example and explanation, the following steps must be followed when estimating the GARCH (1,1) parameters:

1. Using the maximum likelihood methodology, determine the maximising expression to be used in estimating a constant variance (formulas 37 and 38).
2. Relax the assumption of the constant variance and allow the variance to fluctuate. Set the new fluctuating variance to σ_i^2 which is determined by the GARCH (1,1) formula.
3. Redefine the maximising expression using the new fluctuating variance.
4. Determine the maximum as done in table 6.1.
5. Using the maximum, determine the optimal values for the GARCH (1,1) parameters (again, see table 6.1).

According to Hull (1999:377) there is a more robust method that can be used to estimate the parameters in GARCH (1,1) called variance targeting. To employ the variance targeting technique, one must first set the long run variance rate, *V*, to a value deemed to be reasonable (a reasonable value for this would be the sample variance calculated from the data). This allows one to solve for ω because $\omega = V(1 - \alpha - \beta)$. This reduces the number of parameters that have to be estimated. With ω known, the only parameters that have to be estimated are α and β. The sample variance for the data in the above table (6.1) is 0.00004341 which, when rooted, produces a volatility of 0.659%. By substituting the sample variance for V, one is able to estimate new parameters for α and β that maximise the objective function in equation 40. The new parameters for α and β, using the above example, are 0.0607 and 0.8990 respectively. The value of the objective function (the summation of the individual $-\ln(v_i)-u_i^2/v_i$ terms) is 22,063.5274, which is slightly below the actual value calculated in table 6.1 of 22,063.5763.

6.1.3 GARCH (1,1) model -does it suffer from autocorrelation?

As will be seen below, the u_i^2 (the square of the percentage change in the price from day *i* - 1 to day *i*) data set suffers from autocorrelation. Does the GARCH (1,1) model solve this problem? In answering this question one must first start at the assumption underlying the GARCH (1,1) model, which is that volatility changes with the passage of time. During some periods volatility is relatively high; during other periods it is relatively low. When u_i^2 is high there is a tendency for $u_{i+1}^2, u_{i+2}^2, \ldots..$ to be high; when u_i^2 is low there is a tendency for $u_{i+1}^2, u_{i+2}^2, \ldots..$ to be low (Hull, 1999 : 378). This suggests some form of autocorrelation.

To examine this one first assumes that u_i^2 exhibits autocorrelation. Does GARCH (1,1) remove the autocorrelation? The autocorrelation structure for the variables u_i^2/σ_i^2 is examined to determine if this is true. If these variables show little autocorrelation the model for σ_i explains the autocorrelation in the u_i^2 term. The below example in table 6.2 shows the analysis of the autocorrelation.

Table 6.2 - GARCH (1,1) and autocorrelation.

Time Lag	**Autocorrelation for u_i^2**	**Autocorrelation for u_i^2/σ_i^2**
1	0.072	0.000
2	0.041	-0.010
3	0.057	0.005
4	0.107	0.000
5	0.075	0.011
6	0.066	0.008
7	0.019	-0.034
8	0.085	0.015
9	0.054	0.009

10	0.030	-0.022
11	0.038	-0.004
12	0.038	-0.021
13	0.057	-0.002
14	0.040	0.004
15	0.007	-0.026

Source: Hull (1999: 378)

The table refers to the yen-dollar exchange rate analysis performed in table 6.1. The first column in table 6.1 shows the time lag (in days) over which the autocorrelation was tested. The second column shows the autocorrelation results for u_i^2. The third column shows the autocorrelation results for the variables u_i^2/σ_i^2. Column two shows the autocorrelation observations are positive for u_i^2 for all lags between 1 and 15. In the case of u_i^2/σ_i^2, some of the autocorrelation measurements are positive and some are negative. They are also predominantly smaller in magnitude to the observations in column two. For this reason one can conclude the GARCH (1,1) model appears to have been successful in explaining the data by significantly reducing the evidence of autocorrelation.

There is a more scientific test that can be used to test for the existence of autocorrelation called the Ljung-Box statistic (Hull, 1999: 378). The Ljung-Box statistic can be described as follows: if a certain series has m observations the Ljung-Box statistic is:

$$m\sum_{k=1}^{K} w_k \eta_k^2 \qquad (41)$$

Where:

k = The lag in the data tested.

η_k = is the autocorrelation for lag k.

and:

$$w_k = \frac{m-2}{m-k} \qquad (42)$$

For k = 15 zero autocorrelation can be rejected with 95% confidence when the Ljung-Box statistic is greater than 25%. For table 6.2 above, the Ljung-Box statistic for the u_i^2 term is approximately 123. This shows evidence of autocorrelation as the result is greater than 25. For the u_i^2/σ_i^2 term the Ljung-Box statistic is 8.2 that suggests that the autocorrelation has been largely removed by the GARCH (1,1) model. (Hull, 1999 : 379).

6.1.4 Explanation of terminology

The name (G)ARCH stands for (General) Auto-Regressive Conditional Heteroscedasticity. The purpose of this section of the chapter is to explain the meaning of the terminology. The "conditional" part of the (G)ARCH term comes from the fact that the determination of the variance is conditional on past information. This has been demonstrated in both chapter 5 and chapter 7. The conditional variance is a function of three terms, namely:

1. The mean or long term variance: ω,
2. The volatility in the previous period measured as the lag of the squared residual from the mean: u_{n-1}^2 (this is known as the ARCH term),
3. The last period's forecast variance: σ_{n-1}^2 (this is known as the GARCH term).

The "auto-regressive" term means that the individual variance observations automatically regress to the level of the long-term variance, which is ω. This is shown by the presence of the long-term variance term in the (G)ARCH formula.

Heteroscedasticity is a non-random pattern in the residual error term. When analysing data, variability in the error term is assumed not to depend on any factor included in the analysis. This assumption is called the assumption of homoscedastic errors and when violated, heteroscedasticity is said to exist. Heteroscedasticity affects the size of the standard error of the regression coefficient, thereby biasing the results of any hypothesis testing. The problem of heteroscedasticity is solved by giving different weights to the observations in the test. This is done under both ARCH and GARCH. In the case of the GARCH formula the weights are exponential while the ARCH weightings are not (Schroeder, Sjoquist & Stephan, 1986 : 76)

To sum up: the volatility will always return to its long-term moving average if it is apart from it. It is conditional on past observations of volatility and events of the past and when a regression is performed, the variance in its error term is not constant for all values of the independent variables.

6.2 ARCH & GARCH (1,1) - Literature review of model development.

Three of the main papers that have impacted on the development of the ARCH and GARCH (1,1) models are reviewed in this part of the chapter, namely

1. "Autoregressive Conditional Heteroscedasticity with Estimates of the Variance of United Kingdom Inflation" by Robert F. Engle,
2. "Estimating Time-Varying Risk Premia in the Term Structure: The ARCH-M Model" by Robert F. Engle, David M. Lilien and Russell P. Robins and
3. "Generalised Autoregressive Conditional Heteroscedasticity" by Tim Bollerslev.

Other authors and papers may be mentioned but are taken from the references from the above papers. The first and third papers are the papers in which the ARCH and GARCH models are first produced respectively.

6.2.1 ARCH by Engle.

Prior to the existence of the ARCH model, economic forecasters have found their ability to predict the future varies from one period to another. It is suggested that the inherent randomness associated with different forecast periods seems to vary widely over time. NcNees (1979) notes that large and small errors tend to cluster together over different periods. This suggests that there is a usefulness in applying the ARCH model where the underlying forecast variance may change over time and is predicted by past forecast errors.

In monetary theory and the theory of finance, portfolios of financial assets are held as functions of the expected returns and variances of the rates of return. Any shifts in asset demand must be associated with changes in expected means and variances of the rates of return. If the mean is assumed to follow a standard regression the variance is constrained to be constant over time.

Prior to the development of the ARCH methodology, the manner in which variance was measured over time was done on an ad hoc basis. Klein (1977) obtained estimates of variance by constructing the five-period moving variance about the ten-period moving average of the annual inflation rates. Kahn (1980) looked at the concept of variability, which was defined to be the absolute value of the first difference of the inflation rate.

With regards to the observations noted about the characteristics of the variance data points above, Engle is of the opinion that the first order linear ARCH process is well suited to take these characteristics into account. This is because the first order linear ARCH process generates data with fatter tails that the normal conditional density function. Engle notes that many statistical procedures have been designed to be robust to large errors, but to his knowledge, none of the literature has made use of the fact that temporal clustering of outliers (as noted by McNees above) can be used to predict their occurrence and minimise their effects. This is the approach taken by the ARCH model.

Engle uses the maximum likelihood methodology to determine the weighting parameters in the ARCH equation similar to how the methodology is used earlier in the chapter as he determines it to be the most efficient way to measuring the weightings. In the paper he compares using the maximum likelihood methodology to using an ordinary least squares (OLS) method and concludes that the OLS method is less efficient in determining the parameters. The OLS methodology is, however, more appropriate if the disturbances in the data are not conditionally heteroscedastic. To prove that the data is conditionally heteroscedastic, Engle uses the Lagrange multiplier test procedure. The results of the test are that the data is conditionally heteroscedastic and the ARCH procedure is applicable.

Once Engle determines that ARCH is the applicable tool to estimate the variance in the United Kingdom inflation rate, he moves on to actually applying the model. In analysing the data and economic theory concerning inflation, Engle notes that economic agents do not only respond to the mean, but to "higher moments of random economic variables". He further argues that portfolio decisions are not only determined in response to the mean of the rate of return, but the variance as well. Friedman (1977) notes that high inflation will generally be associated with high variability of inflation. For this reason Engle notes that variability in inflation needs to be measured. The ARCH method allows a conventional regression specification for the mean function, with a variance that is permitted to change over the sample period. A linear declining set of weights was formulated after applying the Lagrange multiplier test. A two-parameter variance function was chosen because Engle anticipated the weightings (α) would not necessarily be stationary and non-negative in an unrestricted model.

Engle then looks at the difference between using the maximum likelihood methodology versus the ordinary least squares method to determine the sizes of the weightings. He noted that the maximum likelihood methodology decreases the sizes of the short-run dynamic coefficients (weightings) and increases the coefficient in the long run. Engle notes that these seem to be reasonable results since much of the inflationary dynamics are estimated by a period of very severe inflation in the middle 1970's. This, however is also the period of the largest forecast errors and, hence, the maximum likelihood estimator will discount these observations. By the end of the sample period, inflationary levels were rather modest and one might expect that the maximum likelihood estimates would provide a better forecasting equation.

Finally, Engle examines whether the confidence intervals arising out of the ARCH model were superior to the least-squares model. He notes, after examining the observations exceeding one standard deviation, that the number of outliers for the ordinary least squares method is reasonable; however, the timing of their occurrence is far from random. The ARCH model comes closer to truly random residuals after standardising for their distributions.

The application of the ARCH model to the inflation data illustrates the usefulness of the ARCH model for improving the performance of a least-squares method for obtaining more realistic forecast variances.

6.2.2 ARCH-M a collaboration between Engle, Lilien and Robins.

This paper extends Engle's ARCH model to allow the conditional variance to become a determinant of the mean and results in a new model called ARCH-M(ean). The model explains and interprets recent econometric failures of the expectations hypothesis of the term structure.

The authors are of the opinion that as the degree of uncertainty on asset returns varies over time; the compensation required by risk averse "economic agents" for holding these assets must also be varying. Time-series models of asset prices must therefore both measure risk and its movement over time, and include it as a determinant of price. Any increase in the expected rate of return of an asset as it becomes more risky will be identified as a risk premium.

Relating this to the term structure of interest rates, traditional expectations hypothesis is deemed to be inadequate to explain the observed data. This results in conclusions that there is some form of less than fully rational expectations, or time varying premia on different term debt. The aim of the ARCH-M model is thus to introduce the possibility of time-varying term premia. A review of the literature reveals, according to the authors, that most of the changes in the slope of the yield curve reflect changing liquidity premiums or expectations that do not satisfy the standard postulates of rationality. The results of the different studies suggest the importance of developing models capable of explaining fluctuating liquidity premiums.

The key postulate in the paper is that time-varying premia on different term-debt instruments can be modeled as risk premia where the risk is due to unanticipated interest rate movements and is measured by the conditional variance of the one-period-holding-yield. The paper introduces the ARCH-M model that allows the conditional variance to affect the mean. In this way changing conditional variances directly affect the expected return on a portfolio. The authors found that variables which were useful in forecasting excess returns are correlated with the risk premia and loose their significance when a function of the conditional variance is included as a regressor.

The ARCH-M model is applied to six and two-month treasury bills and to 20 year Aaa rated corporate bonds to determine if there is any time-varying risk premia and how large they are. The authors then move on to developing a theoretical model of the relationship between means and variances, which is formulated as a statistical model. This is followed by a defining of the ARCH-M model and a presentation of its applications.

In looking at the relationship between risk and return the authors examine the simplest set-up of one risky asset with normally distributed returns and one riskless asset. The risk is measured by the variance of the returns from holding the asset and the compensation by a rise in the expectation of the return. The relationship between the mean and the variance of the returns will ensure that the asset is fully held in equilibrium, which will depend on the utility function of the economic agents and the supply conditions of the assets. The authors then look for empirical evidence on the relationship between the proportion of movement in the mean in relation to the movement in the variance given the risk preferences of the agents and the supply elasticity.

In developing the model it was assumed that the risk of holding the long-term bond was not diversifiable so that only variance matters. The initial specification takes the mean as a linear function of the standard deviation.

The results of the testing reveal the following:

i) The precision with which economic agents can predict the future varies significantly over time. In relatively quiet periods, like the mid 1960's, relatively quiet forecasts can be made and agents can speculate on the future without absorbing large risks. In volatile periods, like the early 1970's and early 1980's forecasts are less certain and speculation is riskier. Risk premia therefore adjust to induce investors to absorb greater uncertainty with holding the riskier asset.
ii) ARCH was present in the forecast errors of bond-holding yields indicating substantial variation in the degree of certainty over time.
iii) The measure of certainty proved very significant in explaining the expected returns in two of the data sets, and was significant only at slightly more than the 5 percent level for the third. This enable the authors to conclude:
iv) Risk premia are not time invariant; rather they vary systematically with the agent's perceptions of underlying uncertainty.

The authors finally conclude that while their initial results suggest the promise that the ARCH technique to applications that require the measurement of uncertainty, they feel that the current ARCH model is but a first step. The ARCH framework may be applied to more general models of uncertainty and risk. It may be extended to allow conditional covariances to vary, resulting in time varying risk betas. This generalisation of the ARCH model is achieved in the GARCH model proposed by Bollerslev.

6.2.3 GARCH by Bollerslev.

Bollerslev proposed a natural generalisation of the ARCH model proposed by Engle, to allow for past conditional variances in the current conditional variance equation. In his paper, Bollerslev derives stationary conditions and an autocorrelation structure for this new class of parametric models. The maximum likelihood estimation techniques are also considered. Bollerslev finally presents an empirical example relating to the uncertainty of the inflation rate.

Bollerslev argues that in the applications of Engle's ARCH model the authors use a rather arbitrary linear-declining lag structure in the conditional-variance equation to take account of the "long memory" typically found in empirical work. This is because estimating a totally free lag distribution often will lead to violation of the non-negativity constraints. Bollerslev's GARCH model allows for a much more flexible lag structure. In the empirical applications of the ARCH model a relatively long lag in the conditional variance equation is often called for, and to avoid problems with negative variance parameter estimates a fixed lag structure is typically imposed. Bollerslev argues that, in light of immediate practical interests, the ARCH class of models should be extended to allow for both a longer memory and a more flexible lag structure.

In examining the GARCH (1,1) process Bollerslev notes the following:

1. It is leptokurtic and shares this property with the ARCH model.
2. The GARCH(p,q) process can be interpreted as an autoregressive moving average process.
3. The maximum likelihood methodology is the best to use in determining the GARCH (1,1) parameters.
4. In determining the parameters, the iterative procedure that is most convenient to use is the Berndt, Hall, Hall and Hausmann (1974) algorithm.
5. Because of the complication involved in estimating the GARCH process, it seems of interest to have a formal test for the presence of GARCH.
6. The test applied by Bollerselv (relating to 5 above) is the Lagrange multiplier test.

Bollerslev applies the GARCH model to the observation of inflation. He notes that the uncertainty of inflation is an unobservable economic variable of major importance, and within the ARCH framework several different models have already been constructed to deal with it. Bollerslev concentrates on the model Engle and Kraft (1983) produced where the rate of growth in the implicit Gross National Product deflator in the United States is explained in terms of its own past.

The paper analyses the period second quarter 1948 to fourth quarter 1983 (a total of 143 observations) using ordinary least squares regression methodology. Bollerslev notes that the model is stationary and none of the first ten autocorrelations or partial autocorrelations of the error term are significant at the 5% level. In comparing the findings of GARCH (1,1) model with the findings of the ARCH model of Engle and Kraft (1983), Bollerslev notes that the GARCH (1,1) model provides better fit for the lag and also exhibits a more reasonable lag structure.

Bollerslev further graphed together with 95 per cent asymptotic confidence intervals for the one-step-ahead forecast errors the GARCH model. He noted that from the late 1940's to the mid 1950's the inflation rate was very volatile and hard to predict. This is reflected in the wide confidence intervals for the GARCH model. The 1960's and 1970's, however, were characterised by a stable and predictable inflation rate. During this period Bollerslev felt that the ordinary least squares method was much too wide. Starting with the second oil crisis in 1974 there was a slight increase in the uncertainty of the inflation rate, although it does not compare in magnitude at the beginning of the sample period. Bollerslev concludes that the GARCH (1,1) model is better suited to the data.

6.3 ARCH, GARCH (1,1) & Volatility - Literature review of model application.

The aim of this section is not to have an exhaustive review of the literature, but to get an insight into the basic volatility, ARCH and GARCH (1,1) models through examples of their application. Four studies are examined. The first two deal with the studying of volatility in a South African context (but do not apply the GARCH or ARCH methodology). The second two studies look again at the (G)ARCH application. The studies are:

1. "The Impact of Trading Volume of Share Price Volatility" by Garth Saloner.
2. "Evaluating the Empirical Bias, Efficiency and Forecasting Properties of Various Volatility Estimators for the Futures Contracts Traded on SAFEX" by Suzette Esterhuyse.
3. "Measuring and Testing the Impact of News on Volatility" by Robert F. Engle and Victor K. Ng.
4. "Stock Market Volatility and the Information Content of Stock Index Options" by Theodore E. Day and Craig M. Lewis.

In the case of the last study the focus of the review is not on the information content of stock index options but on the calculation and estimation of stock market volatility.

6.3.1 Volume and Volatility by Saloner.

Saloner focuses on the capital asset pricing model and how volatility increases the cost of capital. The nature of trading volume was investigated on the Johannesburg Stock Exchange. In achieving this attention had to be paid to the measurement of the frequency with which a share is traded. Saloner found that the different methods of measuring trading volume (average annual trading volume, the number of deals consummated and the number of days on which a share is traded) were shown to be equivalent in their measurement of trading volume.

Saloner discovered further that there is a small positive correlation between a company's issued share capital and its trading volume. This was discovered while looking for a relationship between the absolute price level of a share and the frequency with which it is traded. Saloner discovered that these two variables are mutually independent.

The next part of the study concentrated on the empirical data after the salient characteristics of trading volume had been established. Saloner found, after examining a sample of fifty ordinary shares listed on the JSE, that whereas highly traded shares seemed to exhibit behavior consistent with the efficient markets hypothesis, at low volumes several important changes occurred.

The changes noted were:

i) The correlation between the share and market returns becomes a function of volume with the relationship becoming stronger the lower the volume.
ii) Correspondingly, the beta coefficient of the systematic risk also becomes volume-dependent. The lower the recorded volume the lower the recorded beta.
iii) In portfolios the low volume dependency of measured systematic risk manifests itself in greater diversifiable risk.
iv) The measured ex-post risk-return relationship breaks down at low volumes.

These findings had an impact on the efficient markets hypothesis, the absence of an identifiable risk-return trade-off rendered the common tests inoperable as, in effect, there was a trading volume limit to tests of the efficient market hypothesis based on the mean-variance market equilibrium model.

The above findings were prior to Saloner applying statistical methods to the measurement of volatility. In looking at the volatility, Saloner noted that the behavior of the share returns becomes significantly non-random at low volumes with the distributions of returns becoming manifestly leptokurtic with long tails. This occurs while the time series of monthly returns exhibit non-random runs.

The methodology applied by Saloner, in the measurement of volatility, was to examine the relationship between the log volume and the beta for individual shares. This was done by performing a regression analysis between the two (the log volume and the beta for the individual shares). The results of this showed that no significant correlation could be found between the two. Saloner also examined the relationship between trading volume and the standard deviation of returns as a measure of risk. He found that no significant relationship exists between the two. The only reference to the actual measure of volatility in the Saloner study is the reference to the standard deviation of the returns. This suggests that Saloner used the traditional methodology to determine the volatility in the underlying shares. This was partly due to the lack of sophisticated statistical techniques (such as ARCH and GARCH) when the study was completed (ARCH was developed in 1982 whereas the Saloner study was completed in 1977).

6.3.2 Evaluation of Volatility Estimators by Esterhuyse.

In her examination of various volatility estimators, Esterhuyse did not look at either of the ARCH or GARCH model. She did, however look at Auto-Regressive Moving Average (ARMA) models whose principles are incorporated into the GARCH model. The study aimed to evaluate the relative efficiency, bias and forecasting properties of extreme-value estimators of the volatility of the futures contracts traded on SAFEX for the period May 1990 to December 1994. Esterhuyse claims that theory predicts these extreme value estimators could be more efficient than the traditional close-to-close estimators when trading is continuous, always monitored and the price movements are small relative to the price of the stock. Close-to-close estimators based on the differences between the closing price of the previous day and the close of the current day.

The extreme value estimators tested were the Parkinson's extreme-value estimator and the Garman and Klaus extreme-value estimator. An extreme value estimator is an estimator based on the high and low prices observed during the trading day. This differs from the traditional close-to-close estimator that does not place emphasis on intra day movements. The Parkinson's extreme-value estimator looks at generating a diffusion constant, which characterised the random walk pattern of a stock. The diffusion constant is defined as:

$$D_x = \frac{1}{(1-n)} \sum_{i=1}^{n} \left(d_i - \overline{d}\right)^2 \tag{43}$$

Where:

Dx	=	Diffusion Constant.
di	=	$x_{(i)} - x_{(i-1)}$
$\overline{d}$	=	$\frac{1}{n}\sum_{i=1}^{n} d_i$ which is the mean displacement

From this one is able to define the Parkinson's extreme-value estimator as:

$$D_1 = \frac{0{,}361}{n} \sum_{i=1}^{n} 1_i^2 \tag{44}$$

The model employed by Garman and Klass (1980) assumed that stock prices are governed by a diffusion process of the form:

$$P(t) = \Phi(B(t)) \tag{45}$$

Where:

P	=	The stock price.
t	=	Time.
Φ	=	monotonic time-independent transformation.
B(t)	=	a diffusion process with differential presentation, dB = σdz

Where

dz	=	standard Gauss-Weiner process and
σ	=	unknown constant to be estimated.

Esterhuyse found both models to be downwardly biased when trading is discreet. High trading volumes and small minimum price increments can minimise these biases, leading to conditions under which these extreme-value estimators could potentially outperform to traditional close-to-close estimator. The above models were tested against data on the ALSI, GLDI and INDI contracts. Due to outliers (mainly in the reported high low prices) two sets of results were presented for these three contracts. The effect of eliminating the outliers was to reduce the standard errors significantly.

Esterhuyse found the results of the bias tests for the weekly and monthly volatilities to be fairly similar. The amendment of the outliers had very little effect on the bias properties of the two extreme value estimators. In looking at the ARMA tests, Esterhuyse found instances where these tests yielded different conclusions to the efficiency tests. Only in a select few cases could a "best" estimator (that is an estimator that is the best estimator if itself and the traditional close-to-close estimator) be determined.

Off all the results presented, Esterhuyse could not point to a single estimator outperforming all others in all cases. Whilst the traditional close-to-close estimator is still the accepted one in practice, Esterhuyse noted that the extreme-value estimators do show some promise. This is given that the data sets to which they are applied are of sufficient quality (that is exclude extreme outliers) and that the basic assumptions behind these estimators are satisfied.

Based on the results of the study, Esterhuyse drew the following conclusions:

1. Financial data needs to be validated carefully (preferably from a secondary source) when outliers are found, their treatment should be statistically correct and consistent.
2. The ARMA forecasting equations were presented on the basis of comparing the extreme-value estimators "in sample" To compare how accurate the ARMA forecasting equations are "out of sample" forecasts should be done for the various estimators.

6.3.3 News and Volatility: Engle and Ng.

In this paper Engle and Ng define the news impact curve which measures how new information is incorporated into volatility estimates. Various new and existing ARCH models, including a partially nonparametric one, are compared and estimated with daily Japanese stock return data. Engle and Ng examine the response of volatility to news and find that, through the presentation of new diagnostic tests, the volatility response is asymmetric. This asymmetry is captured using a new model - EGARCH (Exponential Generalized Autoregressive Conditional Heteroscedasticity). In assessing the applicability of the new model the authors note that there is evidence of a high variability if the conditional variance implied by the EGARCH.

The authors look at the different methods of predicting volatility and note an approach that they call the "asymmetric" or "leverage" model that is based on the premise that good news and bad news have different predictability for future volatility. The aim of this paper is to build on the work of previous authors in this area by focusing on the asymmetric effects of news on volatility. Specifically, the authors provide new diagnostic tests, a partially nonparametric model for discovering the empirical relationship between news and volatility, and a metric for interpreting the differences between volatility models.

In their review of the ARCH and GARCH models the authors note that the ARCH(p) model gives no weight to news p periods ago whereas the GARCH model does but on a geometrically reduced basis. Despite all the success of these simple parameterisations, the authors are of the opinion that the ARCH and GARCH models cannot capture some of the important features of the data. The most interesting of these being the asymmetric effect discovered by Black (1976). Statistically, this effect occurs when an unexpected drop in price (bad news) increases predictable volatility more than an unexpected increase in price (good news) of similar magnitude. This effect suggests a symmetry constraint on the conditional variance function in past error terms is inappropriate. One model proposed to capture such asymmetric effects is Nelson's EGARCH model. The EGARCH model is defined as:

$$\log(h_t) = \omega + \beta.\log(h_{t-1}) + \gamma.\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}} + \alpha\left[\frac{|\varepsilon_{t-1}|}{\sqrt{h_{t-1}}} - \sqrt{2/\pi}\right] \qquad (46)$$

Where:

h_t	=	volatility at time t.
ω, β, γ and α	=	constant weighting parameters.
ε_t	=	collective measure of news at time t.

When comparing the GARCH and the EGARCH model the authors notice an interesting metric by which to analyse the effect of news on conditional heteroscedasticity. Holding constant the information dated t - 2 earlier, they examine the implied relationship between ε_{t-1} and h_t which produces a curve they call the news impact curve. This curve relates the past return shocks (news) to current volatility and measures how new information is incorporated into volatility estimates. The news impact curve differs from the standard GARCH model in two main respects:

1. The EGARCH model allows good news and bad news to have a different impact on volatility, while the standard GARCH model does not, and
2. The EGARCH model allows big news to have a greater impact on volatility than the standard GARCH model.

The effects of this is that the GARCH model produces results which dictate that positive and negative return shocks of the same magnitude produce the same amount of volatility, whereas the EGARCH gives a higher weighting to bad news.

The authors then apply their theory to the estimation of Japanese stock volatility for the period 1 January 1980 to 31 December 1988. Their findings were that the negative shocks introduce more volatility than positive shocks, with this effect particularly more apparent for the largest shocks. The diagnostic tests employed by the authors, however, indicated that in many cases the modeled asymmetry was not adequate. The authors also found that for reasonable shock values, the volatilities forecast by EGARCH and a partially nonparametric ARCH model were similar. However, for more extreme shocks, the forecasts differed more dramatically. The standard deviation of the EGARCH estimated conditional variance was even higher than that of the squared residual itself. The result was interpreted as evidence against the EGARCH model, because the variability of the conditional variance, if correctly specified, should not be higher than that of the squared residual.

The authors finally conclude that the news impact curve is a good measure of how news is incorporated into volatility estimates. They also conclude that there could be several different types of asymmetry of the news curve and that a partially nonparametric ARCH model is a useful approach to modelling conditional heteroscedasticity.

6.3.4 Stock Market Volatility by Day and Lewis.

The Day and Lewis study looked at the information content of implied volatilities from call options on the S&P 100 index in comparison to the GARCH and EGARCH models of conditional volatility. They found that by adding the implied volatility to the GARCH and EGARCH models as an exogenous variable, the within sample incremental information content of implied volatilities can be estimated using a likelihood ratio test of several nested models for conditional volatility. The ability of these models to predict volatility is also examined by regressing the *ex post* volatility on the implied volatilities and the forecasts from the GARCH and EGARCH models.

The authors contend that the *ex ante* forecast of the average volatility of an underlying asset over the life of an option is interpreted from the implicit instantaneous variance of the price of the call option. The ability of implied volatilities to predict the future volatility of an underlying asset is considered to be a measure of the information content of call prices. This predictive content of implied volatility is examined by adding it to the GARCH model as an exogenous variable. This enables the authors, through the construction of a nested model, to statistically assess whether implied volatility is an important determinant of conditional volatility.

The methodology employed was to first measure the GARCH parameters. This was done by using a maximum likelihood methodology called the Berndt-Hall-Hall-Hausman algorithm. The authors examined two separate time series of weekly returns on the S&P 100 index. The first time series was simply the unadjusted returns computed from the closing index level, which reflects any positive serial correlation induced by nonsynchronous trading. The second time-series of index returns is computed using estimates of the index level implicit in the price of stock-index call options. Once the parameters had been measured the implied volatilities were calculated.

The implied volatilities were calculated using the call options on the Standard and Poor's 100 index from 11 March 1983 to the 31 December 1989. The data was adjusted to eliminate bias by eliminating nonsynchronous trading, option quotations with a daily volume of less than 100 contracts and/or contracts where the absolute value of the difference between the closing price and the contract's exercise price exceeds $15. In addition, option contracts with closing prices less than $0.25 were eliminated because of the size of the bid-ask spread being large relative to the price of the option. The implied volatilities were calculated using the dividend-adjusted version of the Black-Scholes model.

The authors note that the stochastic nature of the volatility captured by the GARCH models suggest that their estimates of implied volatility may be subject to specification error, since they use a European option pricing model that assumes that volatility is nonstochastic. A second source of potential specification error arises from the possibility of early exercise attributable to the discreet nature of dividends on the S&P 100 index. With regards the first potential error, the authors note that the specification error in the estimates of implied volatilities can be minimised by focusing on at the money options. The second potential error is insignificant because since the likelihood of dividend-related exercise of S&P 100 call options is fairly low, the use of a European option-pricing model is adequate for the purposes of the study.

In their conclusion, the authors found that the interpretation of the results became complicated by model misspecification and expiry date effects that add noise to the forecasts of future volatility implicit in option prices. The (within-sample) results suggest that implied volatilities may contain incremental information relative to the conditional volatility from GARCH and EGARCH models. The authors also found strong within-sample evidence that the conditional volatility estimates from GARCH and EGARCH models reflect incremental information relative to implied volatility. These results all suggest that neither implied volatility nor the conditional volatilities from GARCH and EGARCH models completely characterise the within-sample stock market volatility when the excess market return is assumed to be a linear function of conditional market volatility.

The authors explored this further by performing out-of-sample comparisons of the relative predictive power of the volatility forecasts to *ex post* volatility. From this they were able to conclude that weekly volatility is difficult to predict. The authors also found that the GARCH and EGARCH forecasts are unbiased, but were unable to make strong statements concerning the relative information content of GARCH forecasts and implied volatilities. The results did provide limited evidence that, in certain circumstances GARCH models provide better forecasts than EGARCH models.

Chapter 7: Empirical Testing of Market Efficiency – Closing rate data.

This chapter examines the empirical evidence of the efficiency of the SAFEX listed futures using closing rate data. It is useful as it can be compared to earlier closing rate studies performed by Lambrechts (1990), Levett (1991) and Snell (1990). As part of this examination the relationship between the spot and futures price is examined to see if they indeed are correlated. The time delay between the time it takes the one instrument to react to news relative to the other should give some indication as to the efficiency with which the spot and futures markets react to news. The market efficiency is then further tested by calculating the arbitrage gap that is the difference between the bounds of the theoretical futures price and the actual futures price. In the event of a persistent arbitrage gap existing an attempt will be made to examine as to why this is the case. As part of this the market mechanics will be examined as well as the influences on the market such as the different market shocks described in chapter two. The arbitrage gap analysis was performed using a "fair value calculator" which was developed for the purposes of this thesis. The calculator is attached in Appendix 8.1 and the calculations it performs are explained in 8.4 below.

7.1 Objective.

The objectives of this chapter are twofold, namely to first test for the efficiency of the SAFEX listed futures through the examination of how the spot and the futures prices move together and secondly to test the efficiency of the SAFEX listed futures prices by determining if there is any evidence of persistent arbitrage opportunities. In an efficient market one should note a high degree of correlation in the movement of the spot and futures prices. A further characteristic of an efficient futures market is that there will be a lack of persistent arbitrage opportunities. In an efficient market arbitrage opportunities should be eliminated soon after they have arisen. Typically, one should not observe them occurring for more than a few hours. In this chapter the analysis is performed on closing rate data, in the event there are arbitrage opportunities they will have been open for a long period of time (the market closing period and some of the market open period). If these arbitrage opportunities prevail for a number of observations this implies that the arbitrage opportunities exist for more than 1 day which would enable one to conclude the market is inefficient. In chapter nine the focus is in intra day data which allows one to look at the opening and closing of arbitrage "gaps" during the course of the trading day and conclude on the pricing efficiency with greater confidence.

7.2 Introduction and Hypotheses.

Various methods can be used to test for futures market efficiency. Lambrechts (1990) uses four methods ranging from correlations between the spot and the futures price to the calculation and examination of the residual correlation in the futures market. The approach taken by this study is twofold, firstly the correlation between the spot and futures prices is examined to determine if the two are indeed linked through some fixed mechanism. Secondly, once a conclusion has been drawn on the correlation and anticipating it to conclude that the spot and futures prices are correlated, the arbitrage gap is calculated. If the first test returns a result that the spot and future are not correlated the second test looses relevance as this tests the extent to which the futures price remains in its fixed position (relative to the spot price). The hypotheses are:

7.2.1 Hypothesis One - Spot / Future Correlation.

The spot and futures price are related by means of a pricing formula (the cost of carry formula) for this reason one should note a similarity between the movement in the spot and the futures prices. The hypothesis to be examined is that there is a statistically significant correlation between the movements in the spot price and the futures price of the futures contract.

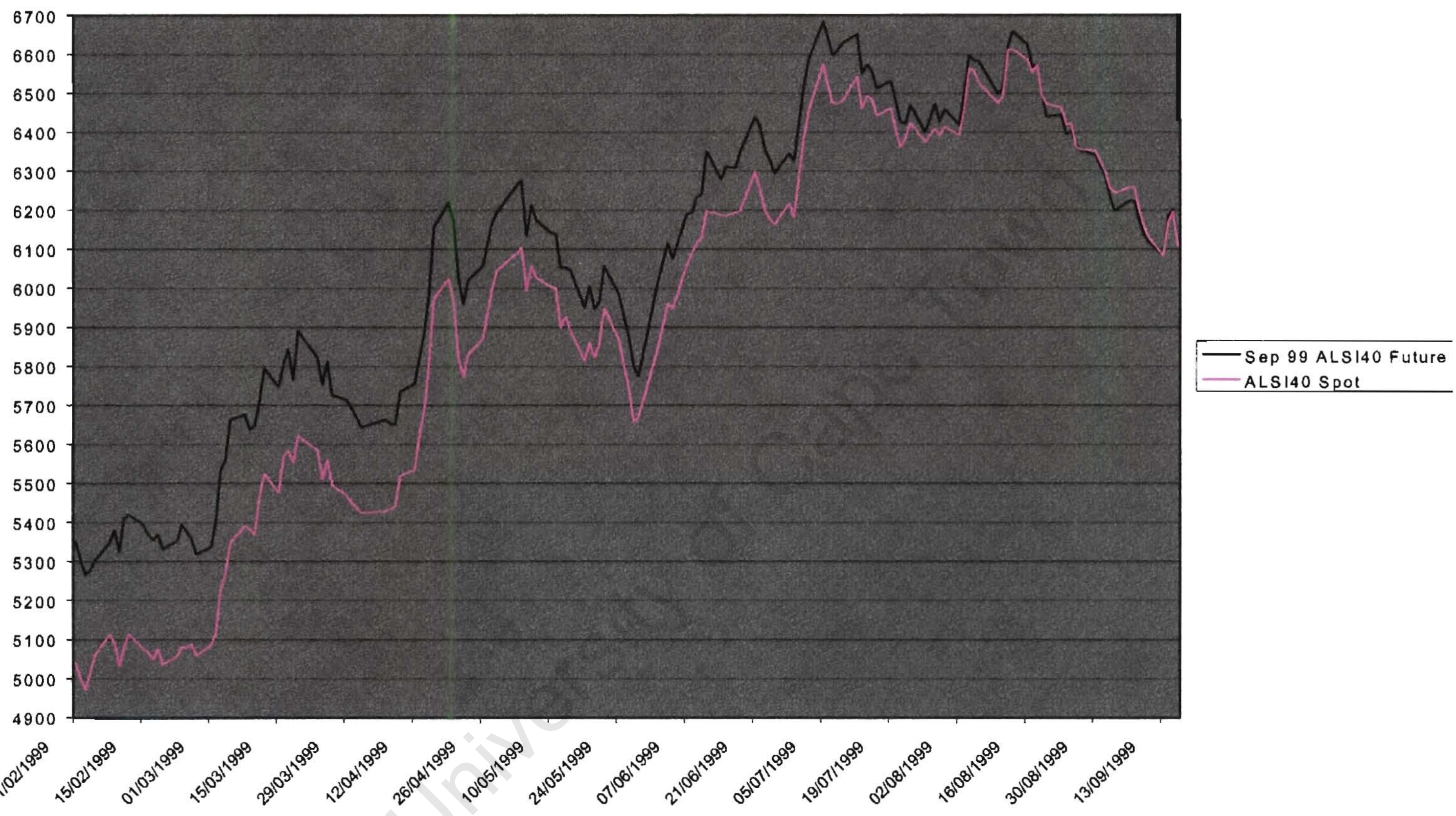
7.2.2 Hypothesis Two - Arbitrage Gap.

In the event futures markets are efficient there would be no opportunity for traders to make arbitrage profits from exploiting price discrepancies between the spot and futures market. The second hypothesis is thus that there is no economically significant arbitrage gap to be exploited between the spot and futures prices over any period of time.

7.3 Theoretical Background and Methodology.

The data for the examination has been supplied by a number of different sources. In determining the data to use consideration needs to be given to the theoretical requirements of the cost of carry model and the correlation calculation. In the case of the cost of carry model one needs to tailor it to the specifics of the market (in this case the South African Financial Markets) before initiating the test. This section of chapter eight looks at the cost of carry model and how it evolves to describe the cost of carry relationship in the South African financial markets. Before undertaking this tailoring process we look at the correlation calculation. The methodology employed in testing hypothesis one was to first break down the data into contract periods then calculate the correlation. Due to data constraints, thirty-eight contract periods were identified, namely the June 1990 contract to the September 1999 contract. For each contract the spot and futures prices were graphed and a reasonability check was performed by examining the convergence of the spot and futures prices (the diminishing of the basis). This can best be seen in the following figure 7.1:

Figure 7.1 - September 1999 ALSI Future vs ALSI Spot.



In the above figure one can see the futures price and the spot price converging (the basis reducing), which is a good example of what to expect over the life of a futures contract. This graph was produced for all the contracts in the series as well as the other futures contracts that are examined in this study (See appendix 8). This was done as a reasonability test of the accuracy of the data. Once the graphs had been produced the log normal changes in the prices of the spot and futures prices were calculated. At this point the correlation calculations were performed. The correlation was calculated by using the square of the Pearson correlation coefficient (the coefficient of determination) between the actual futures and spot prices. The square of the Pearson correlation coefficient is the square of the product moment correlation coefficient through data points in known_y's and known_x's. The r-squared value can be interpreted as the proportion of the variance in y attributable to the variance in x. Returns the Pearson product moment correlation coefficient, r, a dimensionless index that ranges from -1.0 to 1.0 inclusive and reflects the extent of a linear relationship between two data sets. The formula describing the calculation of the Pearson correlation coefficient is:

$$r = \frac{n\left(\sum XY\right) - \left(\sum X\right)\left(\sum Y\right)}{\sqrt{\left[n\sum X^2 - \left(\sum X\right)^2\right]\left[n\sum Y^2 - \left(\sum Y\right)^2\right]}} \tag{47}$$

Where:

X	=	One set of data points.
Y	=	The second set of data points to be regressed against the first one.

By squaring the Pearson correlation coefficient, one determines the coefficient of determination which shows to what extent one variable is explained by the other.

7.3.1 Tailoring the Cost of Carry Model.

In examining the basic cost of carry model as outlined in chapter three the first variable one needs to be aware of is the interest rate. The interest rate used in this research was determined after discussions were held with a number of arbitrage traders at South African Investment Banks. The interest rates they use (i.e. what they have to borrow and lend at) are linked to the negotiable certificate of deposit (NCD) interest rate. The NCD rate used was the three-month rate as the rate faced by the traders is the short-term rate. For the purposes of ensuring a spread between the borrowing and investing interest rate the lending (investing) rate was assumed to be fifty basis points below the NCD rate and the borrowing rate was assumed to be fifty basis points above the NCD rate. This would vary from trader to trader and bank to bank.

The next variable that needs to be finalised is that of the dividends. According to P. Levett (1991) actual dividends should be used rather than the dividend yield. This was found after a comparison was performed using both methods. Traders tend to use the dividend yield due to the computational and administrative burden inherent in using the actual dividends. The actual dividends tend to be "lumpy" in nature and as the cost of carry model is based on the time value of money the effects of spreading the dividends (by the use of the dividend yield) can distort the cost of carry fair value. In this study both methods have been employed. This allows for a comparison between the values generated by the dividend yield cost of carry model and the actual dividend cost of carry model. To set up the actual dividend model the dividends paid by the underlying spot instrument(s) have to be determined. For single stock futures this is fairly easy information to compile. In the case of index futures the administrative burden increases substantially. One first has to reconstruct the index over the period of time that is under analysis. The indices are monitored and changed (if necessary) quarterly by the Johannesburg Stock Exchange. To reconstruct the index one needs to take these changes into account. In between the index changes the companies within the index can undergo corporate actions such as takeovers and share issues. These need to be taken into account and adjusted accordingly when calculating the constituents of the index. Once the index has been reconstructed the dividends paid by each constituent of the index have to be calculated and reduced to a single dividend payment. Due to the administrative burden of doing this the fair value of the futures using actual dividend cost of carry model will only be calculated for the single stock futures and the ALSI futures contract for the period June 1995 to July 1999.

In order to execute the cost of carry and reverse cost of carry arbitrage one needs to be aware of certain practical constraints. The constraints could be discussed under the heading "transaction costs". The transaction costs are made up of two different types, namely direct and indirect transaction costs. Direct transaction costs would involve costs such as brokerage and trading taxes. For the purposes of this study these have been ignored because the trading houses and banks often have seats on the various exchanges and are thus able to avoid the brokerage costs and related taxes thereon. With regards indirect trading costs the situation becomes more complicated. Indirect trading costs would primarily arise out of one of the two following situations: Firstly where the liquidity in the underlying stock is low and the bid offer spread is subsequently wide. This causes the actual traded price to vary significantly from trade to trade. One also will notice an adverse movement in the market price as the traded volume increases in relation to the daily market size. The second "cost" affects index futures and involves the creation and liquidation of baskets. In order to execute a cost of carry arbitrage strategy one must borrow and buy the underlying stock and sell it forward. In buying the underlying stock in the case of an index share one must buy a proportional amount of stock so as to mirror the index. This can result in the purchase of odd lots as well as there will be differences in liquidity across the different stocks within the index. An added complication is the time it will take to buy the whole index - this may jeopardise any attempt to take advantage of the arbitrage gap. In the case of reverse cost of carry arbitrage one must borrow the basket of shares representing the index and sell it short and enter into a contract buying it forward. In this case one must borrow a basket of shares that may or may not be available in the market. If lenders are in the practice of creating baskets (which is not the currently case in the South African securities lending market) one must still liquidate the basket. If the lenders do not offer baskets one must first borrow the proportional amount of the index shares so as to construct a basket. This is both slow (which could see the trader miss the arbitrage opportunity) and can be expensive. Once the basket has been created the trader must sell the basket into the market. In this case one is faced with the same problems as the trader who is buying the basket - liquidity and odd lot constraints.

These problems outlined above are not to be ignored and lead one to ask the question: "How does arbitrage trading take place given these significant practical constraints?" In answer to the question traders currently perform a proxy type of arbitrage. A selection is made of a number of shares within the index (determined by the trader) that will give the trader an approximate index exposure. For example, the trader may buy Didata, DeBeers and Anglo Gold as a proxy for the ALSI40 index. This allows the trader to execute the "arbitrage" without having to buy, borrow or sell a large variety of shares. This proxy form of arbitrage comes with its set of problems too, one does not get an exact arbitrage risk exposure and within an index shares may rise and fall at different rates. This may lead to a share lagging or leading the index. If the share selected for the proxy arbitrage lags or leads the index it open up the possibility to perform a systems based "arbitrage" trade where one can trade-off the fact that the leaders and laggards will have to come back to the average of the rest of the group within the index. All this leads to less than perfect index arbitrage. An obvious answer to this would be for one to have "basket" trading. In this case a selection of market participants would create baskets of shares that directly replicate the index and then trade in complete baskets. The creation of a market in these baskets would result in a more risk efficient type of arbitrage. For the purpose of this study the effects of the practical limitations or costs involved in index arbitrage have been ignored in the calculation of the arbitrage gap. This is because it will vary from trader to trader and there is a new basket type product that has recently been introduced into the market.

During the course of 2000 a basket type product was introduced into the South African financial markets by Gensec Bank and Gensec Asset Management (now known as Sanlam Investment Management), CorpCapital Bank and the Johannesburg Stock Exchange. The product, called the SATRIX 40, is an instrument that represents a basket of underlying ALSI40 shares. The SATRIX 40 is traded as a separate instrument on the JSE and is directly convertible into the underlying shares that make up the index (providing one converts a minimum of one million SATRIX 40 shares into the underlying index shares). The SATRIX 40 product should see a more efficient type of ALSI40 index arbitrage as one is now able to execute an arbitrage strategy where one can directly replicate the index. As the SATRIX 40 is a directly convertible instrument one should also see some form of arbitrage taking place between the underlying basket of shares and the SATRIX 40. This will ensure the price of the SATRIX 40 remains efficient and thus effective in spot / future arbitrage trading activities. One slight difference between the SATRIX 40 and the underlying basket of shares is the timing of the dividend payments: The SATRIX 40 accumulates the dividend flows from the underlying shares and pays them out on a quarterly basis, where one would receive the dividend payments as they occur if one was to hold the underlying basket. Spot / futures arbitrage is based on the time value of money mechanism so any change in the timing of cash flows would have an impact on the valuation. For this reason using the SATRIX 40 instrument in ALSI40 arbitrage would yield slightly different results than if one was to use the actual underlying spot basket of shares.

One of the final practicalities one needs to take into account when performing analysis on spot and futures prices is the timing of the observations. The spot equities market opens from 9:00 am to 4:00 pm each business day. The futures market stays open for longer than this. During the time that the spot market is closed and the futures market is open the US markets are normally open. Thus any changes in the US market can be reacted to by the portfolio managers through the futures market. For this reason the close in the spot market (taken as the closing price for the day) cannot really be compared to the closing price in the futures market (taken as the closing price for the day in the futures market). One cannot draw conclusions from a comparison between the two prices as there have been other market events that the futures have been allowed to react to where the spot has been unable to. For this reason any meaningful spot / futures analysis must take the futures mark - to - market rate to represent the price of the futures. The mark - to - market rate in the futures market is taken at around 4:00pm each day to coincide with the close in the spot market which allows one to draw comparisons between the prices on the two different exchanges at the same (or similar) time.

All of the adjustments outlined above impact on the fair value futures formula. The final fair value formula that has been used for the purposes of this study is as follows:

$$S - A + D + B + C - E + G \leq F \leq S + A - D - B + C - E \qquad (48)$$

For definition of variables see below. This formula is constructed by first defining the cost off carry bounds as being:

Future = Spot + interest on cash borrowed - dividend received - interest on dividend received + interest payable on mismatch of funds - SAFEX interest received on margin deposit.

This is an evolved form of formula 1 outlined in chapter 3 which simply defines the future as the spot multiplied by one plus the cost of carry rate (expressed as a percentage). The above definition takes into account some of the market imperfections. The primary source of the interest payable on the mismatch of funds is the futures margin. The cost of carry fair value is the upper bound when defining the fair value of the future. For this reason the future must lie somewhere below the above defined price for it to be fairly priced in terms of the cost of carry arbitrage mechanism. The above formula can more simply be described as follows:

$$F \leq S + A - D - B + C - E \qquad (49)$$

Where:

F	=	Fair value of the future.
S	=	Current market price of the spot instrument.
A	=	Interest payable on borrowings.
D	=	Dividend received from shares that are held in accordance with the arbitrage strategy.
B	=	Interest received on the above dividends.

C	=	Interest payable on net financing (primarily cash needed to finance the initial margin).
E	=	Interest earned from SAFEX on the margin deposit.

The above variables, in turn, break down into:

A	=	(Contract expiry date - transaction date)/365 x continuously compounding borrowing interest rate x borrowings.
D	=	Number of shares x dividend per share in cents / 100.
B	=	Summation of all the dividends [(Contract expiry date - dividend receipt date)/365 x continuously compounding investing interest rate x D.]
C	=	(Contract expiry date - transaction date)/365 x continuously compounding borrowing interest rate x (initial margin deposit + any other excess cash requirements).
E	=	(Contract expiry date - transaction date)/365 x continuously compounding SAFEX interest rate x initial margin deposit.

The continuously compounding interest rate was defined as: LN(1 + effective annual interest rate). The effective annual interest rate is defined as: $[1 + (P/Q)]^Q - 1$. P is the annual nominal interest rate and Q is the number of compounding periods per year (this applies to both the investing, borrowing and SAFEX interest rates).

The cost of carry formula has now been established. The next step it to establish the reverse cost of carry arbitrage bounds. The basic formula is:

Future = Spot - interest on cash invested + dividend received on shorted stock + interest on dividend + interest payable on mismatch of funds - SAFEX interest received on margin deposit + securities lending fee.

This is an evolved form of the reverse cost of carry formula outlined in chapter. The above definition takes into account some of the market imperfections and practicalities (such as securities lending). In this case the primary source of the interest payable on the mismatch of funds is the futures margin and the excess collateral required for the securities loan (the excess collateral is the amount by which the collateral exceeds the initial value of the underlying loan when the loan is made). The reverse cost of carry fair value is the lower bound when defining the fair value of the future. For this reason the future must lie somewhere above the above defined price for it to be fairly priced in terms of the reverse cost of carry arbitrage mechanism. The above formula can more simply be described as follows:

$$F \geq S - A + D + B + C - E + G \qquad (50)$$

Where:

F	=	Fair value of the future.
S	=	Current market price of the spot instrument.
A	=	Interest received on the invested cash.
D	=	Dividend that would have been received from shares that were borrowed and sold. These dividends now have to be paid across to the lender even though they have not been earned by the arbitrageur (due to the fact that the shares were sold).
B	=	Interest that would have been received on the above dividends.
C	=	Interest payable on net financing (primarily cash needed to finance the initial margin and the excess collateral on the securities loan).
E	=	Interest earned from SAFEX on the margin deposit.
G	=	The securities lending fee payable on the borrowing of the shares needed for the transaction.

The above variables, in turn, break down into:

A	=	(Contract expiry date - transaction date)/365 x continuously compounding investing interest rate x cash received from shorting the borrowed stock.
D	=	Number of shares x dividend per share in cents / 100.
B	=	Summation of all the dividends [(Contract expiry date - dividend receipt date)/365 x continuously compounding investing interest rate x D.]
C	=	(Contract expiry date - transaction date)/365 x continuously compounding borrowing interest rate x (initial margin deposit + any other excess cash requirements such as excess collateral on securities loan).
E	=	(Contract expiry date - transaction date)/365 x continuously compounding SAFEX interest rate x initial margin deposit.
G	=	Initial Rand value of shares borrowed x annual securities lending fee x (Contract expiry date - transaction date)/365.

At this stage one is able to define a more detailed version of formula 48: the fair value bounds of the future. The final formula (formula 51) is:

$$
\left\{
\begin{aligned}
&(S\times N)-\left(\left(\frac{(T_e-T_t)}{365}\right)\times\ln\left(1+\left(\left[1+\left\{\frac{P_i}{Q_i}\right\}\right]^{Q_i}-1\right)\right)\times(S\times N)\right)+\sum_{y=1}^{y}\left(N\times\left[\frac{D_y}{100}\right]\right)+\\
&\left(\sum_{y=1}^{y}\left(\left(\frac{(T_{e_y}-T_{d_y})}{365}\right)\times\ln\left(1+\left(\left[1+\left\{\frac{P_i}{Q_i}\right\}\right]^{Q_i}-1\right)\right)\times\left(N\times\left[\frac{D_y}{100}\right]\right)\right)\right)+\\
&\left(\left(\frac{(T_e-T_t)}{365}\right)\times\ln\left(1+\left(\left[1+\left\{\frac{P_b}{Q_b}\right\}\right]^{Q_b}-1\right)\right)\times(M+(S\times N)\times(L\%-100\%)\right)-\\
&\left(\left(\left(\frac{(T_e-T_t)}{365}\right)\times\ln\left(1+\left(\left[1+\left\{\frac{P_i}{Q_i}\right\}\right]^{Q_i}-1\right)\right)\times M\right)+\left((S\times N)\times U\times\left(\frac{(T_e-T_t)}{365}\right)\right)\right)
\end{aligned}
\right\}
$$

$$\leq F \leq$$

$$
\left\{
\begin{aligned}
&(S\times N)+\left(\left(\frac{(T_e-T_t)}{365}\right)\times\ln\left(1+\left(\left[1+\left\{\frac{P_b}{Q_b}\right\}\right]^{Q_b}-1\right)\right)\times(S\times N)\right)-\sum_{y=1}^{y}\left(N\times\left[\frac{D_y}{100}\right]\right)-\\
&\left(\sum_{y=1}^{y}\left(\left(\frac{(T_{e_y}-T_{d_y})}{365}\right)\times\ln\left(1+\left(\left[1+\left\{\frac{P_i}{Q_i}\right\}\right]^{Q_i}-1\right)\right)\times\left(N\times\left[\frac{D_y}{100}\right]\right)\right)\right)+\\
&\left(\left(\frac{(T_e-T_t)}{365}\right)\times\ln\left(1+\left(\left[1+\left\{\frac{P_b}{Q_b}\right\}\right]^{Q_b}-1\right)\right)\times M\right)-\\
&\left(\left(\frac{(T_e-T_t)}{365}\right)\times\ln\left(1+\left(\left[1+\left\{\frac{P_s}{Q_s}\right\}\right]^{Q_s}-1\right)\right)\times M\right)
\end{aligned}
\right\}
$$

Where:

T_e	=	Date of expiry of contract.
T_t	=	Date of transaction.
P_i	=	Nominal annual investing interest rate.
Q_i	=	Compounding periods per year for the investing interest rate.
S	=	Spot share price at date of transaction.
N	=	Number of shares purchased for transaction.
D	=	Dividends per share in cents.
y	=	Number of dividends received during period the contract was held for.
T_d	=	Date of dividend receipt.

P_b	=	Nominal annual borrowing interest rate.
Q_b	=	Compounding periods per year for the borrowing interest rate.
M	=	Margin deposit.
$L\%$	=	Collateral as a percentage of the initial value of the underlying securities lending loan.
P_s	=	Nominal annual SAFEX interest rate.
Q_s	=	Compounding periods per year for the SAFEX interest rate.
U	=	Annual securities lending fee.

7.4 Building a Futures Fair Value Calculator.

In determining the theoretical value of the futures as explained above, a futures fair value calculator was built. The purpose of the calculator is to show the arbitrage "bands" above, and below which, arbitrage can take place (see figure 3.1 in chapter three above). The first step was to design this in a spreadsheet format that was then transported to an application more able to handle large quantities of data being fed through it. The spreadsheet version is in table 7.1 below, there were no logical changes between this and the final calculator that was used in the analysis. The final calculator can be found in appendix 7.1 on the accompanying CD-ROM.

Table 7.1 - Futures Fair Value Calculator: Spreadsheet Version.

Futures Fair Value Calculator

Input Variables

A	Borrowing Interest Rate	14.0000%
B	Compounding periods per year	12
C	Effective Rate	14.9342%
D	Continuous Compounding Rate	13.9190%
E	Investing Interest Rate	10%
F	Compounding periods per year	12
G	Effective Rate	10.4713%
H	Continuous Compounding Rate	9.9586%
I	Interest earned on margin	8%
J	Compounding periods per year	12
K	Effective Rate	8.3000%
L	Continuous Compounding Rate	7.9735%
M	Transaction Date	01/06/2000
N	Contract Expiry Date	30/09/2000
O	Annual SL Fee	1.50%
P	Collateral Margin	105.00%
Q	Margin on contract:	R 1 200 per contract

R	Share Name:	Didata	
S	Share Code:	DDT	
T	Current Price:	R 64.10	
U	Futures Name:	Didata	
V	Futures Code:	DDTQ	
W	Current Price:	R 6 421	
X	Amount being applied to strategy	R 1 000 000	
III	Actual amount being applied to strategy	R 999 960	(Net of Rounding)
Y	Gross up applied to dividends on Securities Loan:	100%	
	Dividends		
JJJ	Date of first dividend	30-Jun-00	
KKK	Dividend per share (c)	356.00	
LLL	Date of second dividend	01-Sep-00	
MMM	Dividend per share (c)	378.00	

Cash and Carry Arbitrage

			# Contracts / Shares	Cash Flow
t=0	Borrow R 1 million	Z		R 999 960.00
	Buy R 1 million Didata	AA	15600	-R 999 960.00
	Receive Didata dividend	BB		R 114 504.00
	Enter into September contract to sell DDT	CC	156	
	Futures Margin Cash flow required	DD		-R 187 200.00
	Borrow excess cash needed for margin and excess SL collateral	EE		R 187 200.00
t=1	Sell DDT according to future	FF	-156	
		GG	-15600	R 1 001 676.00
	Return R 1 million	HH		-R 999 960.00
	Pay interest on R 1 million	II		-R 46 140.47
	Receive interest on dividend	JJ		R 1 860.58
	Return excess cash	KK		-R 187 200.00
	Pay interest on excess cash borrowed	LL		-R 8 637.84
	Receive margin	MM		R 187 200.00
	Receive interest on margin	NN		R 4 948.17
		Net Total	0	R 68 250.44
		OO	Optimum maximum	5983

Reverse Cash and Carry Arbitrage

	Strategy:		**# Contracts / Shares**	**Cash Flow**
t=0	Borrow R 1 million Didata	PP	15 600	
	Put up security for shares	QQ		-R 1 049 958.00
	Enter into September contract to buy DDT	RR	156	
	Futures Margin Cash flow required	SS		-R 187 200.00
	Sell R 1 million Didata	TT	(15 600)	R 999 960.00
	Borrow excess cash needed for margin and excess SL	UU		R 237 158.00

	collateral			
=1	Buy R 1 million Didata according to futures contract	VV	(156)	
		WW	15 600	-R 1 001 676.00
	Deliver Didata shares to Lender of scrip	XX	(15 600)	
	Receive capital cash flow from lender	YY		R 1 049 958.00
	Receive interest cash flow from lender	ZZ		R 33 012.00
	Pay fee to lender	AAA		-R 4 972.60
	Receive margin back	BBB		R 187 200.00
	Pay dividends earned across to lender	CCC		-R 114 504.00
	Pay interest on dividends	DDD		-R 1 860.58
	Receive interest on margin cash flow	EEE		R 4 948.17
	Repay excess borrowings	FFF		-R 237 158.00
	Repay interest on excess borrowings	GGG		-R 10 943.02
		Net Total	-	-R 96 036.03
		HHH Optimum minimum		5 805

The calculator is divided into three distinct parts. The first part is where the variables needed for the calculation are entered. These are then used to produce two figures, namely the profit or loss from the cost of carry strategy and the profit or loss from the reverse cost of carry strategy (These are the bold "Net Total" figure in the second and third parts to the table above). If the future is fairly priced both the figures will be equal to or less than zero. If there is an arbitrage opportunity the one figure will be positive while the other will be negative, the negative figure must be ignored, as this strategy will not be applied - only the profitable one will. If both figures produce positive values, there is an error in the data that has been entered. One will not be able to profitably apply both the cost of carry and reverse cost of carry arbitrage strategies simultaneously due to the fact that they are mutually exclusive.

7.4.1 Futures Fair Value Calculator - Explanation.

A, B, C & D: The borrowing interest rate that has been used for the purposes of the study is the rate on the three month Negotiable Certificate of Deposit (NCD) plus fifty basis points. This is to take into account different borrowing and lending rates. The compounding period is then required as part of the calculation. This is done to convert the nominal annual rate to an effective one. The compounding period of the NCD rate depends on the way the NCD is quoted. The NCD can either be quoted on a NACQ (nominal, annual compounded quarterly) or NACS (nominal, annual compounded semi-annually) basis. This will be identified in the results. To convert the nominal interest rate into an effective one the following formula is used:

$$re = \left(1 + \frac{r}{m}\right)^{m} - 1 \qquad (52)$$

Where:

re	=	Effective interest rate.
r	=	Nominal interest rate.
m	=	Compounding period.

Finally, once the effective interest rate is established it must be converted into a continuously compounding interest rate. This is done so as to achieve standardisation between the different interest measures. The formula to convert the effective interest rate into the continuously compounding rate is:

$$ce = \ln(1 + re) \qquad (53)$$

Where:

re	=	Effective interest rate.
ce	=	Continuously compounding interest rate.

The same approach is applied to the rate at which the arbitrageur can invest at: E, F, G & H. The only difference is the investment interest rate. For the purposes of this study this is deemed to be the NCD rate less fifty basis points. Again, the reduction in basis points is done to make allowance for the differential in the borrowing and lending interest rates in the market.

I, J, K & L: In chapter three the fact that the futures exchange pays interest on the margin it holds for the market participants was disclosed. This rate is obtained from SAFEX and is also converted into an effective, then continuously compounding interest rate. The rate quoted by SAFEX is an overnight call rate.

M and N are the transaction date and the maturity date of the futures contract. The transaction date is the date on which the arbitrage transaction is entered into. It is assumed that all the different parts of the arbitrage transaction are entered into simultaneously. In practice this may not be the case as it may, for example, take some time to locate the shares to be sold short in the reverse cost of carry arbitrage strategy. Even in practice, however, it should not take more than twenty-four hours to put the transaction in place. Any time longer than this could possibly result in the arbitrage opportunity disappearing with the normal day to day movement in prices. Care must be taken not to confuse the settlement date of the transaction with the actual transaction date. The settlement date is assumed to be the same as the transaction date for the purpose of this study. In practice, it may be a day or two later. This would have implications on the funding costs of items such as collateral on the securities loan under the reverse cost of carry arbitrage strategy. The expiry date is obtained from the futures contract (See Appendix 3.1 below).

O and P relate to the securities loan that is put in place to facilitate the reverse cost of carry arbitrage strategy. O is the annual securities lending fee that is paid to the lender by the borrower (as described in chapter three above). There is no market data relating to the size of this fee. However, Counihan and Malherbe (1999 : 9) examined this and concluded the fee typically ranges from 75 to 150 basis points with securities in demand rising up to 300 basis points. For the purpose of this thesis an annual rate of 150 basis points (one and a half percent) has been used. P relates to the collateral percentage required by the lender for lending out the shares required for the arbitrage strategy to the lender. The collateral levels also vary. As per the Counihan and Malherbe (1999 : 69) report the collateral required in South Africa is typically as follows:

Collateral in the form of Cash:	105% of the value of the underlying securities.
Collateral in the form of Bonds:	110% of the value of the underlying securities.
Collateral in the form of Equities:	115% of the value of the underlying securities.

The collateral is market to market on a daily basis. So, as in the case of the SAFEX margin, there will be further financing requirements as the value of the loan varies. This is not taken into account - it is assumed the margin requirements do not increase over the period of the arbitrage transaction. The securities loan fee does not change as the value of the underlying instruments change, it is based on the initial value of the loan. For the purposes of this thesis the collateral will be assumed to be of a cash nature and the collateral margin will be 105% of the value of the underlying securities.

Q comes from the notices issued by SAFEX from time to time on the required margin levels. The current level of margins can be seen in chapter three, table 3.4. R is the name of the underlying instrument that is being used as part of the arbitrage strategy. This is not used in the calculations; it is an identifying variable. S is used in a similar manner - it is the JSE code of the underlying security. The current price of the underlying security: T is the price that the transaction takes place at. It is used to determine the arbitrage profit, how many shares can be bought and sold as well as how many shares need to be borrowed if the reverse cost of carry arbitrage strategy is followed.

U, V & W are the same as the previous three variables, the only difference is that they are the name, code and price of the future. Again the future's price must be the price at the date the transaction is entered into. The futures price and the underlying spot price should be the simultaneous price when the transaction is initiated. X is the amount, as described, being applied to the strategy. This is more of practical use and does not affect the returns that are calculated. Y relates to securities lending. When an institution lends out a share and the share attracts a dividend while it is lent out; the borrower must remit the dividend to the lender. South African tax law does not, however, see this remitted dividend as a dividend. It sees this remitted dividend as a "manufactured dividend". The significance of this is the manufactured dividend looses its tax status. Dividends are not taxed in the hands of the recipient, but manufactured dividends are. For this reason the borrowers compensate the lenders by the amount of the tax benefit lost by the creation of the manufactured dividend. This is called the dividend "gross up". The dividends are remitted along with the amount of tax that lost. The amount of the gross up depends on the tax status of the lender. In some cases the dividends do not need to be grossed up at all. As tax is being ignored for the purposes of this thesis the dividend gross up is set at 100%. This means that there is no compensation paid from the borrowers to the lenders for the tax benefits lost on dividends on shares being lent out.

Z is the first step in the cost of carry arbitrage leg of the fair value calculator - the borrowing of the cash to be applied to the strategy. The calculator is designed to track both the cash flow and the flow of the number of (futures) contracts / shares in the implementation of each leg of the arbitrage. The number of contracts / shares should be zero at the unwinding of the strategy. The only amount that should be left is an amount in the cash flow column. This cash flow depicts the total profit or loss made from the arbitrage. Z occurs at T = 0, which denotes the trading date and is the same as the transaction date M above. T = 1 is the maturity date and is the date upon which the trade is unwound and the transaction is brought to a close. It is the same as the expiration date - N above. AA shows the purchase of the underlying shares. This is calculated by dividing the amount applied to the strategy (X) by the current share price (T). For the goal of keeping the calculator as accurate as possible the number of shares and contracts are not rounded off. The cash flow in this case is an outflow of R 1 million as the cash that was borrowed is applied to the purchase of the shares.

BB is the dividend declared by the underlying share. In the case of the above example the dividend is assumed to have been paid out in two installments. Practically the dividend date will vary. This will affect the interest earned / paid on the dividend which is dealt with in JJ below. The dividend received is calculated by multiplying the dividend yield by the share price on the date the dividend is paid (In this case the share price on the transaction date). The dividend-received date becomes complicated in the case of index futures. In this case there is no one dividend date - there are numerous. For the purposes of this thesis an average dividend is assumed to be earned / paid. This is done by multiplying the dividend yield per day on the index (dividend yield divided by 365) by the index each day the arbitrage transaction runs for. Each "dividend" received is assumed to be a separate cash flow and is treated separately for interest purposes, again, see JJ below. In the case of the above example the table has allowed for two different dividend dates, the actual futures fair value calculator (see attached CD-Rom) allows for more.

The next step in the transaction is to enter into the futures contract: CC. In the case of the cash and carry arbitrage one must enter into a futures agreement to sell the stock forward. The entering of the contract does not incur any direct cash flow other than what is required for margin purposes (which is outlined in DD below). CC is the number of futures contracts that are needed to enter into the hedged position to the underlying which is the number of shares divided by 100. The margin (DD) is determined by SAFEX from time to time. The margin requirements for the different contracts can be seen in the margin table of chapter three. The margin requirements per contract are multiplied by the number of contracts to determine the total margin cash flow required. The study does not take into account any margin relief due to there being any evidence of set off between the different contracts that a trader may hold (for example an offsetting spread position).

Due to further cash requirements such as the need to put up margin, the arbitrage trader will be exposed to a financing requirement. This is shown in EE. This is where the futures trader borrows the excess that is needed to complete the transaction. For the cash and carry arbitrage trade the excess needed will only be the margin requirement. This can be seen in the example above where the cash requirement is the same as the margin payment.

At this point the arbitrage trader is locked into the trade, the next step is to unwind the trade once the futures contract reaches expiry. This is shown to occur at T = 1 which is equal to the expiry date. The first step in winding up the arbitrage position is to reverse the trades made previously. FF and GG show the expiry of the futures contracts and the sale of the shares respectively. The shares are sold at the predetermined price (the price of the future when the contract was entered into). This will result in a cash flow to the trader that is shown next to the liquidated shares.

From this cash the trader will need to repay the debt used to construct the position. This is shown in HH and II, with II being the interest on the debt. The interest is calculated on a continuously compounding basis as described above (A, B, C & D).

The dividend that was earned during the course of holding the underlying shares is used to set off the effects of the financing requirements. The interest on the dividends is shown as JJ. The interest on the dividends is determined using the continuously compounding investing rate from the date the dividends were received to the expiry date.

The final step in the transaction is to receive the margin from SAFEX and repay it to the party who lent the cash for the margin. The interest on the margin is determined using the continuously compounding SAFEX rate for the period the contract was in place. The interest on the excess cash requirements is determined using the continuously compounding borrowing rate for the period of the contract. The variables covering this are KK, LL, MM and NN in the example above.

The summation of all the cash flows for the transaction are shown by the summary box above the variable OO. This is the total profit or loss made by entering into the cash and carry transaction. In this case the cash and carry transaction yielded a profit of R 68 250.44 which shows the future to be overpriced at the date the arbitrage transaction was entered into. The fair price of the future as calculated by the cash and carry arbitrage model is shown by OO to be 5983. This is the upper bound of the fair value of the future, any price above this means the future is overpriced and is open to being exploited by a trader applying the cash and carry arbitrage strategy.

The reverse cash and carry arbitrage price is determined in a similar way to the above. The transaction is broken down into its relevant components and the cash flows are summed to determine if there is a net profit or loss.

The first step in this transaction is the borrowing of the underlying share, which in the above example is the Didata shares. The number of shares is determined by rounding down the number of shares that can be acquired by the amount that is to be applied to the strategy (which is, in this case R 1 million). This is shown by variable PP. As part of the securities loan the trader must put up collateral for the shares, which is shown by variable QQ. This variable is determined by multiplying the value of the loaned shares at the inception of the transaction by the collateral percentage, which in this case is 105%.

As part of the arbitrage cover the shares must be purchased forward. The next step is thus to enter into a long futures contract. The number of contracts is determined by dividing the number of shares by 100 (see appendix 3.1 to see actual ratio of shares to futures contract). This variable is RR. As in the cash and carry arbitrage, there is no movement of cash on the entering into of the futures contract, the only initial cash flow is the initial margin flow which is dealt with under variable SS. Variable SS is calculated by multiplying the number of contracts entered into by the margin per contract as in the cash and carry arbitrage transaction.

The underlying stock that has been borrowed is then sold as part of the reverse cash and carry arbitrage strategy. This is sold at the market price (see variable TT). This releases a cash flow that can be set off against the collateral needs. The cash received from the sale of the shares does not entirely set off the cash requirements for the collateral. The difference between the two is attributed to the collateral margin over the value of the underlying shares (typically 5% in the case of cash collateral). This excess cash collateral and margin requirements are borrowed by the trader at the borrowing rate. This can be seen in the W variable.

At this point the trader has constructed the reverse cash and carry arbitrage position. The next step is to reverse out of the position and realise the arbitrage profit or loss. This is deemed to occur at time T = 1 which is when the futures contract expires. To realise the profit or loss the trader must reverse the positions entered into above. The first of which is shown by variable VV where the number of futures contracts is reduced to nil as they expire. WW shows the purchase of the shares according to the futures contract as well as the related cash flow. This cash flow would typically not occur due to the mark to market of the futures contract which would ensure the cash flow would occur in stages as the market price of the underlying shares moved rather than as one single movement at the end of the contract. For the purposes of the study the margin cash flow is assumed to occur at expiry where the entire cash flow takes place.

Once the shares have been purchased they are delivered back to the original lender. This is shown by variable XX, which shows the reduction in the number of shares on hand. On returning the shares to the lender the trader will receive the collateral cash flow back as well as any interest earned on it. The collateral cash flow is shown by variable YY. The interest on the collateral is shown by variable ZZ. ZZ is calculated by multiplying the continuously compounding borrowing interest rate by the number of days between the date the arbitrage transaction was entered into (when the shares were first borrowed) and when the futures contract expired. This is then multiplied by the initial value of the collateral.

AAA is the fee the lender receives for the loan of the shares. It is determined by multiplying the number of days the shares were out on loan as a fraction of a year (365 days) by the initial value of the shares and the annual securities lending fee that would have been negotiated at the inception of the securities loan.

BBB and EEE are receipts from SAFEX. On the closing of the transaction any margin cash flow (BBB) and the interest thereon (EEE) will be transferred to the trader as part of this model. The interest is calculated by multiplying the continuously compounding SAFEX interest rate by the number of days the transaction took place over and the initial amount of margin paid over to SAFEX. Again, it is assumed that there are no movements in the margin during the period of the loan.

The core principle or rule of a securities lending transaction is that the lender of the shares should be in the same situation after a securities loan has been conducted than if the securities loan was not made at all. This is bar the receipt of the securities lending fee. This means that if the shares, which have been out on loan, attract dividends the lender must be compensated for this. Variables CCC and DDD take this into consideration. Even though the trader did not actually receive the dividends on the borrowed shares (the shares were sold as part of the arbitrage transaction) the trader must still compensate the lender of the shares for the lost dividends. This is a direct cost to the trader and is shown as such. The dividends are calculated by multiplying the number of shares by the dividend per share for each of the dividends that are declared during the period of the transaction. The trader must further compensate the lender by the interest that would have been forgone on the dividends that the lender did not receive (variable DDD). This is calculated by multiplying the continuously compounding borrowing interest rate by the number of days between each dividend receipt date and the futures contract expiry date and the value of the dividend.

The last step in the arbitrage transaction is to repay the cash flow used to finance the margin on the futures contract and the excess cash collateral on the securities loan as well as any related interest. This is shown by variables FFF and GGG respectively. The excess cash repayment is equal to the W above as it is the repayment of W. The interest (GGG) is calculated by multiplying the continuously compounding borrowing interest rate by the number of days the transaction took place over by the initial excess borrowings.

The summation of all the above cash flows allows one to determine the profit or loss from the transaction. In the case of the above transaction there is a loss when one applies the reverse cash and carry arbitrage transaction. This is correct as only one of the arbitrage transactions can be profitable at any one time. IN this case the cash and carry strategy is the profitable one. The reverse cash and carry strategy must be applied when the price of the future is below the optimum minimum price. In this case the optimum minimum has been calculated to be 5805 (variable HHH) - any futures price below 5805 would yield a profit if the trader applies a reverse cash and carry arbitrage transaction. One is now in a position to determine the range of the fair value of the futures contract. The fair value of the future in the above example lies between 5805 and 5983 .

The remaining variables relate to practicalities when one executes the arbitrage trade. Variable III relates to the actual amount that can be applied to the strategy, this is constrained by the fact that one cannot trade in fractions of shares. JJJ, KKK, LLL and MMM are self explanatory, they are the details of the dividends that are declared while the shares are being held or sold as per the arbitrage strategy described above.

7.5 Data.

The data was obtained for the period 4 May 1990 to 30 September 1999. The data is closing rate data taken at the close of the market each day. In the case of the futures prices the data is mark - to - market data which is taken at 4 o'clock in the afternoon each day which is the time the JSE closes. There was no data available for the period prior to the 4 May 1990. This period has been adequately covered by other studies, notably Lambrechts (1990).

The period covered resulted in the following contracts being studied:

Contract Period	Year
March	1991,2, 3, 4, 5, 6, 7, 8, 9
June	1990, 1, 2, 3, 4, 5, 6, 7, 8, 9
September	1990, 1, 2, 3, 4, 5, 6, 7, 8, 9
December	1990, 1, 2, 3, 4, 5, 6, 7, 8

The following contracts were reviewed: ALSI, ALSI40, INDI, INDI25, GLDI, FINI, ANGQ, GFLQ, SABQ, SOLQ, AGLQ, AACQ, BOEQ, DBRQ, DDTQ, FSRQ, LLAQ, PQHQ, RCHQ and CPXQ.

7.6 Hypotheses.

The theory and the data used are described above. Upon this, the hypotheses need to be to be built. The hypotheses were tested by:

7.6.1 Hypothesis one

The square of the Pearson correlation coefficient (r squared) between the theoretical futures price and the spot price was determined. This was done by first measuring the log normal movement between the data points for both the spot and the futures prices for each day. The r-squared was then calculated between the log normal movements in the spot and the futures prices. A conclusion was then drawn on the relationship between the two for each contract.

The testing of hypothesis one was further extended to perform time series analysis on the r-squares. Each contact was broken down into a series of moths. The r-squares were then calculated between the daily log normal movements in the spot and futures prices for each month. The r-squares were then compared across all contracts to examine whether any deviation in the ability of the future to track the spot (or the other way around) was specific to one contract or a phenomenon affecting the whole market represented by the series of futures contract trading for that given month. This had the effect of allowing some conclusions to be drawn on the state of the market and the correlation between the movements between the spot and the futures market. It is a high level analysis of the market and how its efficiency (represented by the ability of the spot and futures to track one another) is affected by market shocks.

This final analysis was then reduced into a single graph where the mean of the log normal r-squares was calculated and the variance of the individual contracts from the mean was determined. The purpose of this was to examine how the contracts' efficiency moved together. If there was a market shock and the contracts moved together one should note a low variance in the log normal r-squares (even if this meant that the correlation coefficients dropped and the contracts each became more inefficient in terms of pricing). The purpose of this last part of the analysis was to allow conclusions to be drawn to if and how a series of contracts reacts in unison to a market event.

7.6.2 Hypothesis two

Hypothesis two was tested by the futures fair value calculator that was developed (see accompanying CD-Rom). For each day the bounds of the theoretical futures prices were calculated using the spot price and the carry variables (such as the interest rate and securities lending fee). This was compared with the actual futures price and the resulting arbitrage gap was calculated. The arbitrage gap was graphed so that analysis could be performed by comparing the arbitrage gap with the volatility in the spot.

7.7 Results.

In analysing the results the overall objective of the study must be kept in mind: to determine how the pricing efficiency on SAFEX reacted to the various market shocks of the late 1990's. This means that an exhaustive discussion of each of the contracts for each of the contract periods is unnecessary. For this reason a sample of contracts and contract periods have been selected for analysis with the focus being placed on the periods during the market shocks. The inclusion of the futures calculator and the data in CD-Rom will allow the reader to perform further analysis in the event the reader wishes to do so. The below analysis of the results should allow for conclusions on how the market shocks affected the market and how the market has changed or progressed over the past ten years.

7.7.1 Hypothesis One.

The calculations of the R squared for each of the contracts over the period June 1990 to September 1999 shows low R squares for the early nineteen nineties which move closer to one as the decade progresses. This suggests the contracts become more efficient as the decade moves towards the year 2000. See the below table (table 8.2) for the average annual squared Pearson correlation coefficients (r squared) for the various contracts.

Table 7.2 - Annual Average Squared Pearson Correlation Coefficients (R Squares) for the ALSI and ALSI40 Futures Contracts.

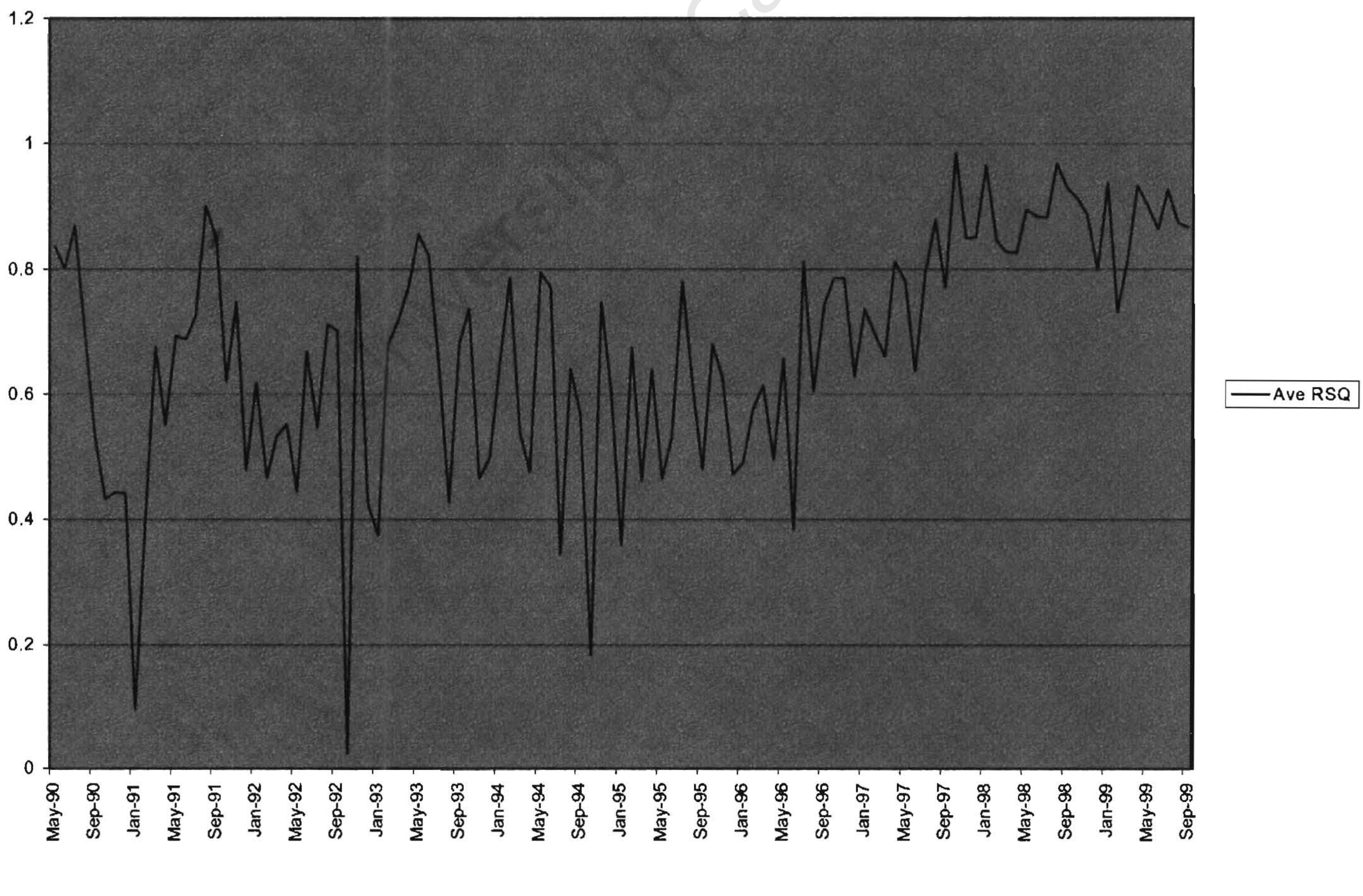
Year	ALSI Contract
1990	75.5%
1991	65.3%
1992	54.0%
1993	68.5%
1994	56.7%

1995	56.8%
1996	53.0%
1997	75.3%
1998	92.2%
1999	90.5%

Graphically the movement of the contract to a higher level of pricing efficiency can best be seen in the example of the ALSI contract (see figure 7.2 below). Also note, for the sake of continuation the ALSI and the ALSI 40 contract have been combined to provide better time series analysis. This was also done for the INDI and INDI25 as it allows for comparison of the index over the period.

In the case of the ALSI, the efficiency of the contract seems to improve over the period. The average log normal R Squared moves from an average of around 0.6 to 0.9. This shows the movements in the spot and futures contracts tend to track one another closer as the decade progresses. This can best be seen graphically in the below figure 7.2.

<u>Figure 7.2 - Average Log Normal R Squares for the ALSI and ALSI40 Future</u>



This closer relationship between the spot and the future suggest increased arbitrage to ensure the prices act in concert. This is backed by the fact that the ALSI futures contract was changed from being a future based on the whole market index to one based on the 40 largest companies. This occurred in 1996 and would have enabled the arbitrageurs to exploit any arbitrage gaps more efficiently. Prior to the introduction of the ALSI 40 index and related futures contract, for an arbitrage trader to take advantage of an arbitrage gap, he or she would have had to purchase (or borrow and sell) more shares to take advantage of a price discrepancy. This would have made the process time consuming and expensive. This would have widened the arbitrage bounds around the fair value of the future where the trader would have been willing to trade. With the introduction of the ALSI 40 there now are less shares that need to be purchased (or borrowed and sold) for a trader to take advantage of an arbitrage opportunity. The ALSI 40 would also make it easier for the trader to approximate the index with the use of a small number of shares and thus increase arbitrage activity and thus price efficiency. This would have played a role in the increase in the "long run" average log normal R squares in the change in prices of the future and the spot prices from 0.6 to 0.9.

The Second part of hypothesis one was the creation of an R squared matrix. The matrix consisted of the monthly R squares for each contract over the period under analysis. This was done so as to examine how the contracts act in concert as the broader market moves and absorbs news. The result of this matrix was graphed and can be seen in the below figure 7.3. The graph shows each contract in a different colour and allows one to see how each contract moves in relation to the others. This allows for a high-level efficiency type of analysis. In figure 7.3 below the ALSI and ALSI 40 index R squares have been graphed. One is able to see the trend that was identified in the above analysis (in figure 7.2) where the average R squared increases from around 0.6 to 0.9 during the period covered.

The disadvantage of the graph in figure 7.3 below is the existence of a single figure or variable which will show how closely the contracts are related from month to month. One can see that from May 1993 to September 1994 the different ALSI contracts seems to track one another closely. This pattern is broken between May 1996 to May 1998 where the contracts become more varied, however it is difficult to say whether the contracts are more or less related over this period than in the early nineteen nineties where the contracts also exhibit a lack of equality. For this reason a second level of analysis was performed. The mean of the monthly contracts was determined and the variation of the individual contracts from the mean was calculated and graphed in figure 7.4 below. The above analysis is for the ALSI and ALSI 40 contract. The other futures contracts are included in the accompanying CD – Rom where more extensive analysis can be performed and the individual graphs can be found.

Figure 7.3 - ALSI & ALSI40 monthly R Squared for all contracts from June 1990 to September 1999.

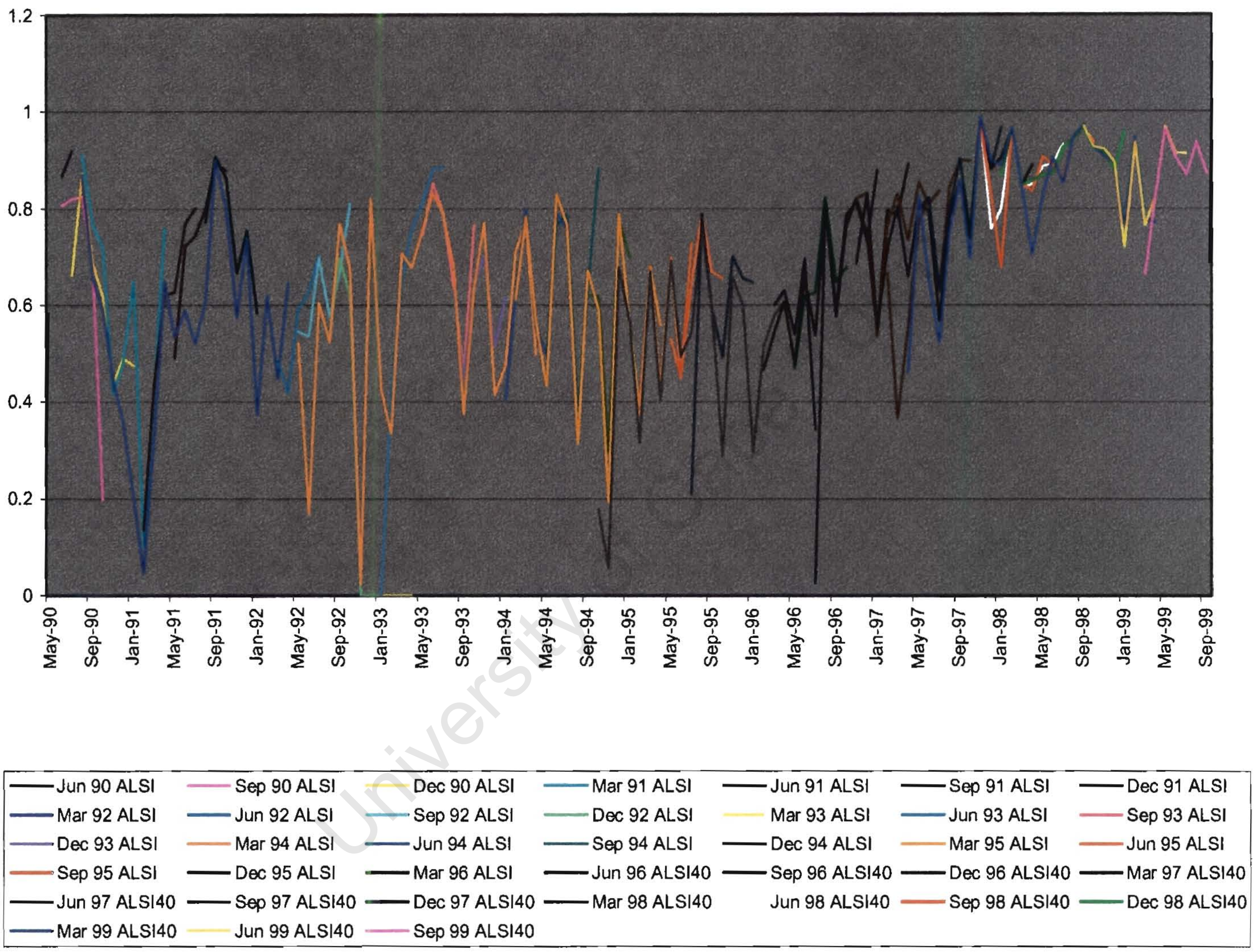
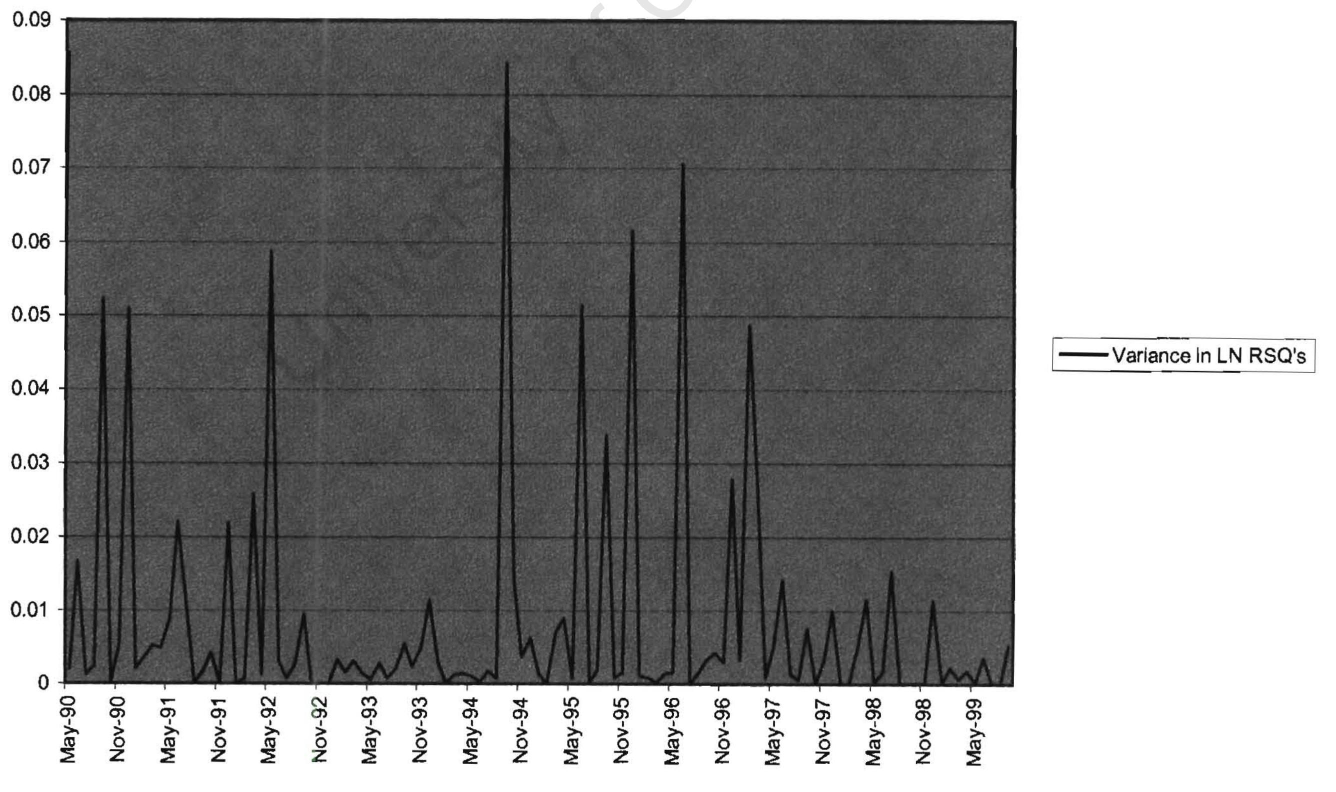


Figure 7.4 allows for clearer analysis, the variance of the R Squares shows how the different contracts were affected by the same market news. Further analysis could be performed on the reasons for the variation but this is outside the scope of this study. The relationship between the movements and the spot prices for the different contracts holds for the period July 1992 to September 1994 and again from May 1997 to the end of the period under review – September 1999. The log normal movements in the spot and futures contracts

for the series of traded contracts do not track each other closely for the period May 1990 to July 1992 and again from October 1994 to April 1997.This is in contrast to the market shocks which were predominantly experienced during the period where the contracts track one another closely. The first period of high variance can be explained through the market being still relatively new and the fact that the future was based on the all share index rather than a more compact and manageable ALSI 40 index. The second period is influenced by contracts that originate and terminate. If one looks back at figure 7.3 one can see that where the variance is at is highest is when new contracts are launched such as in the case of the December 995 and December 1996 contracts. They are launched in June 1995 and June 1996 respectively – months where the variance is at a high level in figure 7.4 below. There is no plausible explanation for this as in the periods where the variance is at a low point contract are launched and terminated with no significant change in the variance. If one removes the originating and terminating contracts the trend over the period October 1994 to April 1997 is one of lower variance that is reinforced by the troughs between the variance spikes in figure 7.4 below.

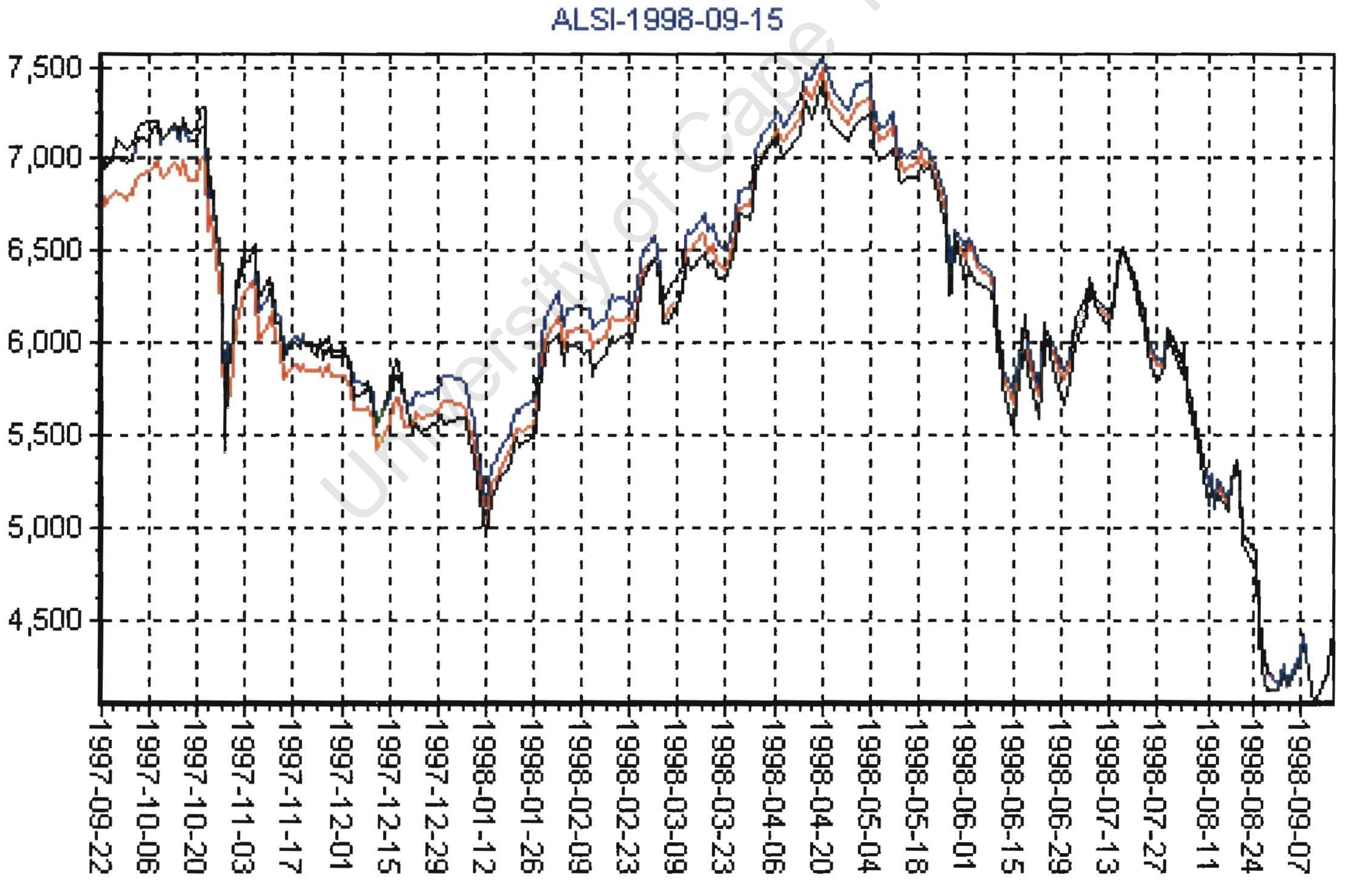
Figure 7.4 – Variance in Monthly Log Normal R Squares for the ALSI and ALSI 40 Spot and Futures Contracts



7.7.2 Hypothesis Two.

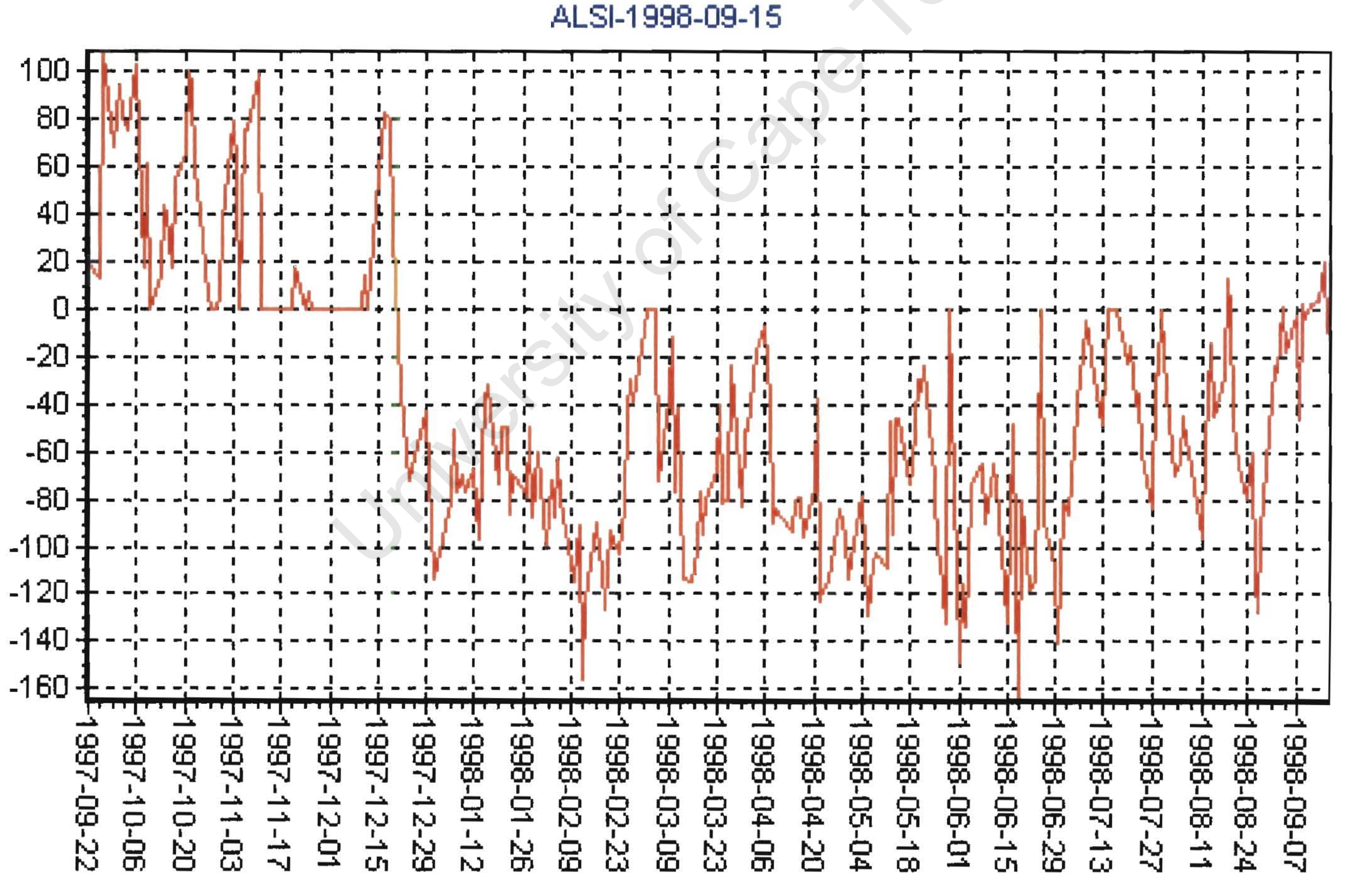
The daily closing data was run through the futures fair value calculator and the fair value bounds were determined for each trading day. These fair value bounds were graphed and the actual futures price was graphed with them. The graph for the combined ALSI and ALSI 40 futures contract is graphed below (figure 7.5). The green line represents the actual futures price, the blue line represents the cost of carry fair value bound and the red line represents the reverse cost of carry fair value line.

Figure 7.5 – September 1998 ALSI 40 Future and Fair Value Bounds.



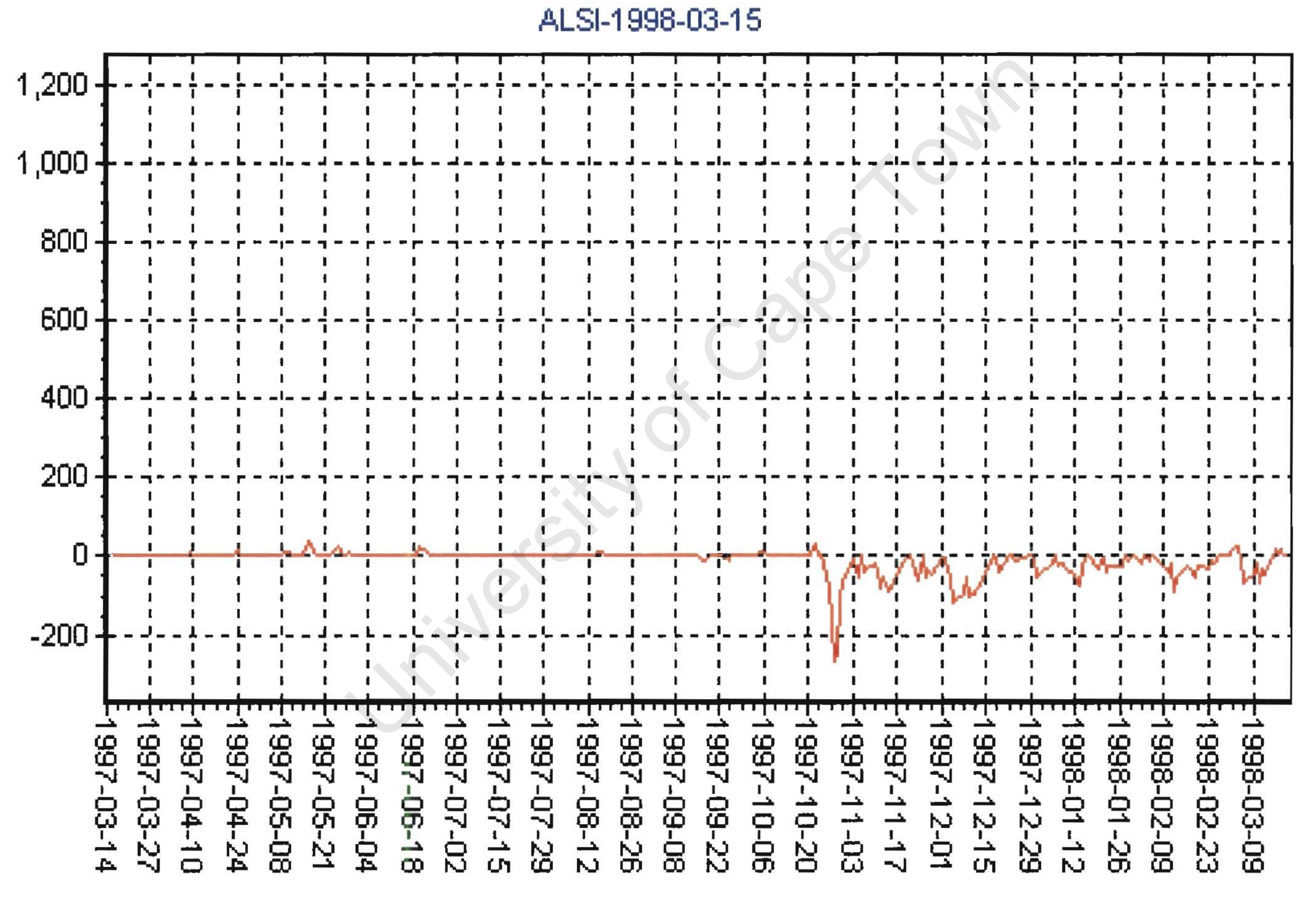
From the above graph one can see that there are periods where the future is mispriced and open to arbitrageurs entering the market to exploit the difference. An example of this can be seen between the period 22 September 1997 and 20 October 1997 where the actual future is above the fair value bounds. Here the arbitrageur would apply the cost of carry arbitrage trade to exploit the pricing inefficiency. Between the period 2 February 1998 and 22 February 1998 one can clearly see the actual futures price is below the fair value bounds which indicates that an arbitrageur is able to profit from applying the reverse cost of carry arbitrage strategy. It is, however difficult to draw conclusions on the arbitrage gap as it is difficult to see on the above graph. For this reason a second graph is produced by the futures fair value calculator – the arbitrage gap. For the same September 1998 ALSI 40 contract the arbitrage gap is graphed in figure 7.6 below.

Figure 7.6 – Arbitrage Gap for the September 1998 ALSI 40 Futures Contract.



The red line shows the arbitrage gap over the life of the contract. The arbitrage gap (y axis) is measured in basis points. Here one can see that early in the contract's life there were cash and carry arbitrage opportunities which fell away between November 1997 and mid December 1997 when they were replaced by reverse cash and carry opportunities until the end of the contract. The above contract suggests that South African Futures contracts are mispriced from most of their lives. This is not necessarily the case, if one looks at the March 1998 ALSI 40 contract (figure 7.7 below) one can see that for the bulk of its life the contract is fairly priced. In this case the first significant mispricing occurs in October 1997 at the time of the Asian crisis.

Figure 7.7 - Arbitrage Gap for the March 1998 ALSI 40 Futures Contract.



The graphs for each of the contracts examined (as mentioned earlier in the chapter) can be found on the accompanying CD-Rom in appendix 7.2. To be able to draw a conclusion a table was drawn up showing the percentage of arbitrage opportunities (by type) for each of the contracts over the period. The table is produced below (table 7.3). In the table COC represents cost of carry opportunities, RCOC reverse cost of carry opportunities and None – the number of trading days where there are no arbitrage opportunities.

The table shows a number of arbitrage opportunities that are significant. The predominant arbitrage strategy that is open to be applied is the reverse cost of carry model. The data suggests that there is a limitation on the application of the reverse cost of carry strategy, which thus results in the predominance of the arbitrage gap on the reverse cost of carry side of the fair value of the future. The main reason for this is the lack of liquidity and the prevalence of general restrictions in the securities lending industry. There are few legislated restrictions on the securities lending industry and the ones that do exist, do so as part of a broader financial market's regulatory framework. This has resulted in restrictive credit risk policies being applied by the lending market participants. This suggests that there are arbitrage traders who wish to borrow stock for purposes of arbitrage trading, but are unable to do so due to the "unacceptable" state of their balance sheets (from a credit risk perspective).

Table 7.3 – Percentage Arbitrage Opportunities per Contract.

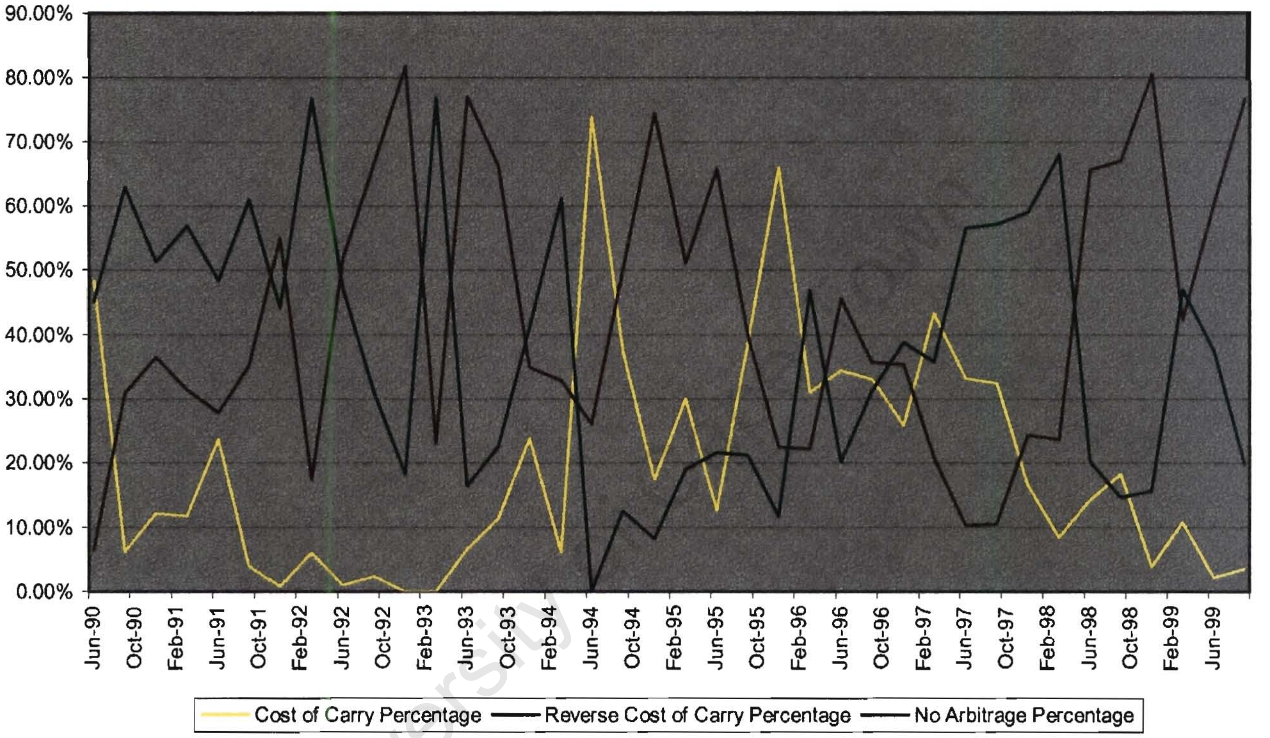
	ALSI & ALSI 40			INDI & INDI 25		
	COC	RCOC	None	COC	RCOC	None
Jun-90	15	2	14	18	5	8
Sep-90	6	31	61	3	39	55
Dec-90	18	54	76	14	50	84
Mar-91	22	59	107	9	53	53
Jun-91	29	34	59	5	68	49
Sep-91	5	45	78	1	76	49
Dec-91	1	71	57	0	89	40
Mar-92	28	82	362	10	78	94
Jun-92	1	55	50	6	71	68
Sep-92	3	84	39	3	82	27
Dec-92	0	63	14	0	69	11
Mar-93	0	80	267	0	10	0
Jun-93	8	94	20	3	115	5
Sep-93	14	82	28	2	121	3
Dec-93	30	44	52	7	115	2
Mar-94	30	162	302	9	112	18
Jun-94	34	12	0	8	120	28
Sep-94	42	56	14	8	93	22
Dec-94	17	73	8	12	83	3
Mar-95	71	121	45	12	110	23
Jun-95	14	73	24	3	103	4

Sep-95	44	45	24	37	64	6
Dec-95	91	31	16	62	19	24
Mar-96	123	88	186	99	156	37
Jun-96	65	86	38	41	110	38
Sep-96	38	41	36	48	46	21
Dec-96	30	41	45	29	34	53
Mar-97	181	87	149	63	33	174
Jun-97	55	17	94	39	34	93
Sep-97	59	19	94	70	10	102
Dec-97	32	47	114	39	41	112
Mar-98	29	82	236	52	62	184
Jun-98	26	120	37	30	105	48
Sep-98	45	165	41	71	121	54
Dec-98	10	211	41	8	150	14
Mar-99	55	217	241	33	150	14
Jun-99	5	139	86	10	136	222
Sep-99	6	132	32	11	84	43

The above table has been graphed below (figure 7.8) to show the trend in the arbitrage opportunities over the period under review. One can see the cash and carry arbitrage opportunities diminish over the period whereas the reverse cost of carry arbitrage gaps fluctuate with little or no downward trend. This suggests that the futures market is becoming more efficient as the cost of carry arbitrage opportunities have become less over the years. This means that arbitrageurs are taking advantage of arbitrage opportunities to force the actual value of the future to within its fair value bounds. The cost of carry arbitrage is easier to construct than the reverse cost of carry position. The fluctuation of the reverse cost of carry suggests that the reverse cost of carry is restricted in its application. One plausible answer for this restriction is the lack of securities lending activity as it accounts for the main difference between the cost of carry and reverse cost of carry arbitrage strategies. The fluctuation in the no arbitrage opportunities line is mainly caused by the reverse cost of carry opportunities. When combined with the cost of carry opportunities, the fluctuating reverse cost of carry line forces the no arbitrage indicator to zero in June 1994 which shows that there are arbitrage opportunities within the South African Futures market and the futures market is not priced efficiently.

Between June 1998 and September 1999 the arbitrage opportunities available through the application of the reverse cash and carry strategy suggest that the persistence of market shocks caused a break down in the pricing efficiency of the futures. Because the inefficiency was predominantly due to the reverse cash and carry strategy this is evidence that there could be bottlenecks in the securities lending market that restricted the necessary reverse cash and carry strategy. This period, during which the market shocks were experienced, is examined in more detail below.

Figure 7.8 – Graphic Representation of Percentage Arbitrage opportunities for the ALSI & ALSI40 Contracts.



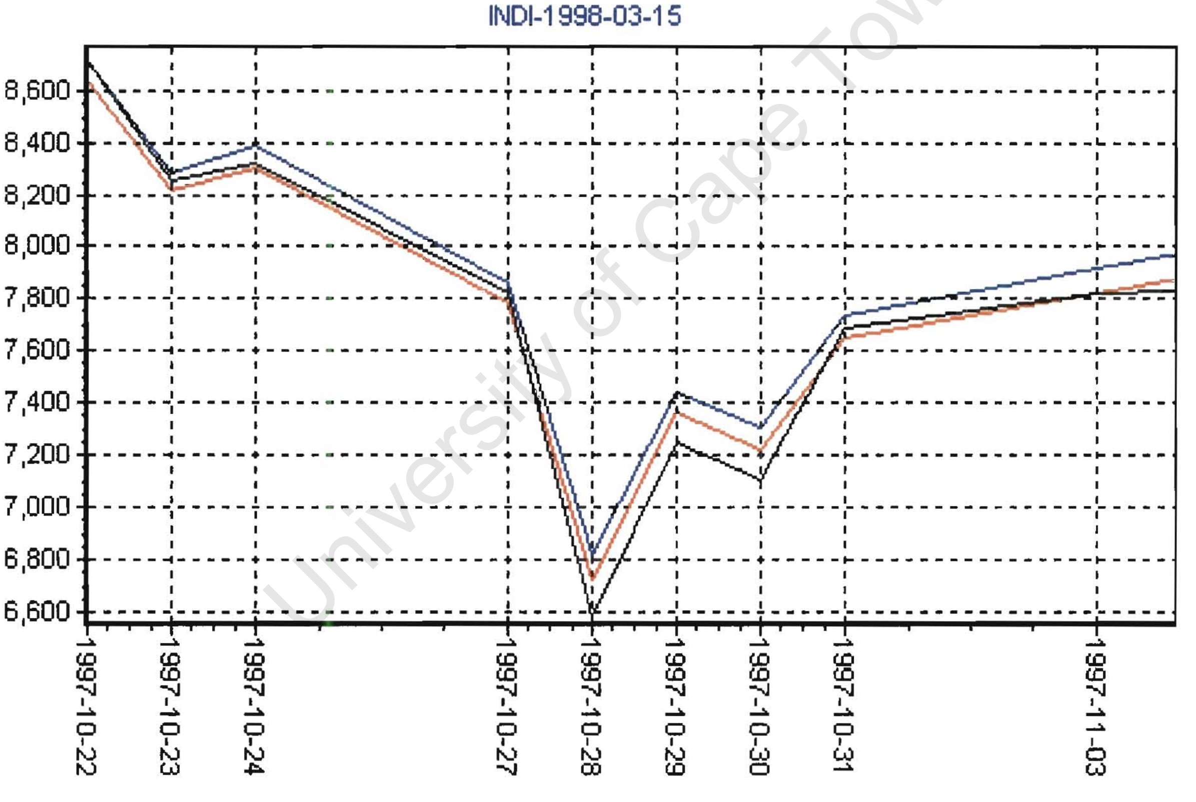
7.7.3 Comments on the Crises.

For each of the crisis periods the above graphs will be zoomed in on to determine the effect of the crises on the pricing efficiency of the futures market. The first crisis period had an initial drop between the 22 and 28 October 1997 (the Eastern Crisis) which continued until the 12 January 1998.During this period the variance in the log normal R-Squares for the series of contracts dropped close to nil over the month of October, rising to a low 0.01 in December and back down lose to nil in January 1998. From this high level examination of the efficiency of the contracts, the market's pricing efficiency seems to have held during the first market shock.

Looking at the arbitrage gap one should first examine figure 7.9 below. Figure 7.9 shows the period of the Asian crisis magnified for the theoretical fair value bounds for the future and the actual futures price. This graph shows the actual value and the fair value bounds of the March 1998 INDI contract for the period 22 October 1997 to 4 November 1997. The green line represents the actual price of the future, while the red line represents the reverse cost of carry line and the blue line represents the cost of carry fair value.

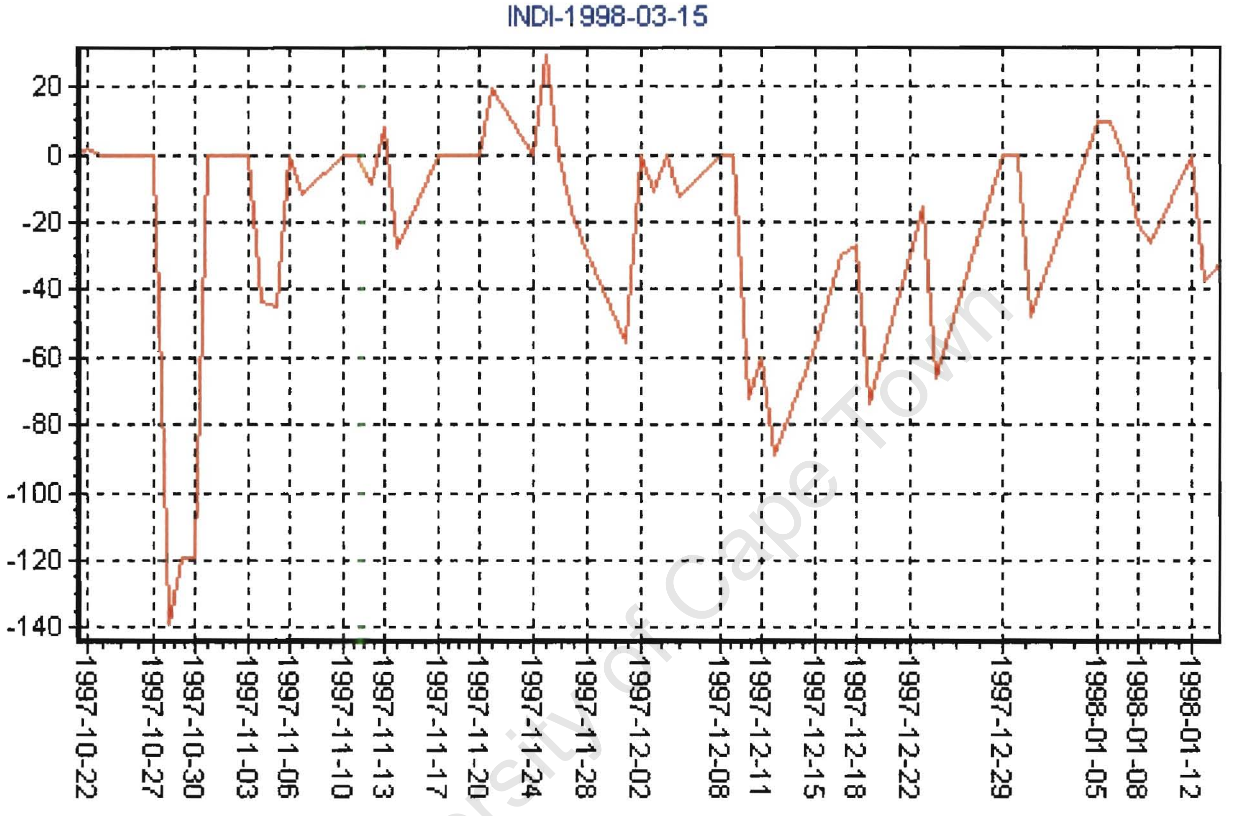
From the graph one can see that the future initially remained within its fair value bounds as the crisis began have effect on the South African market. This was broken between the 27 October and the 31 October when the future dropped below the fair value bounds indicating reverse cost of carry arbitrage opportunities were not being taken. This would lead one to conclude that as the market shocks increased in severity so the pricing efficiency broke down due to problems with the reverse cash and carry arbitrage mechanism.

Figure 7.9 – The March 1998 INDI Futures Contract and Fair Value Bounds During the Asian Crisis.



This is further expanded on in figure 7.10, which shows the arbitrage gap for the INDI contract between the 22 October 1997 and the 12 January 1998. Here one can more clearly see the market inefficiency. When the crisis begins the INDI future remains efficiently priced. As the market deteriorates further the arbitrage gap opens to a point where it achieves its widest gap on the 28 October 1997 (which is consistent with figure 7.9 above). The pricing mechanism then does go on to recover and the pricing becomes more efficient, however, the reverse cost of carry arbitrage opportunity persists throughout the period of the market shock. This again supports the observation that the pricing efficiency breaks down as market shocks persist due to problems with the reverse cost of carry arbitrage strategy.

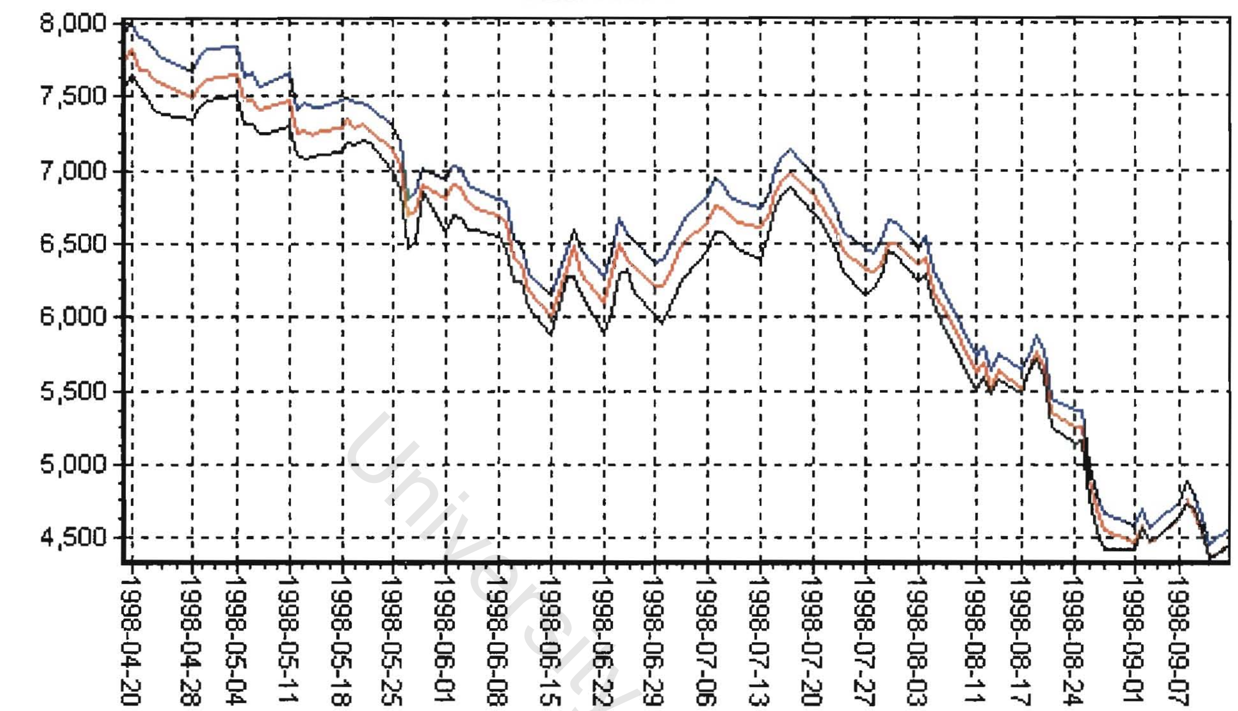
Figure 7.10 – The Arbitrage Gap for the March 1998 INDI future during the Asian Crisis.



The Russian Crisis took place over the period 21 April to 11 September 1998. This can best be seen through figure 7.11 which shows the effects of the crisis through the fair value arbitrage bounds and the actual value of the future. As above, the red line represents the reverse cash and carry arbitrage fair value bound while the blue line represents the cash and carry fair value. The actual futures price is the green line. After the Eastern Crisis the arbitrage gap persists for most of the period. This can be seen as the actual future remains below the fair value bounds in figure 7.11 below.

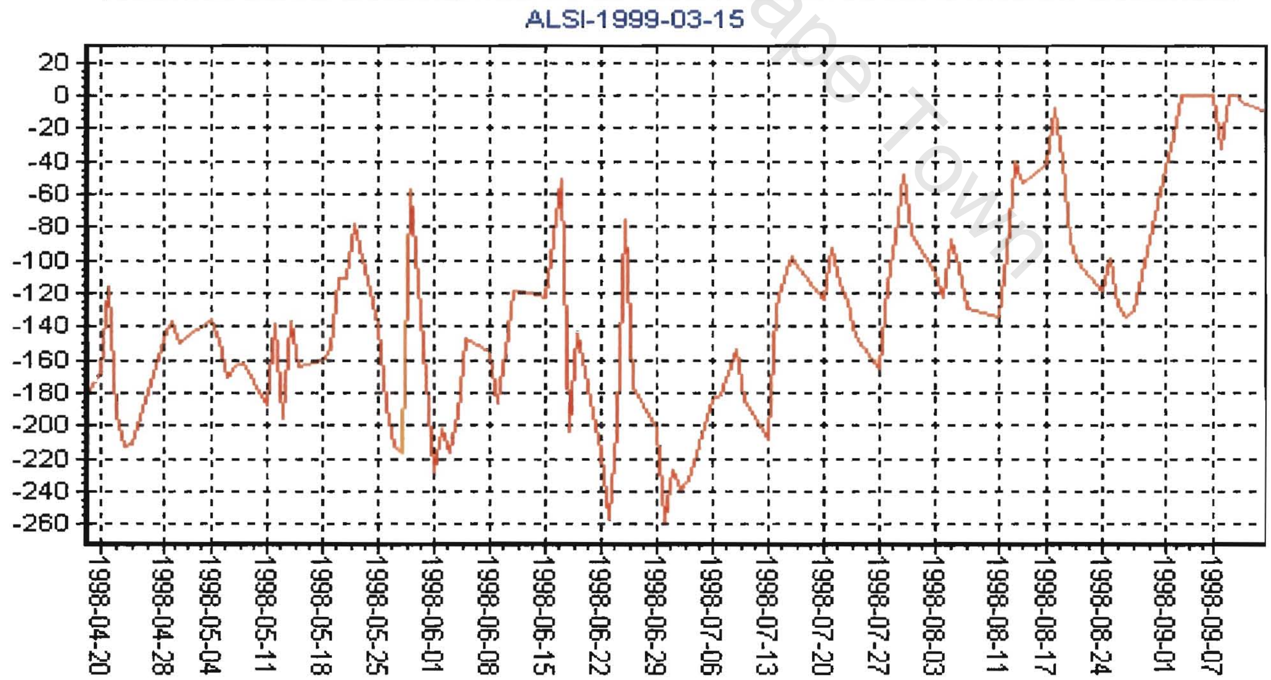
This persistence of the reverse cash and carry arbitrage opportunity as the market deteriorates would lead one to again conclude that there are inefficiencies in the reverse cash and carry mechanism. As the main difference between the cash and carry and the reverse cash and carry strategies involved the borrowing of shares a fair comment to make would be that the shares are more difficult to borrow than the cash, leading one to suggest there being liquidity problems in the securities lending market.

Figure 7.11 – The March 1999 ALSI Futures Contract and Fair Value Bounds During the Russian Crisis.



The above is further reinforced by the graph of the arbitrage gap that can be seen in figure 7.12 below:

Figure 7.12 – The Arbitrage Gap for the March 1999 ALSI future during the Russian Crisis.



The last emerging market crisis was the Brazilian Crisis which took place between the 6 November and the 17 December 1998. At this stage the reverse arbitrage mechanism had improved. This can be seen in the below graph in figure 7.13 where the December 1998 INDI future and its theoretical bounds have been graphed. The arbitrage gap is smaller than in the two previous shocks and fluctuates between being a reverse cost of carry gap and a cost of carry gap. This can better been seen in figure 7.14.

Figure 7.13 - The December 1998 INDI Futures Contract and Fair Value Bounds During the Brazilian Crisis.

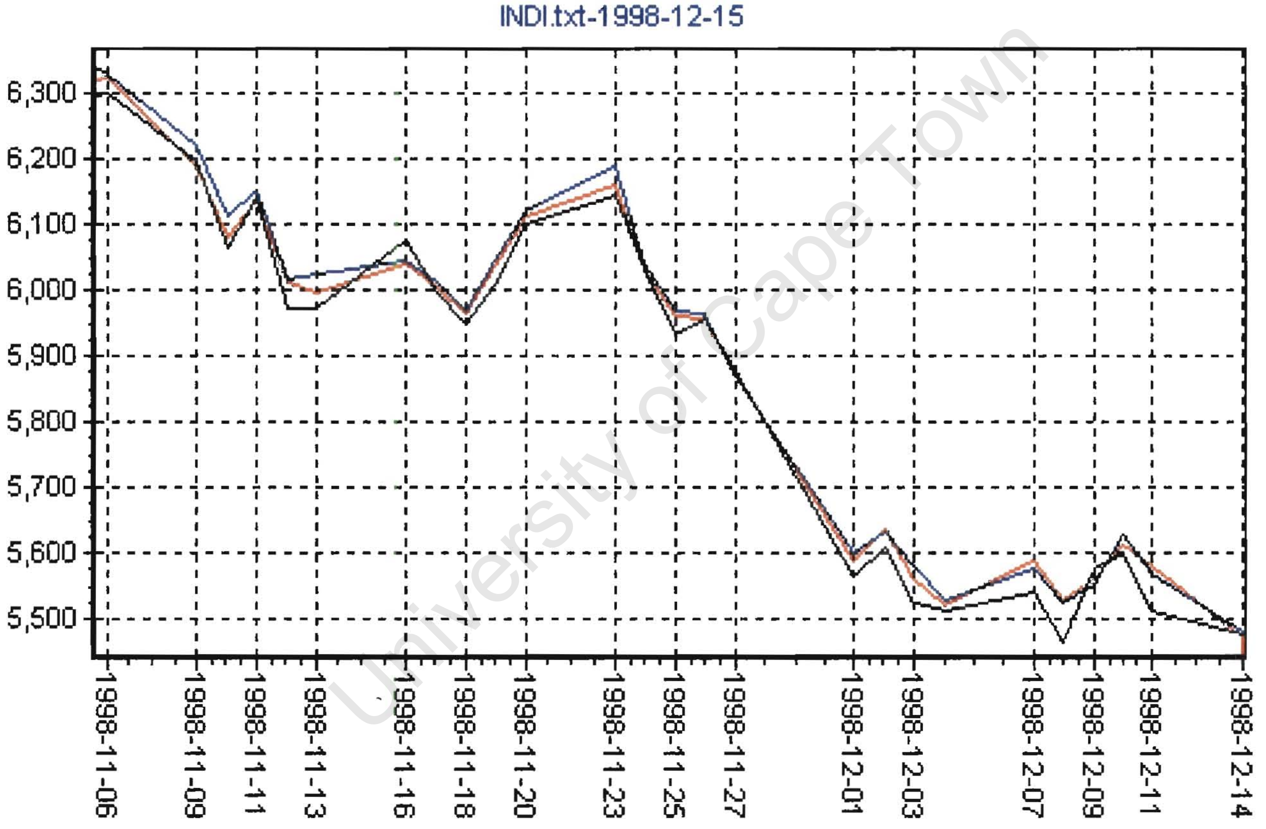
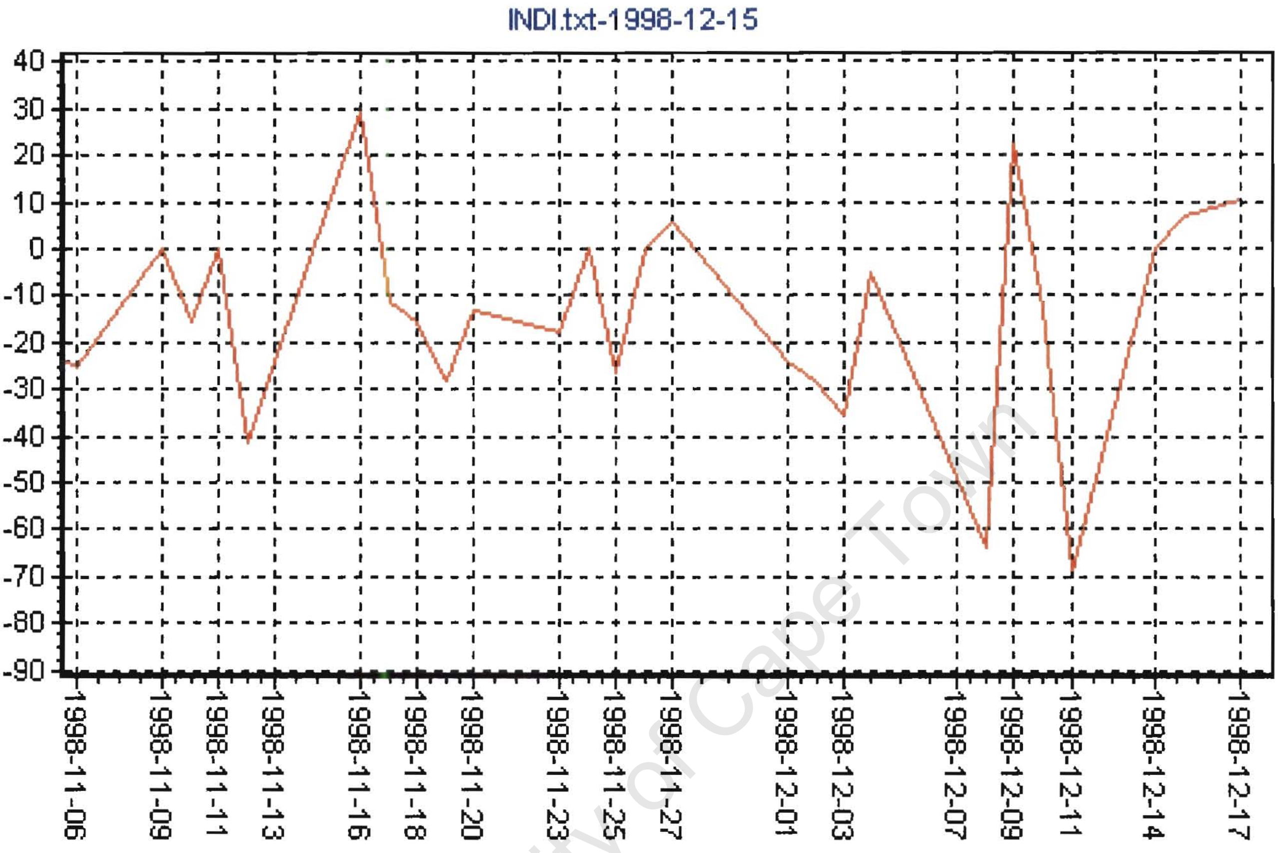


Figure 7.14 shows the arbitrage gap over the same period as above. One first notes the gap oscillating around the zero axis showing a more efficiently priced contract. This is counter to the above two crises where the trend was for the arbitrage gap to increase in size (on the reverse cost of carry side of the fair value bounds). In this case the gap is smaller than the previous two examples and there is clear evidence of there being a cash and carry arbitrage gap which is contrary to the previous examples which only exhibited large reverse cash and carry arbitrage gaps.

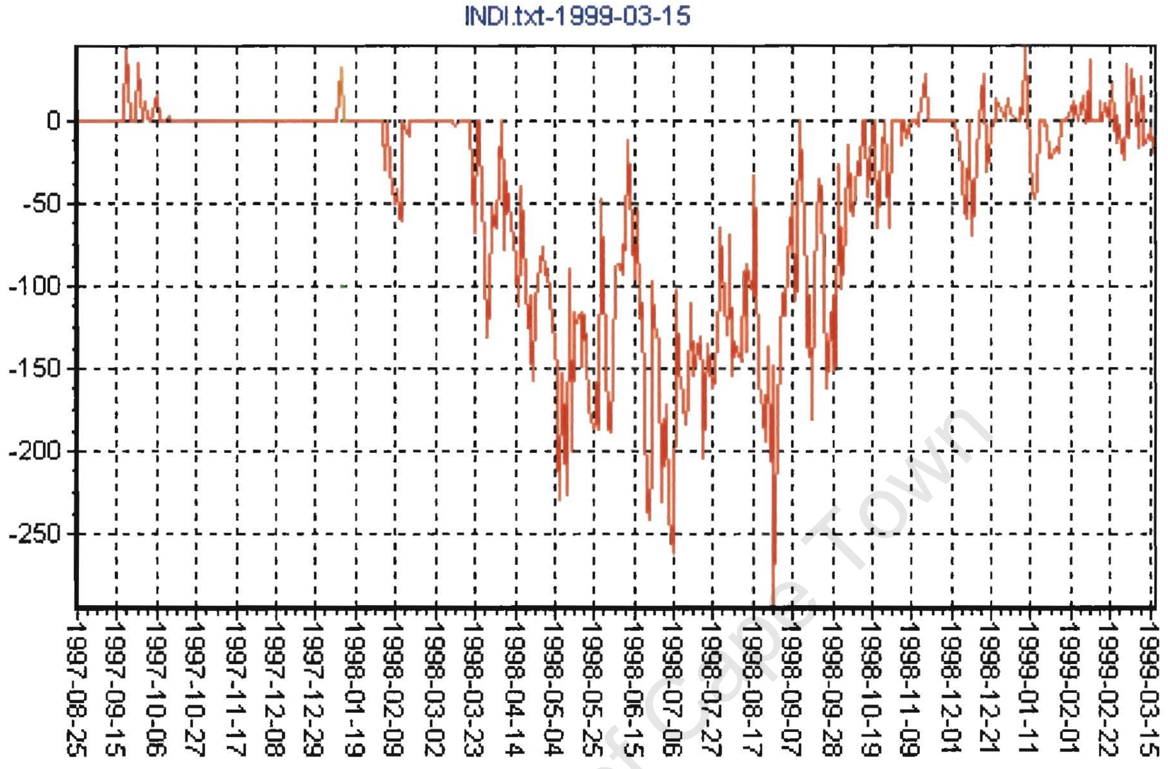
Figure 7.14 - The Arbitrage Gap for the December 1998 INDI future during the Brazilian Crisis.



The combined effect of the crises can best be seen through the March 1999 INDI future arbitrage gap (see figure 7.15 below). There is a delay between when the first crisis (Asian) begins and when the arbitrage gap opens. The gap is predominantly on the side of the reverse cost of carry arbitrage. The gap continues to widen as each crisis occurs with it reaching its widest at the beginning of September 1998 (when the drop suffered by the market due to the second shock was at its worst). The gap then begins to disappear as the markets recover. By the time the Brazilian crisis occurs the market has recovered to a point where it is more efficient and the gap disappears altogether for a short period of time.

Prior to the crises the future is predominantly efficiently priced with the occasional cash and carry arbitrage opportunity presenting itself. After the market shocks (January 1999) the market does not return to the same level of stability as before the shocks were experienced. This could be due to increased uncertainty in the market after the shocks had been experienced.

Figure 7.15 – The March 1999 INDI Arbitrage Gap Showing the Combined Effect of the Crises.



7.8 Conclusions.

The conclusions drawn have been separated between general conclusions concerning the market since 1990 and the conclusions concerning the period during which the emerging market crises were experienced.

Over the period there is evidence of the market becoming more efficient. This is most evident through figure 7.8, which shows the percentage of arbitrage opportunities per contract over the period. The earlier contracts generally have more arbitrage opportunities than the later contracts for the cash and carry arbitrage strategy. The exception to this is the period 199 October 1991 to October 1993 which this study is unable to explain. From November 1993 to September 1999 there is clear evidence of a reducing trend in the number of cash and carry arbitrage opportunities. This has been further supported by the introduction of the more focused indices that allowed arbitrage traders to construct arbitrage trades easier and thus promote more efficiently priced futures.

In the case of the reverse cash and carry arbitrage strategy there is no clear reducing trend. The number of opportunities per contract fluctuates and results in the total number of arbitrage free days remaining relatively low for the period. This leads one to conclude that the reverse cost of carry arbitrage transaction needs to be looked at closer in determining market efficiency. In comparing the two arbitrage transactions the main difference is that where the cash and carry results in the arbitrage trader borrowing cash, the reverse cash and carry arbitrage trader borrows shares. The above results point to the share borrowing mechanism being deficient during the period. This could be either due to restrictive credit policies on the part of the institutional lenders and market agents or simply a lack of adequate liquidity in the market.

With regards the emerging market crises, the following facts have been ascertained: the market is inefficient and the inefficiency is caused by a failure in the reverse cost of carry arbitrage mechanism. This can be seen by looking at the arbitrage gaps of the contracts that were being traded during the period 22 October 1997 to 17 December 1998. In each case there were large arbitrage gaps in the direction of the reverse cost of carry arbitrage trade. Without a detailed study of the liquidity and general market conditions experienced by the securities lending market it is difficult to draw conclusions. However one postulate that does seem to flow from the findings above is the following: as the market suffers shocks the available supply of loanable securities is used up so that as either more market shocks are experienced or the extent of the market shocks increases there are no securities available for arbitrageurs to maintain efficient pricing. This leads to an opening of the arbitrage gap in the direction of the reverse cash and carry arbitrage trade until the supply of shares increases and arbitrageurs are able to rectify the inefficiencies through profitably exploiting the arbitrage gap which, in turn, leads to a closure of the gap.

This postulate is only an attempt to explain the above findings. For it to be the definitive answer a detailed study would have to be undertaken on the efficiency and liquidity within the securities lending market. The theory does, however, help explain the seeming lag in the arbitrage gap and its widening as the market deteriorates. When the arbitrage gap reduces as the Brazilian shock occurs the above theory explains this in terms of the lag in the securities lending market. By the time the Brazilian shock has occurred the securities lending market has increased its supply of loanable stock to the point where the reverse cash and carry arbitrage strategy can be efficiently carried out.

The conclusion that the market is inefficient is not complete. In order for a clearer understanding of the market to be had the nature and extent of the market shocks needs to be examined. This is done in the next two chapters, which look at the market volatility during the three emerging market crises.

Chapter 8: Empirical Testing of Volatility – Traditional.

In this chapter the volatility of the market is examined by using traditional volatility measures as explained in chapter five. Given the inefficiencies identified in the previous chapter, this chapter is an attempt to explain what part the market conditions played in these inefficiencies occurring. The volatility and the market inefficiencies are regressed to determine if there is any correlation between the two. This should help the understanding of both the pricing inefficiency and how volatility affects it. An attempt will be made to establish if there is a causal relationship between the market volatility and the opening or closing of the arbitrage gap identified in the previous chapter. A further part in the analysis will be to examine leads and lags in any relationship between volatility and the arbitrage gap.

8.1 Objective.

The objectives of this chapter are threefold, namely to first model the market volatility during the past 10 years, secondly to determine the market volatility as the emerging market crises occurred and thirdly to determine the correlation between the calculated volatility and the arbitrage gap.

One would expect the volatility to be correlated with the market inefficiencies given the above findings. A market shock would be associated with periods of high volatility, this would then mean that as the market shocks were experienced the volatility in the market would have been above its long run average. This in turn would mean the inefficiencies would be correlated with the market volatility. The objective of the chapter is to either confirm or refute this theory by examining the relationship between the arbitrage opportunities and the volatility in the underlying share prices.

As noted in the previous chapter the market efficiency improved in one case (cash and carry arbitrage) and remained inefficient in another (reverse cash and carry arbitrage) during the period under examination (see figure 8.8 and related commentary). In this chapter an attempt will be made to identify any long-term trends in the volatility of the underlying share prices over the 10-year period. The study will attempt to explain any changes in long-term volatility as well as how this affected the pricing efficiency within the futures market (it at all).

The conclusion in the previous chapter was that the inefficiencies in the market were caused largely by a lack of liquidity in the underlying securities lending market, especially during periods of market shocks. As a market shock is a period where volatility spikes an examination of the volatility will allow for a clearer analysis of the theory that as market shocks persist so the pricing mechanism breaks down.

8.2 Introduction and Hypotheses.

As mentioned in chapter 5, there are numerous methods that can be used to determine market volatility. This chapter will use the traditional method and ignore the more advanced methods such as GARCH(1,1) and ARCH. This is because this chapter is firstly an attempt to gain a fundamental understanding of the volatility within the markets and secondly is backed by further volatility calculation in chapter 9 below (which looks at the more advanced calculation mechanisms).

Various methods can be used to test for futures market efficiency. Lambrechts (1990) uses four methods ranging from correlations between the spot and the futures price to the calculation and examination of the residual correlation in the futures market. The approach taken by this study is twofold, firstly the correlation between the spot and futures prices is examined to determine if the two are indeed linked through some fixed mechanism. Secondly, once a conclusion has been drawn on the correlation and anticipating it to conclude that the spot and futures prices are correlated, the arbitrage gap is calculated. If the first test returns a result that the spot and future are not correlated the second test looses relevance as this tests the extent to which the futures price remains in its fixed position (relative to the spot price). The hypotheses are:

8.2.1 Hypothesis One – Spot / Futures Correlation.

The spot and futures price are significantly correlated. This is examined to allow for the second test to take place: if the hypothesis is rejected the volatility of the spot and futures prices will have to be modeled against the arbitrage gap independently in the second test.

8.2.2 Hypothesis Two – Arbitrage Gap / Spot Volatility Correlation.

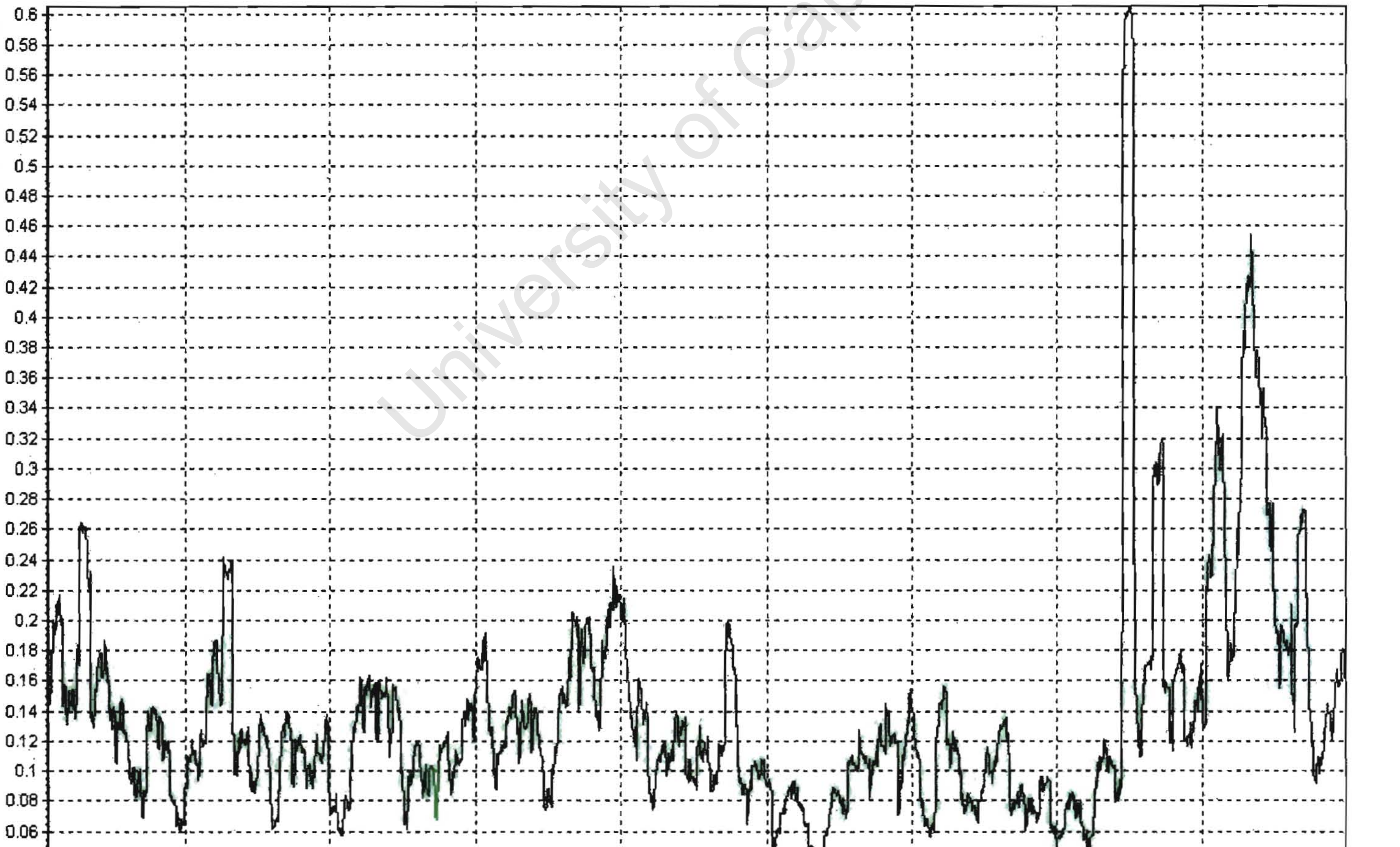
The arbitrage gap and the volatility of the spot prices are significantly correlated.

8.3 Theoretical Background and Methodology.

The data used for the examination came from the same source as what was used for the arbitrage gap calculation in the previous chapter. The spot data is for the period 4 May 1990 to 17 May 1999. The focus of this chapter is to determine if there is any relationship between the spot or futures price and the volatility of the spot or futures. The first step is to examine the correlation between the spot and futures prices. If this correlation is high the remainder of the study will use the volatility of the spot prices to mean the volatility of both the spot and futures prices. The volatility is, in turn compared with the periods of market turbulence identified in chapter two to identify any obvious relationships. Given the spot and futures prices are closely correlated, the next step is to correlate the spot volatility and the arbitrage gaps calculated in the previous chapter to determine if market volatility causes the arbitrage gap to open. This is done by correlating the data points at different time lags to see if there is any relationship whether it be instantaneous or delayed. Where there is a high correlation between the volatility of the spot prices and the arbitrage gap a regression analysis is performed to determine the extent of any relationship for a given time lag (whether it be nil or longer). Again, due to data constraints, thirty-eight contract periods were chosen, namely the June 1990 contract to the September 1999 contract.

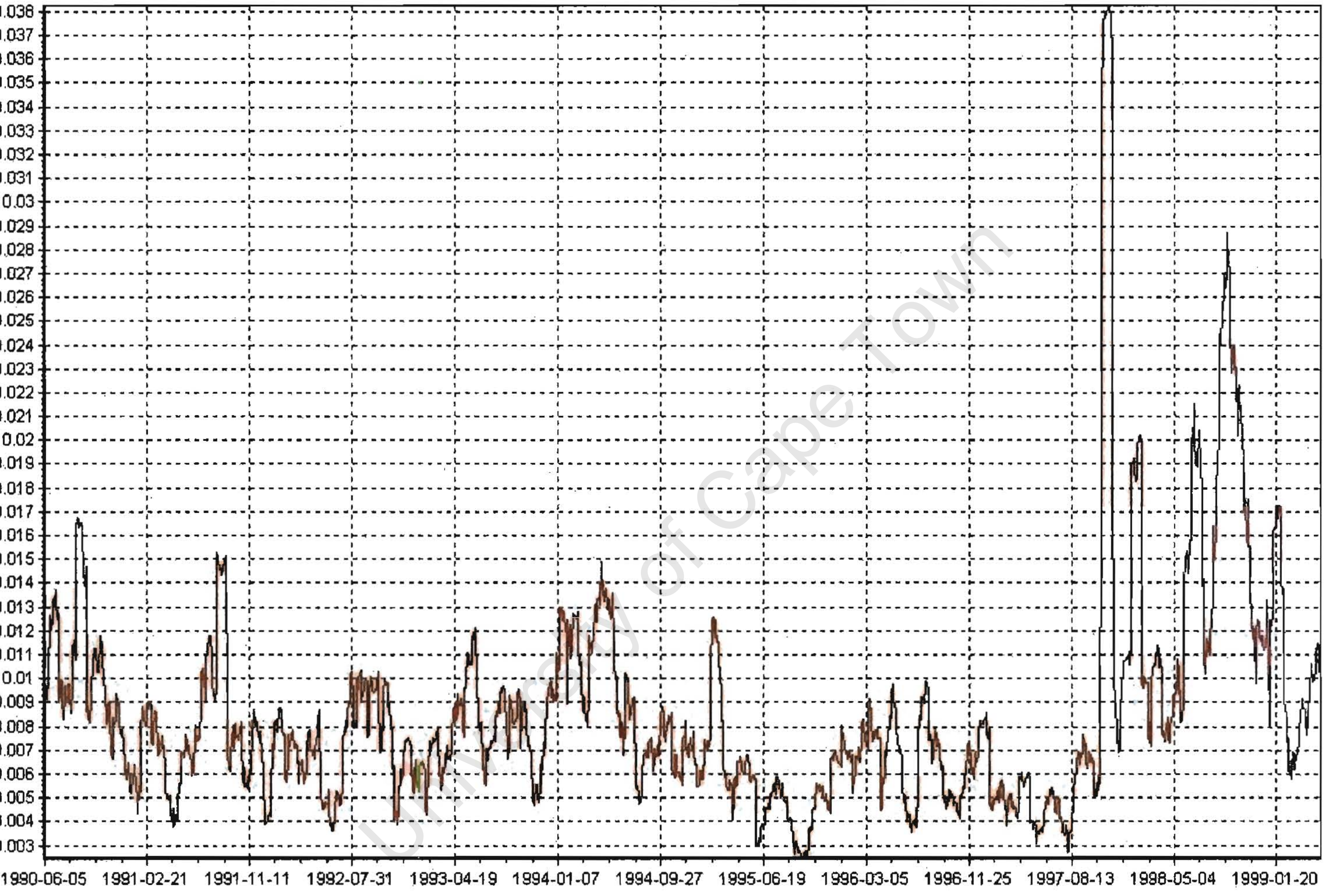
For the calculation of the traditional volatility a period of 20 trading days was taken to approximate a monthly volatility. This was done to allow short-term volatility spikes to be accentuated so to allow for any relationships between this and the arbitrage gap to be identified easier. The volatility of the ALSI spot prices for the period 4 May 1990 to 17 May 1999 can be seen below:

Figure 8.1 – ALSI Spot Volatility 4 May 1990 to 17 May 1999.



The volatility was further examined by the annualized volatility being calculated (as shown in chapter 5). This was based on 252 annual trading days and can be seen in the figure below:

Figure 8.2 – Annualised ALSI Spot Volatility 4 May 1990 to 17 May 1999.



In the above graphs one can quite clearly see the slight increase in volatility in 1994 when the Mexican Peso crisis occurred. The first item to note is that the volatility spikes before the Peso Crisis actually takes place (at the end of 1994) but when it was building up. When the crisis finally breaks in late 1994 the volatility subsides, suggesting the market had taken into account any fallout from the Mexican Crisis.

When the emerging market crises break the volatility increases significantly. Looking at both the above graphs, the volatility peaks during late 1997, early 1998 which is at the same time the Asian crisis occurs. The next peak in volatility is mid 1998 – the same time of the Russian crisis which suggests a link between the two. The last "mini" peak in volatility occurs at the end of 1998, which is the same time the Brazilian crisis occurs. From the above, basic analysis there seems to be a relationship between the crises and volatility levels. When the crises occur, volatility seems to increase accordingly. The actual calculation of the volatility was performed by the futures calculator that has been included in the appendices on an attached CD Rom. The last module in the futures calculator calculates the traditional volatility levels for a given time period. The above finding does tie up with what one would expect – that market shocks would result in an increase in market volatility.

The objective of this analysis is to look for a relationship between the volatility calculated above and the arbitrage gap. Before moving on to this, the relationship between the spot and futures prices needs to be investigated as described above. To this end the ALSI contract was investigated over the same period that the volatility was calculated over and the correlation between the futures prices for each contract and the spot prices was examined. The results are shown below:

Table 8.1 – ALSI & ALSI40 Spot / Futures Correlation

Future	Spot	Correlation	Future	Spot	Correlation
Jun 90 ALSI Future	**Spot (ALSI)**	0.9831478	**Mar 95 ALSI Future**	**Spot (ALSI)**	0.863207446
Sep 90 ALSI Future	**Spot (ALSI)**	0.967258881	**Jun 95 ALSI Future**	**Spot (ALSI)**	0.92976346
Dec 90 ALSI Future	**Spot (ALSI)**	0.985284512	**Sep 95 ALSI Future**	**Spot (ALSI)**	0.680005162
Mar 91 ALSI Future	**Spot (ALSI)**	0.976213173	**Dec 95 ALSI Future**	**Spot (ALSI)**	0.970164171
Jun 91 ALSI Future	**Spot (ALSI)**	0.966308156	**Mar 96 ALSI Future**	**Spot (ALSI)**	0.905201524
Sep 91 ALSI Future	**Spot (ALSI)**	0.985148167	**Jun 96 ALSI40 Future**	**Spot (ALSI40)**	0.677798519
Dec 91 ALSI Future	**Spot (ALSI)**	0.826112016	**Sep 96 ALSI40 Future**	**Spot (ALSI40)**	0.90331511
Mar 92 ALSI Future	**Spot (ALSI)**	0.842761934	**Dec 96 ALSI40 Future**	**Spot (ALSI40)**	0.830351589
Jun 92 ALSI Future	**Spot (ALSI)**	0.920158838	**Mar 97 ALSI40 Future**	**Spot (ALSI40)**	0.372346293
Sep 92 ALSI Future	**Spot (ALSI)**	0.970534264	**Jun 97 ALSI40 Future**	**Spot (ALSI40)**	0.540220933
Dec 92 ALSI Future	**Spot (ALSI)**	0.984722242	**Sep 97 ALSI40 Future**	**Spot (ALSI40)**	0.324284081
Mar 93 ALSI Future	**Spot (ALSI)**	0.643719712	**Dec 97 ALSI40 Future**	**Spot (ALSI40)**	0.968750576
Jun 93 ALSI Future	**Spot (ALSI)**	0.958122477	**Mar 98 ALSI40 Future**	**Spot (ALSI40)**	0.897022661
Sep 93 ALSI Future	**Spot (ALSI)**	0.990249542	**Jun 98 ALSI40 Future**	**Spot (ALSI40)**	0.947443353
Dec 93 ALSI Future	**Spot (ALSI)**	0.967813923	**Sep 98 ALSI40 Future**	**Spot (ALSI40)**	0.946296687
Mar 94 ALSI Future	**Spot (ALSI)**	0.979151753	**Dec 98 ALSI40 Future**	**Spot (ALSI40)**	0.985318961
Jun 94 ALSI Future	**Spot (ALSI)**	0.981833653	**Mar 99 ALSI40 Future**	**Spot (ALSI40)**	0.935849723
Sep 94 ALSI Future	**Spot (ALSI)**	0.942718934	**Jun 99 ALSI40 Future**	**Spot (ALSI40)**	0.93622919
Dec 94 ALSI Future	**Spot (ALSI)**	0.910500744	**Sep 99 ALSI40 Future**	**Spot (ALSI40)**	0.992670581

The average correlation coefficient for the above 38 ALSI futures contracts is 0.88 which indicates a close relationship between the spot and futures contracts. For this reason either the spot of futures prices can be used to calculate volatility to be compared with the arbitrage gap.

Now that the spot volatility has been accepted as a proxy for volatility of the instruments (both spot and future) and the volatility has been measured, the next step is to measure the relationship between the arbitrage gaps and the market volatility.

8.4 Results.

The analysis of the relationship between the arbitrage gap and the underlying market volatility was performed using the statistical analysis package EViews. The correlation between the arbitrage gap for each ALSI futures contract calculated in chapter eight and the volatility of the underlying spot market was established at different time lags. Fifty different time lags were used, where each lag was increased by one day from the previous one. The correlations were calculated and cross correlograms were produced for each lag. An example of this can be seen in figure 8.3 below, in this case the contract is the December 1994 ALSI futures contract. From figure 8.3 one can see that the maximum correlation between volatility and the arbitrage gap for the December 1994 futures contract is 0.38, which occurs at a lag of 35 days. This means that volatility occurring 35 days before has a 0.38 correlation with the size of the arbitrage gap. For each contract the highest correlations (and respective lags) were:

Table 8.2 – ALSI Spot / Arbitrage Gap: Highest Correlations over 50 Lags

Number	Contract	Highest Correlation	Lag (days)
1	Jun-90	0.66	11
2	Sep-90	0.94	32
3	Dec-90	1.00	3
4	Mar-91	1.00	3
5	Jun-91	0.40	45
6	Sep-91	1.00	3
7	Dec-91	0.64	4
8	Mar-92	0.59	24
9	Jun-92	1.00	9
10	Sep-92	1.00	25
11	Dec-92	0.49	17
12	Mar-93	0.16	45
13	Jun-93	1.00	11
14	Sep-93	0.78	17
15	Dec-93	1.00	3
16	Mar-94	0.45	28

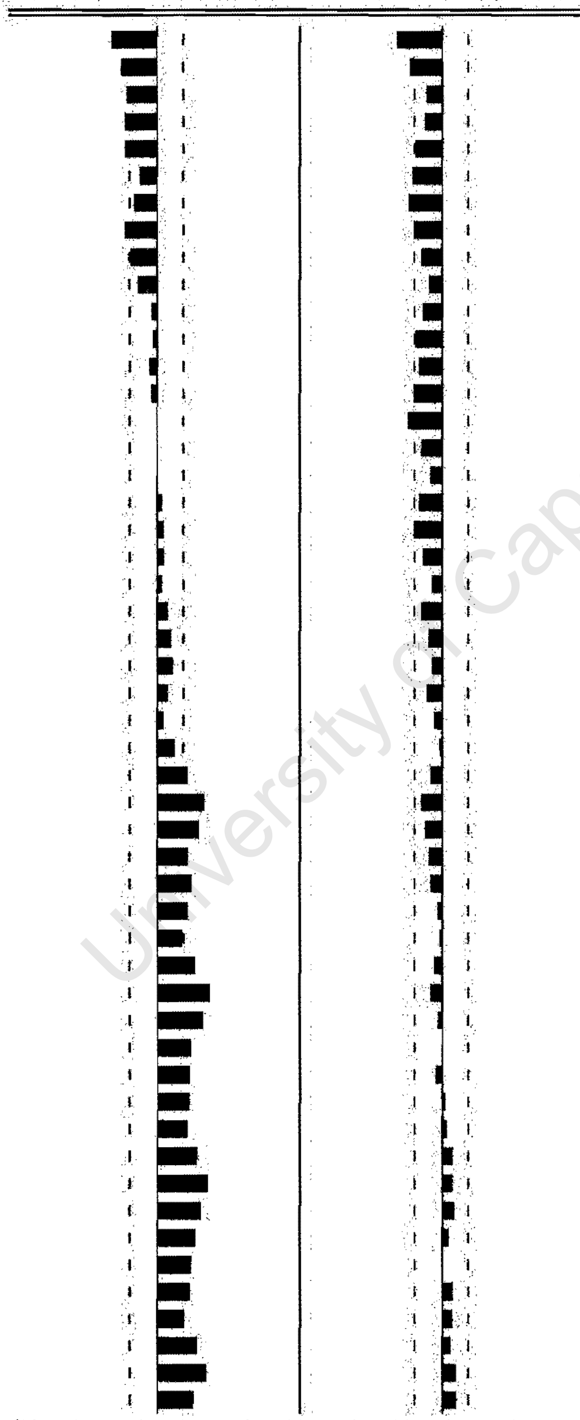
17	Jun-94	0.44	28
18	Sep-94	0.52	14
19	Dec-94	0.38	35
20	Mar-95	0.14	50
21	Jun-95	0.45	7
22	Sep-95	0.24	49
23	Dec-95	0.27	42
24	Mar-96	0.34	28
25	Jun-96	0.60	35
26	Sep-96	0.41	14
27	Dec-96	0.21	42
28	Mar-97	0.48	49
29	Jun-97	0.16	42
30	Sep-97	0.12	42
31	Dec-97	0.31	7
32	Mar-98	0.23	7
33	Jun-98	0.48	35
34	Sep-98	0.38	35
35	Dec-98	0.51	49
36	Mar-99	0.18	49
37	Jun-99	0.60	49
38	Sep-99	0.62	0

The above table shows that the highest correlations are not particularly significant, even when one takes different lags into account. The above table illustrates that there is no one lag where the correlations are significant. The individual correlograms are included in the appendix (see appendix 9.1). The only incidence of high correlations are in the earlier contracts. This is most likely due to the reduced sample sizes. For this reason the contracts pre March 1994 are ignored for the rest of this analysis.

For correlations in excess of 0.6 a regression was performed to confirm the above findings where the volatility of the spot was regressed against the arbitrage gap for the respective futures contract. In the case of the above this was applied to the June 1996, June 1999 and the September 1999 contracts. The regressions are presented in table 8.3 below. In the case of the June 1996 contract the R Squared was calculated to be 0.28 while the June and September R Squared's were calculated to be 0.01 and 0.13 respectively. This confirmed the fact that any relationship between the underlying volatility of the spot / futures prices and the spot futures arbitrage gap is not particularly significant.

Figure 8.3 – December 1994 Correlogram between the Arbitrage Gap and the underlying volatility.

Sample: 6/05/1990 5/17/1999
Included observations: 98
Correlations are asymptotically consistent approximations



i	lag	lead
0	-0.3171	-0.3171
1	-0.2532	-0.2276
2	-0.2102	-0.1012
3	-0.2228	-0.1229
4	-0.2146	-0.1741
5	-0.1162	-0.2094
6	-0.1523	-0.2348
7	-0.2224	-0.2044
8	-0.1792	-0.1334
9	-0.1269	-0.0862
10	-0.0267	-0.1264
11	-0.0237	-0.1735
12	-0.0428	-0.1585
13	-0.0332	-0.1986
14	0.0080	-0.2390
15	0.0092	-0.1396
16	0.0005	-0.0815
17	0.0364	-0.1583
18	0.0526	-0.1972
19	0.0506	-0.1279
20	0.0407	-0.0609
21	0.0715	-0.1465
22	0.0951	-0.0886
23	0.1118	-0.0648
24	0.0723	-0.0984
25	0.0511	-0.0551
26	0.1273	-0.0042
27	0.2205	-0.0698
28	0.3448	-0.1317
29	0.2970	-0.1203
30	0.2157	-0.0884
31	0.2466	-0.0791
32	0.2294	-0.0204
33	0.1800	-0.0089
34	0.2786	-0.0519
35	0.3799	-0.0670
36	0.3230	-0.0181
37	0.2511	0.0059
38	0.2382	-0.0367
39	0.2306	0.0209
40	0.2154	0.0394
41	0.2789	0.0662
42	0.3609	0.0723
43	0.3178	0.0853
44	0.2769	0.0474
45	0.2473	0.0132
46	0.2349	0.0808
47	0.2004	0.0783
48	0.2925	0.0576
49	0.3681	0.0923
50	0.2596	0.0959

Table 8.3 – Regression Analysis for the June '96, June '99 and September '99 ALSI40 Futures Contracts between their underlying Spot Volatility and their Arbitrage Gaps.

Dependent Variable: **JUN96**
Method: Least Squares
Sample(adjusted): 9/14/1995 6/18/1996
Included observations: 189
Excluded observations: 90 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-468.0963	41.61300	-11.24880	0.0000
VOLATILITY(-28)	2811.533	330.5931	8.504511	0.0000
R-squared	**0.278902**	Mean dependent var		-131.1601
Adjusted R-squared	0.275046	S.D. dependent var		205.5190
S.E. of regression	174.9876	Akaike info criterion		13.17783
Sum squared resid	5726065.	Schwarz criterion		13.21214
Log likelihood	-1243.305	F-statistic		72.32672
Durbin-Watson stat	0.379106	Prob(F-statistic)		0.000000

Dependent Variable: **JUN99**
Method: Least Squares
Sample(adjusted): 7/09/1998 6/17/1999
Included observations: 229
Excluded observations: 115 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-16.22241	9.261999	-1.751502	0.0812
VOLATILITY	-51.89440	32.88232	-1.578185	0.1159
R-squared	**0.010853**	Mean dependent var		-29.76213
Adjusted R-squared	0.006496	S.D. dependent var		52.98619
S.E. of regression	52.81383	Akaike info criterion		10.78012
Sum squared resid	633171.1	Schwarz criterion		10.81011
Log likelihood	-1232.324	F-statistic		2.490668
Durbin-Watson stat	0.154778	Prob(F-statistic)		0.115916

Dependent Variable: **SEP99**
Method: Least Squares
Sample(adjusted): 2/01/1999 9/15/1999
Included observations: 150
Excluded observations: 77 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.405671	6.723808	1.101410	0.2725
VOLATILITY	-197.2874	41.70801	-4.730205	0.0000
R-squared	**0.131327**	Mean dependent var		-23.29219
Adjusted R-squared	0.125458	S.D. dependent var		23.03162
S.E. of regression	21.53847	Akaike info criterion		8.990802
Sum squared resid	68658.06	Schwarz criterion		9.030944
Log likelihood	-672.3102	F-statistic		22.37483
Durbin-Watson stat	0.817664	Prob(F-statistic)		0.000005

8.4.1 Comments on Volatility during the Crises.

Looking at the correlograms of the ALSI40 futures contracts over the period 28 August 1997 to 28 August 1999 (see appendix 9.1) one does not notice any significant events or correlations. The September 1997 contract has a low correlation (at all lags) between the spot volatility and the arbitrage gap. The December 1997 and March 1998 contracts have slightly higher correlations at the earlier or shorter lags, once one moves past 20 days of lags the correlations reduce to insignificance. The June 1998 contract has low correlations (below 0.05) for the first 10 lags. As the lags increase the correlation increases and peaks after 35 days. This pattern is also followed by the September and December 1998 contracts though the December 1998 has lower correlations. As in the case of the previous contracts, there does not seem to be a relationship between the volatility of the underlying spot and futures prices and the arbitrage gap calculated in chapter eight for the contracts that existed during the period of the emerging market crises.

8.5 Conclusions.

The findings above lead one to conclude that there is no relationship between the volatility of the underlying spot prices and the arbitrage gap. This does seem counterintuitive, as a reasonable expectation would be that periods of high volatility result in a break down in established pricing mechanisms (such as the spot / futures cost of carry model). One could argue that the above findings do support an alternative theory – that there is another factor that leads to the opening and closing of the arbitrage gap that has a greater effect than the volatility of the underlying share / futures prices. The alternative factor outlined in chapter eight could be the missing variable – the liquidity in the underlying stock lending market.

Before a final conclusion is drawn on the volatility / arbitrage gap relationship one needs to examine the issue closer. There are possible weaknesses in the above measurements of volatility that need to be addressed and the exercise (undertaken in this chapter) re-performed before a final conclusion is reached. This is dealt with in chapter nine below.

Chapter 9: Empirical Testing of Volatility – (G)ARCH.

As mentioned in the conclusion of the previous chapter, there is a need to examine the volatility of the underlying closer in order to be able to draw firm conclusions. In this chapter the volatility of the market is examined by using the GARCH measurement technique as explained in chapter seven. The main problems associated with using the traditional volatility measurement techniques is that there is a) the possibility that the data is heteroscedastic and b) the issue of what time period to use when calculating the volatility. In the chapter above the period was set to one month (approximately 20 trading days), this leads one to ask the question "is this enough, too much or too little?" The GARCH measurement tool takes into account long run volatility levels that the traditional technique does not and thus removes the problem of what period to select. The reason behind choosing the period to measure the volatility over is to acknowledge that there is some effect from historic price movements in the current movements of the share – GARCH does this more efficiently that an arbitrary selection of a number of days.

As in the previous chapter, this chapter will attempt to explain the part market conditions played in the inefficiencies identified in chapter eight. The GARCH determined volatility and the market inefficiencies are regressed to determine if there is any correlation between the two as in the previous chapter. This should help the understanding of both the pricing inefficiency and how volatility affects it. An attempt will be made to establish if there is a causal relationship between the GARCH determined market volatility and the opening or closing of the arbitrage gap identified in chapter eight. A further part in the analysis will be to examine leads and lags in any relationship between the GARCH volatility and the arbitrage gap.

9.1 Objective.

The objectives of this chapter are similar to the objectives of the previous chapter which were threefold, namely to first model the market volatility during the past 10 years, secondly to determine the market volatility as the emerging market crises occurred and thirdly to determine the correlation between the calculated volatility and the arbitrage gap. The difference in this case is that the modelling of volatility is to be done using the GARCH model.

Before the above objectives can be fulfilled the data in the previous chapter must first be examined to see if it indeed does suffer from heteroscedasticity. This is dealt with in section 9.3 below. This should justify the use of the GARCH model in measuring volatility. The application of the GARCH model in this study will not result in the forecasting of volatility. The GARCH model will simply be used to model the volatility of the underlying spot prices.

As in the previous chapter the objective of the chapter is to either confirm or refute the theory that volatility destabilized the spot / futures pricing mechanism by examining the relationship between the arbitrage opportunities and the GARCH volatility in the underlying share prices.

As GARCH takes into account long term volatility an attempt will be made to identify any long-term trends in the volatility of the underlying share prices over the 10 year period. This should be done with more accuracy than in the previous chapter. The study will attempt to explain any changes in long-term volatility as well as how this affected the pricing efficiency within the futures market (it at all).

The previous chapter found that volatility is not conclusively related to the deterioration in the spot / futures pricing mechanism during the emerging market shocks. This chapter will seek to either confirm this or refute it and place volatility as a significant reason for the breakdown in market efficiency.

9.2 Introduction and Hypotheses.

This part of the chapter will follow a similar route to that in the previous chapter. The main differences are firstly that we examine, in this chapter, if the findings from chapter nine do indeed suffer from heteroscedasticity. In the event they do, this would add to the justification that one should use GARCH to model the volatility. This investigation results in the first hypothesis below.

In the previous chapter the correlations between the spot and futures prices were calculated to determine if it would be possible to use just one of the spot or futures prices in the volatility calculation exercise. These results will be relied on for this chapter. The findings were that the correlation was high enough between the spot and futures contracts to allow one to use just the volatility spot price to act as a proxy of volatility for both spot and futures process.

The hypotheses are:

9.2.1 Hypothesis One – Traditional Volatility and Heteroscedasticity.

The "traditional" volatility of the spot prices suffers from heteroscedasticity that the application of GARCH(1,1) is able to remove. This is examined to allow for the second test to take place: if the hypothesis is rejected the significance of the second test is reduced as the need for the GARCH modelling is reduced (because it does not need to counter the traditional volatility measure being heteroscedastic).

9.2.2 Hypothesis Two – Arbitrage Gap / Spot (GARCH) Volatility Correlation.

The arbitrage gap and the GARCH(1,1) volatility of the spot prices are significantly correlated.

9.3 Theoretical Background and Methodology.

The data used for the examination is again, the same as what was used in the previous chapter. The spot data is for the period 4 May 1990 to 17 May 1999. The focus of this chapter is to determine if there is any relationship between the spot or futures price and the volatility of the spot or futures. The first step is to examine the heteroscedasticity in the traditional volatility measure.

The study of whether the data suffers from heteroscedasticity was performed along similar lines to the methodology employed by Hull (1999 : 378). The data was first assumed to exhibit heteroscedastic tendencies that would mean that a GARCH(1,1) model would be more suited from a modelling perspective. The next step would be to examine any autocorrelation in the data for both the traditional model and the GARCH(1,1) model. If the GARCH(1,1) model resulted in less autocorrelation then one could conclude that the GARCH(1,1) model was a better fit for the data and that the data suffered from heteroscedasticity.

Figure 9.1 below shows the autocorrelation in the traditional data (the autocorrelation in the u_i^2 term) while figure 9.2 below shows the autocorrelation in the GARCH modeled data (the autocorrelation in the u_i^2/σ_i^2 term).

One can see from examining both the figures that the autocorrelation reduces significantly in the case of the autocorrelation in the GARCH model. This shows that the GARCH model is a better fit for the underlying data and that the data does have heteroscedastic tendencies. This proof is similar to the one employed by Hull (1999 : 378) to prove GARCH is a better model to use in the case of heteroscedasticity.

In the case of the autocorrelation figures produced from the traditional data set, the highest autocorrelation reading is 0.24, which is taken at a lag of 1 day. There are 9 lag days in total where the autocorrelation figure exceeds 0.1. In the case of the autocorrelation figures for the GARCH data set, the highest reading is 0.13 at a lag of 13 days. There are no other lags where the autocorrelation exceeds 0.1. This clearly illustrates a drop in the autocorrelation readings from the one data set to the other.

Figure 9.1 – Autocorrelation in the Traditional ALSI Spot Volatility Data Set.

Sample: 5/04/1990 12/08/2000
Included observations: 2666

	AC	PAC	Q-Stat	Prob
1	0.239	0.239	152.66	0.000
2	0.208	0.160	268.69	0.000
3	0.111	0.034	301.72	0.000
4	0.064	0.003	312.79	0.000
5	0.173	0.148	392.46	0.000
6	0.101	0.029	419.57	0.000
7	0.142	0.071	473.57	0.000
8	0.101	0.028	500.67	0.000
9	0.047	-0.019	506.65	0.000
10	0.090	0.040	528.35	0.000
11	0.004	-0.048	528.39	0.000
12	0.014	-0.029	528.95	0.000
13	0.149	0.147	588.82	0.000
14	0.037	-0.030	592.43	0.000
15	0.110	0.046	624.97	0.000
16	0.024	-0.018	626.47	0.000
17	0.017	-0.011	627.27	0.000
18	-0.002	-0.046	627.28	0.000
19	0.043	0.056	632.28	0.000
20	0.014	-0.047	632.82	0.000
21	0.090	0.086	654.64	0.000
22	0.012	-0.036	655.03	0.000
23	0.042	0.011	659.83	0.000
24	0.002	-0.009	659.85	0.000
25	-0.004	-0.001	659.89	0.000
26	0.061	0.028	670.00	0.000
27	0.023	0.018	671.45	0.000
28	0.069	0.015	684.28	0.000
29	0.006	-0.028	684.37	0.000
30	-0.002	-0.015	684.38	0.000
31	0.003	-0.002	684.40	0.000
32	-0.001	-0.005	684.40	0.000
33	0.007	0.005	684.53	0.000
34	0.012	-0.023	684.90	0.000
35	0.024	0.039	686.48	0.000
36	0.029	-0.006	688.80	0.000

From the above, one can see that the results in the previous chapter did indeed suffer from heteroscedasticity. This adds to the justification to use a GARCH model for the measurement of the volatility of the spot prices. For the purposes of the study a GARCH(1,1) process was used. This is because, according to Hull (1999 : 372) the GARCH (1,1) is the most appropriate model for the analysis of volatility. This is in preference to the more general form of the GARCH model : the GARCH (p,q) model.

Figure 9.2 - Autocorrelation in the GARCH(1,1) ALSI Spot Volatility Data Set.

Sample: 5/04/1990 12/08/2000
Included observations: 2660

Autocorrelation	Partial Correlation		AC	PAC	Q-Stat	Prob
		1	0.017	0.017	0.7773	0.378
		2	-0.007	-0.007	0.9021	0.637
		3	-0.024	-0.024	2.4894	0.477
		4	0.003	0.004	2.5116	0.643
		5	0.037	0.037	6.2284	0.285
		6	0.018	0.017	7.1238	0.310
		7	0.026	0.026	8.9449	0.257
		8	-0.002	-0.001	8.9567	0.346
		9	-0.029	-0.028	11.238	0.260
		10	-0.021	-0.021	12.429	0.257
		11	-0.031	-0.032	14.987	0.183
		12	-0.026	-0.029	16.738	0.160
		13	0.127	0.126	59.765	0.000
		14	0.035	0.031	62.961	0.000
		15	0.025	0.028	64.645	0.000
		16	-0.015	-0.005	65.231	0.000
		17	-0.019	-0.015	66.164	0.000
		18	-0.028	-0.036	68.200	0.000
		19	-0.005	-0.013	68.281	0.000
		20	0.004	-0.009	68.318	0.000
		21	0.044	0.041	73.510	0.000
		22	0.004	0.010	73.560	0.000
		23	-0.016	-0.007	74.275	0.000
		24	-0.023	-0.009	75.724	0.000
		25	-0.031	-0.021	78.306	0.000
		26	-0.004	-0.022	78.346	0.000
		27	0.010	-0.002	78.610	0.000
		28	0.029	0.017	80.878	0.000
		29	-0.003	-0.004	80.909	0.000
		30	-0.012	-0.003	81.294	0.000
		31	-0.032	-0.019	84.099	0.000
		32	-0.022	-0.016	85.453	0.000
		33	-0.020	-0.019	86.557	0.000
		34	-0.002	-0.017	86.567	0.000
		35	0.016	0.008	87.272	0.000
		36	0.029	0.029	89.497	0.000

Using EViews the GARCH(1,1) model of the volatility in the spot prices was fitted over the period. It has been broken down into two distinct periods to help focus on the emerging market crises. EViews was also used to derive the parameters of the GARCH(1,1) model. The final GARCH(1,1) formula (as derived by EViews) is as follows:

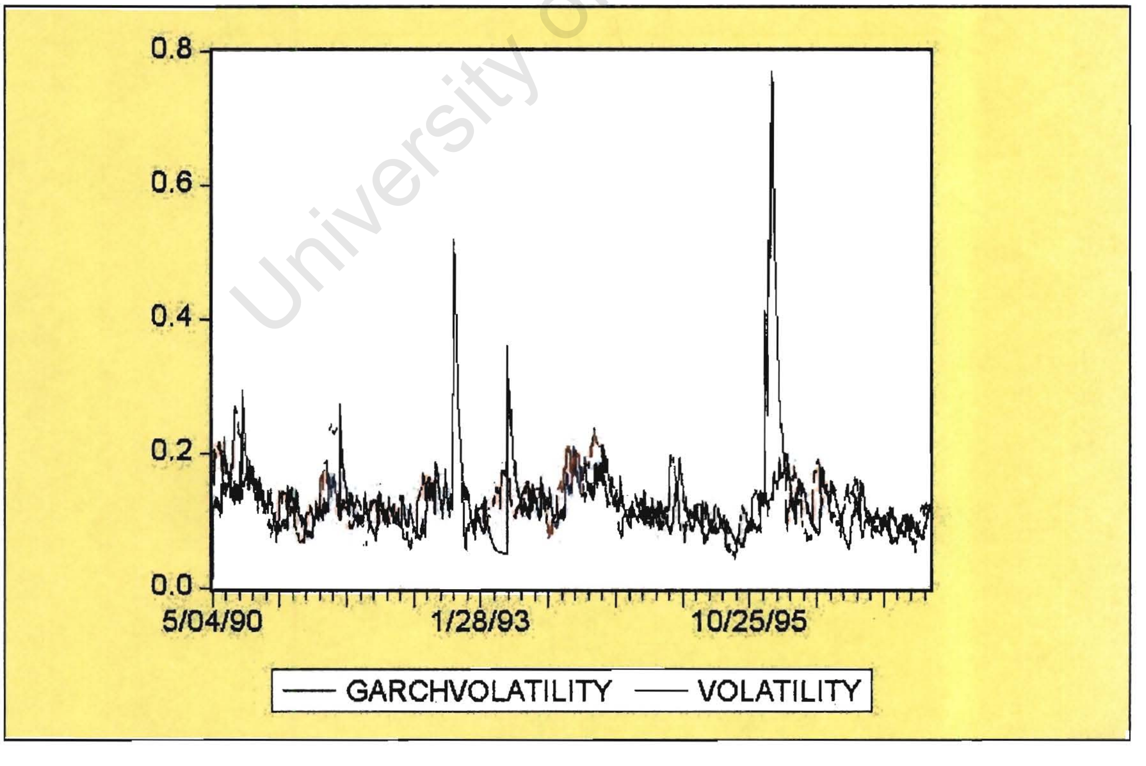
$$\sigma_n^2 = 8{,}42E^{0.7} + 0.081103u_{n-1}^2 + 0.921224\sigma_{n-1}^2 \qquad (54)$$

Once the GARCH(1,1) model has been justified, the analysis of the GARCH-determined volatility over the needs to be undertaken. This yielded the following results:

9.3.1 Period One: 4 May 1990 to 28 August 1997

The comparison between the traditional volatility and the GARCH(1,1) volatility can be seen in figure 9.3 below. The GARCH(1,1) volatility has more extreme movements and some of the market shocks of the period are picked up more clearly using the GARCH(1,1) volatility measurement. An example of this is the political shocks that destabilized the market at the end of 1992. These shocks are not that clear using traditional measurement techniques but stand out when one looks at the GARCH(1,1) model. The market rally, which occurred at the end of 1995, is not really picked up that clearly when one uses the traditional volatility technique, however, the GARCH(1,1) model picks it up visibly.

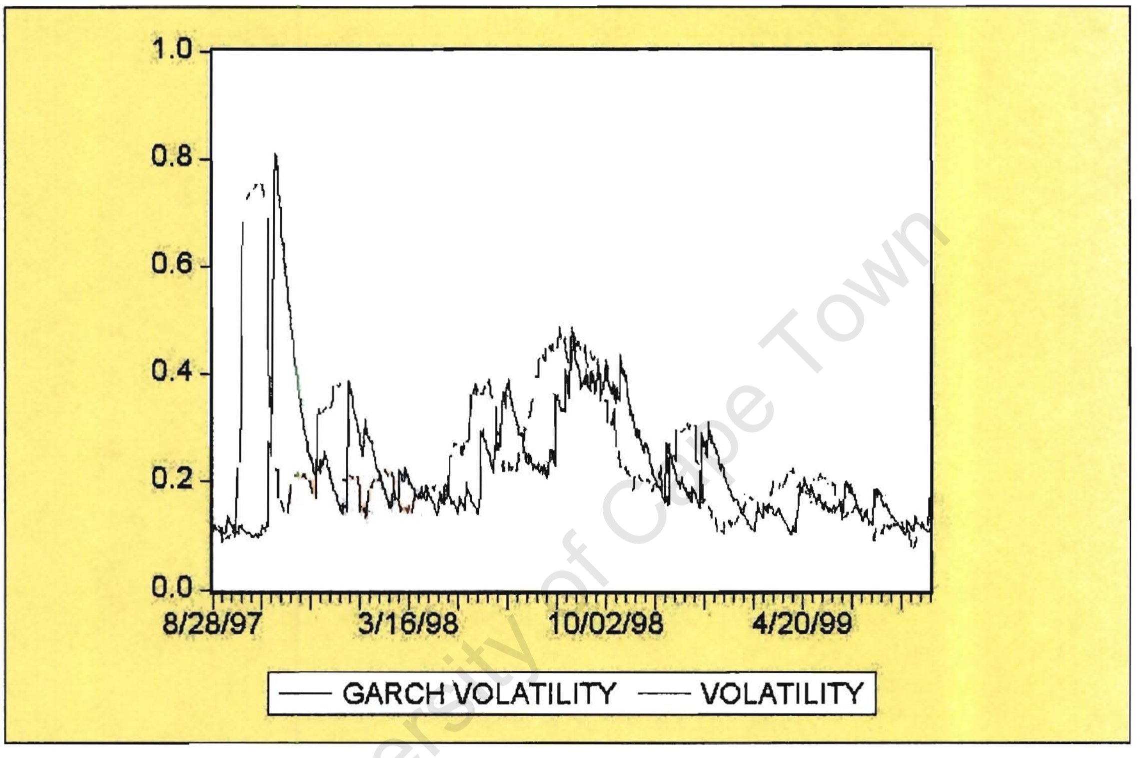
Figure 9.3 – GARCH(1,1) Volatility and Traditional Volatility from 4 May 1990 to 28 August 1997



9.3.2 Period Two: 28 August 1997 to 28 August 1999

The analysis for this period can be seen in figure 9.4 below. During this period the GARCH(1,1) volatility tracks the traditional volatility fairly closely but with a persistent lag.

Figure 9.4 – GARCH(1,1) Volatility of the ALSI from 28 August 1997 to 28 August 1999



From the above one can see that the market volatility spiked during the Asian crisis at the end of 1997. This compares favorably with the volatility calculated in the previous chapter. The traditional volatility also determined the Asian crisis to produce the highest market volatility. The GARCH(1,1) volatility is marginally higher when compared with the traditional methodology.

Surprisingly the volatility remains fairly low during the bulk of 1998 (Russian crisis). The volatility then picks up towards the time of the Brazilian crisis. This is not quite the same as the traditional volatility measures. The difference is that the increase in GARCH(1,1) volatility appears to occur after the pickup in the traditional volatility picks up.

On completion of the time series analysis of the GARCH(1,1) volatility model the next step is to determine the relationship between the GARCH(1,1) volatility data and the arbitrage gap.

9.4 Results.

The analysis of the relationship between the arbitrage gap and the underlying GARCH(1,1) market volatility was performed using the statistical analysis package EViews as in the previous chapter. The correlation between the arbitrage gap for each ALSI futures contract calculated in chapter eight and the GARCH(1,1) volatility of the underlying spot market was established at different time lags. Fifty different time lags were used, where each lag was increased by one day from the previous one. For the earlier futures contracts there were a limited number of observations and in some cases less than 50 lags could be calculated. The correlations were calculated and cross correlograms were produced for each lag. An example of this can be seen in figure 9.5 below, in this case the contract is the September 1998 ALSI futures contract. From figure 9.5 one can see that the maximum correlation for the September 1998 ALSI futures contract is 0.44 which occurs at a lag of 33 days. This means that GARCH(1,1) volatility occurring 33 days before has a 0.44 correlation with the size of the arbitrage gap. For each contract the highest correlations (and respective lags) were:

Table 9.1 – GARCH(1,1) Volatility of ALSI Spot / Arbitrage Gap: Highest Correlations over 50 Lags

Number	Contract	Highest Correlation	Lag (days)
1	Jun-90	0.59	1
2	Sep-90	0.75	3
3	Dec-90	0.62	25
4	Mar-91	0.70	50
5	Jun-91	0.47	32
6	Sep-91	0.73	12
7	Dec-91	0.57	36
8	Mar-92	0.36	47
9	Jun-92	0.47	46
10	Sep-92	0.75	11
11	Dec-92	0.62	0
12	Mar-93	0.16	33
13	Jun-93	0.67	2
14	Sep-93	0.55	50
15	Dec-93	0.40	34
16	Mar-94	0.45	6
17	Jun-94	0.66	19

18	Sep-94	0.60	12
19	Dec-94	0.36	1
20	Mar-95	0.16	49
21	Jun-95	0.44	18
22	Sep-95	0.35	1
23	Dec-95	0.31	36
24	Mar-96	0.33	50
25	Jun-96	0.54	50
26	Sep-96	0.44	15
27	Dec-96	0.37	48
28	Mar-97	0.45	50
29	Jun-97	0.21	1
30	Sep-97	0.24	35
31	Dec-97	0.36	2
32	Mar-98	0.28	1
33	Jun-98	0.52	33
34	Sep-98	0.44	33
35	Dec-98	0.57	50
36	Mar-99	0.21	50
37	Jun-99	0.66	50
38	Sep-99	0.25	30

The above table shows that the highest correlations are not particularly significant, even when one takes different lags into account. This is similar to the findings of the traditional volatility model. The above table illustrates that the only significant correlations are pre March 1994, which was ignored in the previous chapter as the number of observations per contract was not enough to allow for robust conclusions to be drawn. The individual correlograms are included in the appendix (see appendix 9.2). A general comment is that, even though the individual correlation scores are not significant to allow one to draw a conclusion that the arbitrage gap and the GARCH(1,1) volatility is related, the GARCH(1,1) volatility has, on average, higher correlation data points at the different lags when compared to the traditional volatility measurement.

For correlations in excess of 0.6 a regression was performed to confirm the above findings where the GARCH(1,1) volatility of the spot was regressed against the arbitrage gap for the respective futures contract. As mentioned above, this was only done for the contracts after March 1994. In the case of the above this was applied to the June 1994, September 1994 and the June 1999 contracts. The regressions are presented in table 9.2 below. In the case of the June 1994 contract the R Squared was calculated to be 0.002 while the September and June R Squared's were calculated to be 0.11 and 0.01 respectively. This confirmed the fact that any relationship between the underlying GARCH(1,1) volatility of the spot / futures prices and the spot futures arbitrage gap is not particularly significant.

Figure 9.5 – September 1998 Correlogram between the Arbitrage Gap and the underlying GARCH(1,1) volatility.

Sample: 5/04/1990 12/08/2000
Included observations: 246
Correlations are asymptotically consistent approximations

SEP98,GARCHVOLATILIT	SEP98,GARCHVOLATILIT	i	lag	lead
		0	0.1411	0.1411
		1	0.1664	0.1349
		2	0.1725	0.1401
		3	0.1602	0.1371
		4	0.1548	0.1416
		5	0.1816	0.1564
		6	0.1686	0.1698
		7	0.1529	0.1972
		8	0.1544	0.2206
		9	0.1547	0.2417
		10	0.1433	0.2394
		11	0.1454	0.2396
		12	0.1536	0.2522
		13	0.1379	0.2469
		14	0.1264	0.2463
		15	0.1431	0.2456
		16	0.1593	0.2321
		17	0.1622	0.2142
		18	0.1608	0.2205
		19	0.1677	0.2189
		20	0.1644	0.2174
		21	0.1679	0.2197
		22	0.1780	0.2400
		23	0.1904	0.2678
		24	0.1821	0.2654
		25	0.1817	0.2877
		26	0.1902	0.3265
		27	0.1784	0.3629
		28	0.1756	0.3917
		29	0.1711	0.4282
		30	0.1762	0.4314
		31	0.1854	0.4114
		32	0.1931	0.4166
		33	0.1947	0.4402
		34	0.1884	0.4295
		35	0.1782	0.4116
		36	0.1759	0.3998
		37	0.1813	0.3893
		38	0.1821	0.3709
		39	0.1820	0.3616
		40	0.1817	0.3493
		41	0.1678	0.3257
		42	0.1645	0.3090
		43	0.1661	0.2872
		44	0.1594	0.2619
		45	0.1428	0.2466
		46	0.1413	0.2402
		47	0.1434	0.2272
		48	0.1181	0.2164
		49	0.0966	0.1930
		50	0.0677	0.1686

Table 9.2 - Regression Analysis for the June '94, September '94 and June '99 ALSI40 Futures Contracts between their underlying GARCH(1,1) Spot Volatility and their Arbitrage Gaps.

Dependent Variable: **JUN94**
Method: Least Squares
Sample(adjusted): 4/05/1994 6/15/1994
Included observations: 46
Excluded observations: 26 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	8.413763	45.72196	0.184020	0.8548
GARCHVOLATILITY	92.14307	283.7345	0.324751	0.7469

R-squared	**0.002391**	Mean dependent var	23.12724
Adjusted R-squared	-0.020282	S.D. dependent var	41.27075
S.E. of regression	41.68717	Akaike info criterion	10.34077
Sum squared resid	76464.08	Schwarz criterion	10.42027
Log likelihood	-235.8377	F-statistic	0.105463
Durbin-Watson stat	0.562870	Prob(F-statistic)	0.746909

Dependent Variable: **JUN99**
Method: Least Squares
Sample(adjusted): 7/09/1998 6/17/1999
Included observations: 230
Excluded observations: 114 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-17.44029	9.564483	-1.823443	0.0695
GARCHVOLATILITY	-52.12510	37.74668	-1.380919	0.1687

R-squared	**0.008294**	Mean dependent var	-29.74314
Adjusted R-squared	0.003945	S.D. dependent var	52.87116
S.E. of regression	52.76677	Akaike info criterion	10.77830
Sum squared resid	634827.8	Schwarz criterion	10.80819
Log likelihood	-1237.504	F-statistic	1.906936
Durbin-Watson stat	0.154373	Prob(F-statistic)	0.168656

Dependent Variable: **SEP94**
Method: Least Squares
Sample(adjusted): 4/05/1994 9/15/1994
Included observations: 112
Excluded observations: 52 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-97.27184	24.68947	-3.939811	0.0001
GARCHVOLATILITY	680.5085	180.2898	3.774525	0.0003

R-squared	**0.114667**	Mean dependent var	-6.204436
Adjusted R-squared	0.106619	S.D. dependent var	58.67885
S.E. of regression	55.46258	Akaike info criterion	10.88699
Sum squared resid	338370.8	Schwarz criterion	10.93553
Log likelihood	-607.6714	F-statistic	14.24704
Durbin-Watson stat	0.643646	Prob(F-statistic)	0.000260

9.4.1 Comments on Volatility during the Crises.

Looking at the correlograms of the ALSI40 futures contracts over the period 28 August 1997 to 28 August 1999 (see appendix 9.2) one does not notice any significant events or correlations. This is the same as what was found when the Traditional volatility examination was performed. The September 1997 contract has 5 lags where the correlation between the spot volatility and the arbitrage gap is greater than 0.6. This does not necessarily show any relationship between the two variables. The December 1997 and March 1998 contracts have slightly higher correlations than in the case of the traditional volatility correlations, the main difference is that the correlations vary between the different time lags more I the case of the GARCH calculated correlations. The June and September 1998 contracts have higher correlations for the first 15 lags. As the lags increase the correlation decreases, this is directly contrary to the findings of the traditional model in which one observes the opposite occurring. The December 1998 correlograms shows the correlations increasing over the different lags. As in the case of the previous contracts, there does not seem to be a relationship between the GARCH(1,1) volatility of the underlying spot and futures prices and the arbitrage gap calculated in chapter eight for the contracts which existed during the period of the emerging market crises.

9.5 Conclusions.

As in the previous chapter, the use of the GARCH(1,1) model to calculate volatility has not yielded any significant relationship between the market volatility and the arbitrage gap. The results derived from the use of the GARCH(1,1) model suggests that there is a closer relationship between volatility and the arbitrage gap even though it is difficult to comment on the closeness of this relationship.

These findings, as in the previous chapter, do seem counterintuitive, as a reasonable expectation would be that periods of high volatility result in a break down in established pricing mechanisms (such as the spot / futures cost of carry model). Again, one could argue that the above findings do support an alternative theory – that there is another factor that leads to the opening and closing of the arbitrage gap that has a greater effect than the volatility of the underlying share / futures prices. As suggested before, the alternative factor outlined in chapter eight could be the missing variable – the liquidity in the underlying stock lending market.

Chapter 10: Implications of Findings.

The findings of this study do have some implications for the capital markets. The implications have been treated on a finding-by-finding basis (only the significant findings have been focused on):

1. There are index arbitrage trading opportunities in the South African Markets.

This implies that the South African index futures are not priced correctly. This could have implications for the hedging effectiveness of the South African financial markets. The implications should also be examined against a backdrop of how potential inefficiencies are removed. In order to remove the pricing efficiencies one should be able to conduct index arbitrage using all the constituents of the underlying index. In order for this to take place there either needs to be a creation of an effective and efficient "basket" market where one can buy and sell the constituents of an index as a basket of stocks, thereby avoiding timing problems of trying to assemble an index position over a period of time and the resultant transaction costs, or a liquid, high volume Exchange Traded Funds (EFT) market. There is not a great deal of evidence of a basket market, however, there is an emerging EFT market in South Africa with the creation of the SATRIX40 market. An implication of this study is that there is a profitable opportunity for an active ETF market in South Africa.

There are thus pricing inefficiencies in the local index futures markets. This is not a reflection on the effectiveness and efficiency of the market, rather it shows there is a need for products that allow for practical index arbitrage to take place.

2. The index arbitrage opportunities are greater for the reverse cash and carry strategy.

This finding results in interesting implications and to ascertain what these are one needs to look closely at the reverse cash and carry strategy. Clearly, one of its mechanisms are failing and as the cash and carry strategy is becoming more efficient, it must be a leg of the transaction that the cash and carry strategy does not have – securities lending.

In the case of the cash and carry strategy one also needs to purchase and sell a basket of shares that constitute the underlying index as one would need to do in the case of the reverse cash and carry strategy. The primary difference between the two strategies is the securities lending component. The persistence of the reverse cash and carry arbitrage gap suggests that the securities lending market is not functioning correctly. This implies that there are profitable opportunities in this regard. This is explored further in the conclusion.

3. The cash and carry opportunities have been decreasing over the past few years.

With the cash and carry opportunities decreasing over the past few years, this implies that the index futures market is being priced correctly through increased activity. This is supported by the increase in volumes traded (of both the futures contracts (Swart, 1998 : 53) and the spot market) and the increased participation of both niche financial services companies and foreign banks in our local capital markets.

4. There were market volatility spikes during the emerging market crises.

The implications of this finding is that the South African Futures and Equity markets were adversely affected by the emerging market crises. This finding is not necessarily ground breaking, it confirms the opinions that were presented in the financial and popular press. This implies that South Africa is increasingly becoming a member of the global capital markets and is thus affected by movements in foreign markets.

5. There is seemingly little or no relationship between market volatility and futures pricing efficiency.

The result of the study as to whether market volatility affected the arbitrage gap and therefore the pricing efficiency of the equity and equity futures markets showed that there seems to be little or no relationship between volatility and pricing efficiency. At best, there is a relationship that is not significant and is difficult to measure.

The implications of this are that, even though our markets seemed to fail the efficiency test during the crises, the reason for this is unclear and is not likely to be due to increased volatility. This implies that there is some other variable affecting the pricing efficiency of the equity spot and futures markets.

One implication of the above findings is that the market's pricing efficiency seemed to handle volatility spikes – when the volatility spikes occurred the pricing efficiency did not necessarily break down. This suggests that further work needs to be done in this area to determine what the destabilizing variable may be.

The above implications seem to support a view that the market is inefficient from time to time, but the reasons for this are possibly not directly attributed to the market or its mechanics, but rather as a consequence of other external factors.

Chapter 11: Conclusions

In answer to the question posed by this study "does volatility impact on the pricing efficiency of the South African Futures Exchange" there is no evidence of the volatility having a significant impact on the pricing efficiency. While this does not rule out some relationship between the two variables, the relationship is not significant.

As speculated above, this begs the question: "what drives the movements in the arbitrage gap for the index futures?" It was suggested that the answer could lie in the products supporting the primary capital markets, specifically stock lending and exchange traded funds. In this regard further research should be done in the area of liquidity in the securities lending market and how this impacts on the execution of the reverse cash and carry arbitrage strategy and consequently the pricing efficiency of the futures market. Further research should also be done on the ETF funds (which currently comprise SATRIX40), the volumes traded and liquidity and use by institutional traders. The volumes could be compared to the open interest on the Futures Exchange to determine how much, if at all, of the SATRIX40 is used in index arbitrage. This could be further augmented by an investigation into the existence of a "basket" trading market.

One can conclude that the South African Index Futures Market is inefficient but the efficiency is constantly increasing to the point where the current market does not allow for many cash and carry arbitrage trades. This leads one to further conclude that the South African Equity and Equity Futures markets are constantly improving in terms of efficiency which will allow for more accurate hedging and actively traded markets as the fair value pricing mechanism can be more relied on.

The market volatility did increase during the emerging market crisis and one should be able to conclude that as the shocks occurred, notably the Asian crisis, the market's pricing mechanism remained stable. This could lead one to conclude that the South African equity and equity futures market absorbed the market shocks with little adverse effects. Where the market's efficiency did suffer was where the market instability persisted, as in the case of 1998 where the Russian and Brazilian crisis occurred. One must note that the volatility peaked in October 1997 – at the time of the Asian Crisis – and was lower during 1998, which is in contrast to the pricing efficiency that remained intact during the Asian crisis but deteriorated during 1998. GARCH(1,1) appeared to model volatility more accurately than the traditional volatility measure. This also showed a marked increase in the average volatility levels from pre 28 August 1997 to post 28 August 1997. The average volatility levels approximately doubled between the two periods.

One aspect of the market that was not taken into account in this investigation was market liquidity. As identified by Swart (1998 : 66), an investigation into liquidity could shed some light on the changes in volatility and market efficiency. A study into the area of market liquidity would thus be an area for further research.

Further work also needs to be done on the efficiency measurement using actual dividends rather than a dividend yield. As the futures pricing mechanism is based on the time value of money, the timing of dividends is important and the dividends should not be spread on an annual basis. This could yield alternative results on the efficiency of the futures market.

Ultimately one can conclude that the South African futures market is efficiently priced, but with persistent market instability the reverse cash and carry arbitrage trade breaks down thereby causing periods of inefficiency. The market instability is characterized by higher long-term volatility and, even though there is no significant relationship between market volatility and pricing inefficiency, there appears to be a weak relationship between long-term volatility (persistent market instability) and the efficiency of the pricing mechanism.

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Appendices

Appendix 1.1 – Financial Services Companies Listed on the JSE at 31 October 1999.

Banks Sector

Short Name	Listed 31/10/99	Listed 1/1/95
ABSA	Yes	Yes
BOE	Yes	Yes
FBC FIDELITY	Yes	Yes
FIRSTRAND	Yes	Yes
INVESTEC	Yes	Yes
MERCANTILE	Yes	No
NEDCOR	Yes	Yes
NRB	Yes	Yes
REGAL	Yes	No
SAAMBOU	Yes	Yes
SARB	Yes	Yes
SIB	Yes	Yes
STANBIC	Yes	Yes

Financial Services Sector

Short Name	Listed 31/10/99	Listed 1/1/95	Short Name	Listed 31/10/99	Listed 1/1/95
ALEXFBS	Yes	No	IOTA	Yes	No
AMB	Yes	No	NAIL	Yes	Yes
APPLETON	Yes	No	NIBH	Yes	No
ARCAY	Yes	No	OUTSORS	Yes	No
BJM	Yes	No	PERGRIN	Yes	No
BRAIT	Yes	Yes	PSG	Yes	Yes
CADIZ	Yes	No	PSGINVBANK	Yes	No
COROHLD	Yes	Yes	QUYN	Yes	No
CREDCOR	Yes	No	RAD	Yes	No
DECILLION	Yes	No	SASFIN	Yes	Yes
EQUINOX	Yes	No	SOLUTNS	Yes	No
FINSHARE	Yes	No	TBBH	Yes	No
FURNCAP	Yes	No	THUKANI	Yes	No
GENSEC	Yes	No	TIGON	Yes	No
GLENMIB	Yes	No	TISEC	Yes	No
GLOBAL	Yes	No	UNIFER	Yes	No
GREENWICH	Yes	No			
HEDGE	Yes	No			
INCENT	Yes	No			

Appendix 1.2 - Detailed list of Definitions

ADVANCE/DECLINE RATIO: This is a ratio that is calculated by dividing the difference between the total number of shares that have increased in value and the total number of shares that have decreased in value, by the total number of shares that have been traded that day.

ALL-IN-PRICE: This is the actual price paid for a bond or gilt (or other interest based instrument). It is calculated from the yield-to-maturity (YTM), and consists of the clean price plus accrued interest.

ALSI: All share index. SAFEX provides futures on this index, the specifications of which are discussed in chapter 3.1.

ASK PRICE: This is the price at which a seller is prepared to part with his shares or contracts (also known as the OFFER PRICE). The BID PRICE and ASK PRICE together make up the DOUBLE in the futures market. (SAFEX, 1999 : 2)

AT BEST: An instruction given to a broker by the client to sell or buy "at best" would give the broker freedom to purchase or sell the instrument concerned at the price most advantageous to his client as soon as possible. (SAFEX, 1999 : 2)

AVERAGE COST: This is a method of valuing assets at the average of their cost price. A simple average is performed by totaling the cost of the assets and dividing by the number of assets purchased.

BASIS: In the case of the futures market, basis describes the difference between the price of a future and the spot price of the underlying asset. For example, if the ALSI is at a level of 8500 index points and the ALSI future is trading at 9000 the basis is 500 points (see below for the definition of a point).

BASIS POINT AND POINTS: Points are associated with bonds and gilts a basis point is equal to one-hundredth of one percent. However, a point can also describe an index unit, so where an index moves from 8000 to 8050, this can be described as a movement of 50 points.

BASIS RISK: The risk that the BASIS will move against the position held, thereby reducing the profit for a speculator or the effectiveness of a hedge. A speculator who is long an index future with a 50 point positive basis does not benefit if the underlying asset goes up by ten points while the basis narrows by ten points (i.e. the futures price does not rise with the index). (SAFEX, 1999 : 3)

BEAR: An investor or speculator (or other market participant) who looks to profit from downwards movements in prices. A bear can be a participant who also expects downward movements in prices.

BEAR MARKET: This term is given to markets where either the main index is dropping or the majority of the share prices are dropping.

BEAR RAID: Where investors who have sold short (made bear sales) attempt to force the price of a share down by making further bear sales so that they can cover their positions profitably at lower prices. (SAFEX, 1999 : 3)

BEAR SALE: This is known also as a short sale and involves selling shares before they have been purchased. The form of the sale is an agreement to sell the shares at an agreed future date. The seller looks to profit by waiting to purchase the shares before delivery has to take place, at a price lower than the agreed selling price. Bear selling was originated by the Eskimos who used to sell polar bear skins to European traders. The demand for polar bear skins varied depending on whether they were fashionable or not. The Eskimos, realising this, took the opportunity when the demand for skins was strong to sell not only their current stock of skins, but also their next hunting trip's skins. In this way they actually sold the skins of polar bears that they had not yet killed to take advantage of the higher prices. (SAFEX, 1999 : 4) Bear or short sales can be created synthetically with the use of securities lending. Here the trader will borrow shares, sell them into the market, buy them back at a later lower price, and deliver them back to their owner, profiting on the drop in the price of the shares.

BID PRICE: When a buyer tenders a price for a share, future, or any other instrument, the price of this tender is known as the bid price.

BPV: BPV is short for "Basis point value", which is the Rand value of one basis point change in the yield of the security. (SAFEX, 1999 : 6)

BULL: This is an individual who has an optimistic outlook for the market, a share or contract.

BULL TREND: A bull trend is an upward trend in the market, share or contract. This is on contrast to a bear trend, which is a downward trend.

BUY PRICE: The buy price is the price of the buy offer closest to the last trade of the day that is published in the financial press. This is different to a bid offer as it is the last bid offer of the day, which is closest to the last traded price.

CARRYING CHARGE MARKET: A futures market in which farther dated contracts trade at successively higher prices, so called because this conforms to the theoretical model in which the premium of the futures price over the spot price should increase the longer the time to expiry due to the increased carry costs. (SAFEX, 1999 : 8)

CARRY RATE: This is the cost, per day, of holding an asset. This cost is the basis for the "Cost of Carry" futures pricing model. This cost will include opportunity costs such as interest foregone.

CASH MARKET: This is an alternative for the spot market and is the market for the underlying asset in a futures contract. The spot market for the ALSI future would be the Johannesburg Stock Exchange.

CBOT: The Chicago Board of Trade, the oldest and largest futures exchange in the world. (SAFEX, 1999 10)

CLEAN PRICE: The clean price of a gilt or bond is the present value of the redemption value of the principal plus the present value of the periodic compound payments over the remaining life of the bond. The all-in-price is the clean price plus the accrued interest. (SAFEX, 1999 :10)

CLEARING HOUSE: A clearing house is responsible for the matching of all trades. In a futures market this function is extended to include the daily marking-to-market of each open futures position. The clearinghouse associated with SAFEX is called SAFCOM.

CLOSE OUT: This is the "exiting" of a position by a market participant. This is usually done by taking an equal but opposite trade to the one the trader is currently exposed to. This has the effect of locking in any profits or losses that the trader has made. This action is necessary, as, unlike in the share markets, the future cannot be sold as it is a contract. The trader will then enter into an opposite contract. This has the effect of canceling the trader's position and thus simulated the "sale" of the contract.

CLOSING PRICE: The closing price is the price of the last trade at the end of the trading day. This is also known as the "ruling" price or "last" price. Technically there are differences as the ruling or last prices are adjusted in the case where the last buy offer is higher than the closing price or the sell offer is lower than the closing price. These prices are quoted in the financial press.

CME: Chicago Mercantile Exchange.

COMEX: Commodity Exchange Inc.

CORRECTION: This occurs where a price trend is broken temporarily with a movement in price, in the opposite direction to the direction of the trend. It is traditionally associated with a temporary drop in prices when the overall trend is an increase in prices.

DAILY LIMIT: A limit imposed by certain exchanges on the extent to which a particular instrument can move in one day. (SAFEX, 1999 :13). This is designed to protect market participants from both default and irrational behavior in the markets. If the price move exceeds the limit, trade in the instrument is suspended. Due to the high initial margin called for in our market SAFEX has not felt it necessary to impose daily limits.). SAFEX, 1999 : 13)

DAY ORDER: When placing an order the trader has to put a time limit of the filling of the order. A day order is an offer that is set to expire by the end of the trading day during which time it was made.

DELIVERY DATE: When an instrument or commodity is sold, this is the date upon which it must be delivered to the buyer. In the case of futures, delivery often does not occur and market participants will settle the net price gain or loss with their counterparts. This also happens on the delivery date and thus the delivery date is also known as the settlement date.

DGLD FUTURE: A future on the dollar price of gold, which was discontinued in 1994. The contract specification was R100 times the dollar price of gold with a margin requirement of R1,600 per contract. The contract was replaced by the Krugerrand Future (KRND). (SAFEX, 1999 : 15)

DOUBLE: This is another term for the "bid offer spread". This refers to the difference between the closest buy offer and sell offer. Collectively these are often referred to as the double. The double, or bid-offer spread is related to the liquidity of the underlying instrument. The more liquid the instrument the smaller the double.

ELCI: Equity-linked cash instrument issued by Eskom. (SAFEX, 1999 : 17)

ELFI: Equity-linked fixed-interest stock.

FINANCIAL FUTURE: Essentially this instrument is a future that, has as its underlying instrument, a financial asset such as a share. This is in contrast to a future which has as its underlying a commodity.

FORWARD CONTRACT: The difference between a forward and a future is the future is a standardised contract traded on a recognised exchange. A forward agreement is an agreement between two parties to transact in the future (like a futures contract) however, the agreement can be to transact in anything. This non-standardisation leads to difficulty when one of the parties looks to close out the agreement by entering into another opposite agreement.

FORWARD PRICE: The price at which the future delivery of the underlying instrument or commodity has been agreed to.

GLDI: SAFEX's All-Gold Index future, based on the JSE's All-Gold index (SAFEX, 1999 : 22)

HEDGE: When a market participant purchases or sells a security that is the opposite to an existing position so as to reduce the risk that the market participant is exposed to, this is known as Hedging. This has the effect of reducing the price risk in the open position. Hedging typically occurs when a market participant is exposed to a security which he or she has no desire to sell or buy (in the case of a short position), but is of the opinion that temporary adverse price movements are to occur. A hedge will be entered into to avoid this.

HEDGE RATIO: The proportion of futures contracts or of the underlying asset required to hedge an open position. The need for the hedge ratio derives from the fact that the price movements in spot and derivative markets are not exactly matched. (SAFEX, 1999 : 23).

HEDGER: This is the individual who engages in hedging. Hedgers are market participants who wish to reduce risk by hedging and can range from fund managers to farmers (in the case of farmers, the underlying security will be a commodity).

INDI: SAFEX's Industrial Index future, based on the JSE's Industrial index. (SAFEX, 1999 : 24)

INITIAL MARGIN: Initial margin is the margin required by the broking firm before a futures position can be entered in to. This margin as adjusted daily as the future price changes. These changes are dealt with as variation margin.

INVERTED MARKET: A futures market in which the near-dated contract is trading at a higher price than farther dated contracts (considered "abnormal"). (SAFEX, 1999 : 25)

KRND FUTURE: Kruger Rand futures are contracts to deliver Kruger Rands at some time in the future. The Kruger Rand Futures was launched in 1994 (SAFEX, 1999 : 26) and is the first South African futures contract to allow for physical delivery. Kruger Rand futures were the first of their kind and result in the actual delivery of the underlying commodity.

LIFFE: London International Financial Futures Exchange.

LONG: A long position is where a market participant has purchased a security and aims to profit from the increase in the price of the security. Where a market participant is "long" a future the individual is contracted to purchase the underlying securities at an agreed rate at some date in the future.

LONG HEDGE: The purchase of derivatives in anticipation of (a) future cash flows and (b) a rise in the price of the underlying asset. The long hedge therefore allows a portfolio manager to lock in current prices in a rising market before he has the funds to take a position in the underlying asset. (SAFEX, 1999 : 28)

MARK-TO-MARKET: This occurs at the end of each trading day. The profits or losses on each market participants trading accounts are calculated and the clients are either given their profits or required to make good their losses. All changes (that is, cash flows) occur through the margin account. This mark-to-market process exists in order to ensure that market participants are able to meet their liabilities that may arise due to adverse price movements. If this mechanism was not in place, a trader could find, after a few days, that the losses would be so large that default would occur – the trader would not be able to meet his or her obligations arising from the losses. The exchange would then face risk of failing as participants lost confidence in it.

MARKET MAKER: A market maker is a market participant who will offer to buy or sell a given security and thus ensure its liquidity. The Market maker is usually a member of the exchange. Market makers expose themselves to price risk by trading and thus will compensate themselves for taking on this risk by keeping a wide spread between the prices at which they are prepared to buy and sell. Market makers try to reduce the price risk they experience by ensuring they buy as much as they sell.

MARKETABLE SECURITIES TAX (M.S.T.): A tax levied on all purchases of shares and other securities, which stands at 0.25% of the value of the transaction (SAFEX, 1999 : 29). M.S.T. was replaced with U.S.T. (Uncertified Securities Tax) in 1999. The rate and tax mechanism, however, remained the same.

NEGOTIABLE CERTIFICATE OF DEPOSIT (N.C.D.): An N.C.D. is issued by banks that wish to raise funds. It is a fixed deposit that is actively traded. It is the same as a treasury bill, but issued by banks. The secondary market for N.C.D's is the money market where N.C.D's are traded between money market participants. An N.C.D. is a short-term deposit and interest is usually paid in six-month installments. In the event of the N.C.D. having a term of less than one year the interest is usually paid on maturity.

NET CARRY COSTS: These costs are the costs of holding a security or commodity. These costs include storage and insurance costs (in the case of a commodity) and the interest that one is unable to earn while one's cash is invested in the commodity or instrument (opportunity cost). Against this cost, one nets off the realised benefit of holding the instrument. This will be interest or dividends, or other cash inflows the investor will receive while holding the instrument or commodity. Once the net off has taken place one is left with the net carrying costs.

NOMBI: Market shorthand for the Notional Medium Dated (five year) bond future. This FCO instrument traded for eighteen months but was discontinued in 1989 due to poor liquidity. (SAFEX, 1999 : 32).

NOTIONAL CONTRACT: When a futures contract is based on an instrument that does not exist it is known as "Notional". Delivery of the underlying cannot occur and thus the final settlement between the two parties involved in the trade is on a net basis. The concept of a notional contract is most often encountered in the area of bond derivatives where the notional bond is based on a selection of bonds. This collection of a number of securities to form a future is how the index-linked future is structured. The index cannot be delivered, a notional contract can. This index contract is thus notional.

OFFER PRICE: Where bid is the price a market participant is willing to buy at, the offer price is the price the market participant is willing to sell at.

OFFSET: Positions in the futures and options market are not on-sold in the secondary market; rather, a trader offsets a position by entering into an exactly opposite contract. A long call is closed out by selling an equivalent call; a long futures position is offset by the sale of the same contract. (SAFEX, 1999 : 33)

OFFSET MARGIN: Where a trader has opposite exposure to contracts that are similar, the trader's risk is reduced. This traditionally occurs most in the case of contracts of different maturities or contracts on similar underlying assets. This opposite exposure will serve to reduce the need for margin. The exchange will often allow the margin requirements to be relaxed in these cases. SAFEX allows offset for margin calculating purposes where the trader has opposite positions in similar contracts of different maturities (calendar spreads) or contracts where the underlying instruments are similar (inter series spreads). An example of this would be where the trader has a contract to buy the INDI and a contract to sell the ALSI. To some extent the trader is reducing risk – this is similar to the situation where the trader buys and sells the same security, which reduces risk. The reason for the reduced risk is that some of the equities in the INDI will also be in the ALSI, as well as the fact that the movements in the INDI should be correlated with movements in the ALSI.

OPEN INTEREST: If a party enters into a futures contract to buy the underlying in the future without a corresponding seller, this is known as an open position. The same holds for a seller of a futures contract – if there is no corresponding buyer the contract is open. The "open interest" is the accumulation of all these open positions for each contract at each maturity date. As a contract is closed out the open interest will be reduced by one.

PRINCIPAL: The market participant who accepts the risk of holding the security is known as the principal. This is in contrast to agents who will not accept risk and hold securities on behalf of a third party.

PHYSICALS: When a futures contract matures, settlement can occur in different ways. One way is to actually deliver the underlying commodity or instrument. This is known as physical delivery and consequently, when this occurs the settlement is known to be a "physicals" settlement. It is important to note that this term does not only govern commodities. There may be a case where a futures contract on a specific share will result in the physical delivery of the share certificates at maturity.

REPO AND REPO RATE: A repurchase agreement (repo) refers to the case where an organisation needs cash and "sells" securities to a lender who will "purchase" the securities on the promise that the securities will be repurchased by the "seller" at a future date. The repo rate is the rate of interest on a repo transaction.

SERIES: In the context of the futures markets, this term refers to the different maturities of a specific futures contract. For example, the March, June, September and December maturities of the Industrial Index (INDI) future will be collectively known as the INDI series.

SETTLEMENT: This occurs at the maturity of the futures contract. Where the futures contract has not been closed out and is allowed to mature, either delivery of the underlying instrument(s) must take place or a net cash settlement must occur, at maturity. In the cash of a notional underlying, delivery cannot take place and the settlement must take the form of a net cash payment between the parties.

SETTLEMENT DATE: The date on which a transaction is given effect and on which payment and delivery takes place. In the gilts market, for example, settlement takes place on the second Thursday after the transaction is executed. Share Index Futures are settled on the 15th (or next business day) of March, June, September, and December. (SAFEX, 1999 : 43)

SETTLEMENT PRICE: This is the price that is used for settlement purposes. The price is usually the price at the close of trade on the maturity date of the futures contract. In some cases this is calculated with the use of a formula. This is done so as to stop market participants manipulating the price in the last trading session on the maturity date and thus influence the amounts used in settlement.

SETTLEMENT RISK: This risk is similar to default risk in that it deals with the risk of the counter party not performing as per the contract in discharging their obligations. More specifically, it is the risk that the counter party to a deal will not be able to settle as agreed to in the futures contract. Settlement risk is negligible when one uses an organised exchange such as SAFEX.

SHORT: A short position is where a market participant has sold a security and aims to profit from the decrease in the price of the security. An important fact to note is that the short seller does not own the shares when the sale takes place. The short seller hopes to sell the security at a price (without delivering it), wait for the price to drop, purchase it (for less) and deliver it against the original sale. This has the effect of the short seller profiting from the drop in the price of the security. A short seller thus has a bearish view of the security. Where a market participant is short a future the individual is contracted to sell the underlying securities at an agreed rate at some date in the future.

SPREAD: There are two possible definitions of a spread. The most common is the difference between the bid and offer prices (see double above). The other definition of a spread is where a future of one maturity is purchased and another, at a different maturity is sold. This, as will be seen lower, is another form of arbitrage. It is not, however, arbitrage in the strictest sense, as there is an element of risk in the trade.

TICK: A short horizontal strike on a bar graph, showing the price at which the share closed within the trading range. (SAFEX, 1999 : 49)

TRADING SESSION: SAFEX does not impose trading hours on the futures market, and deals are sometimes concluded as early as 7:00 am or as late as 8:00 pm. (SAFEX, 1999 : 50)

VARIATION MARGIN: Where initial margin is required to enter into a futures trade, variation margin is the cash flow that must occur when a trader incurs losses and must pay into the margin account in order to keep the position open. As described in the mark-to-market process above, the daily profits or losses a trader experiences are adjusted through the margin account. Where the market participant makes a profit, he or she is able to take funds out of the margin account. Where a loss is incurred funds must be paid in. This is variation margin.

Appendix 3.1 – SAFEX Contract Specifications.

The following are the specifications of the SAFEX-listed futures contracts at the end on 1999. All information has been supplied by SAFEX.

Part 1: Index futures.

Futures Contract	All-share Index	Industrial Index	Mining Index	Financial Index
Code	ALSI	INDI	RESI	FINI
Underlying Instrument	JSE Actuaries Top 40 Companies All share Index	JSE Actuaries Top 25 Companies Industrial Index	JSE Actuaries Top 20 Companies Resource Index	JSE Actuaries Top 15 Companies Financial Index
Contract Size	R10 x Index Level	R10 x Index Level	R10 x Index Level	R10 x Index Level
Expiry dates and times	16h00 on 3rd Thursday of March, June, September and December (or previous business day)	16h00 on 3rd Thursday of March, June, September and December (or previous business day)	16h00 on 3rd Thursday of March, June, September and December (or previous business day)	16h00 on 3rd Thursday of March, June, September and December (or previous business day)
Quotations	Index Level (no decimal points)	Index Level (no decimal points)	Index Level (no decimal points)	Index Level (no decimal points)
Minimum price movement (tick)	One index point (R10)	One index point (R10)	One index point (R10)	One index point (R10)
Initial Margin	Revised periodically by the risk committee. Reduced margin for spread positions.	Revised periodically by the risk committee. Reduced margin for spread positions.	Revised periodically by the risk committee. Reduced margin for spread positions.	Revised periodically by the risk committee. Reduced margin for spread positions.
Expiry Valuation Method	Arithmetic average of the index taken every 2 minutes, over the final two hours of trading on expiry date, as calculated by the JSE.	Arithmetic average of the index taken every 2 minutes, over the final two hours of trading on expiry date, as calculated by the JSE.	Arithmetic average of the index taken every 2 minutes, over the final two hours of trading on expiry date, as calculated by the JSE.	Arithmetic average of the index taken every 2 minutes, over the final two hours of trading on expiry date, as calculated by the JSE.
Settlement Method	Cash Settled	Cash Settled	Cash Settled	Cash Settled
Clearing House Fees	Futures R 1.00 Options R 0.50	Futures R 1.00 Options R 0.50	Futures R 1.00 Options R 0.50	Futures R 1.00 Options R 0.50

Part 2: Interest rate and Currency Futures.

Futures Contract	**Long Bond**	**Long Bond**	**Long Bond**	**Long Bond**	**Short Term Interest Rate**	**3 Month JIBAR interest Rate**	**Rand Dollar**
Code	R153	R150	R162	R157	BBF3	JBAR	RNDD
Underlying Instrument	RSA R153 Loan Stock 13% 2010	RSA R150 Loan Stock 12% 2005	RSA R162 Loan Stock 12.5% 2002	RSA R157 Loan Stock 13.5% 2015	91 – day Bank Acceptance (BA) rate	The three month Johannesburg Inter-bank agreed rate (JIBAR)	The rate of exchange between the South African Rand and US Dollars.
Contract Size	R 1 000 000 nominal	R 1 000 000 nominal	R 1 000 000 nominal	R 1 000 000 nominal	R 1 000 000 nominal	R 1 000 000 nominal	$ 100 000 nominal
Expiry dates and times	12h00 on first Thursday of February, May, August or November (or previous business day)	12h00 on first Thursday of February, May, August or November (or previous business day)	12h00 on first Thursday of February, May, August or November (or previous business day)	12h00 on first Thursday of February, May, August or November (or previous business day)	11h00 on third Thursday of each month (or previous business day)	11h00 on third Wednesday of the contract month (or previous business day)	12h00 on the Monday preceding the third Wednesday of each month (or previous business day)
Quotations	Yield to maturity to 4 decimal places	Yield to maturity to 4 decimal places	Yield to maturity to 4 decimal places	Yield to maturity to 4 decimal places	Discount rate to 2 decimal points	100 minus the Yield	In Rand per dollar to four decimals
Minimum price movement (tick)	One twentieth of a point (0.0005%)	One twentieth of a point (0.0005%)	One twentieth of a point (0.0005%)	One twentieth of a point (0.0005%)	One point (0.01%)	0.001 (R2.50)	0.0001 (R10)
Initial Margin	Revised periodically by the risk committee. Reduced margin for spread positions.	Revised periodically by the risk committee. Reduced margin for spread positions.	Revised periodically by the risk committee. Reduced margin for spread positions.	Revised periodically by the risk committee. Reduced margin for spread positions.	Revised periodically by the risk committee. Reduced margin for spread positions.	Revised periodically by the risk committee. Reduced margin for spread positions.	Revised periodically by the risk committee. Reduced margin for spread positions.
Expiry Valuation Method	Midpoint of best spot bid and offer yields advertised on Reuters at 12h00 on expiry.	Midpoint of best spot bid and offer yields advertised on Reuters at 12h00 on expiry.	Midpoint of best spot bid and offer yields advertised on Reuters at 12h00 on expiry.	Midpoint of best spot bid and offer yields advertised on Reuters at 12h00 on expiry.	Average rate of 8 participants selected by SAFEX at 11h00 on expiry day.	Based on the three month JIBAR rate quoted on the Reuters SAFEY page. The settlement price will be 100 minus the JIBAR rounded to three decimal places.	Obtain notional offers to buy and sell $5 000 000 from six authorised dealers. Midpoint of each is calculated and highest and lowest discarded. Average of the remaining four.
Settlement Method	Physically settled.	Physically settled.	Physically settled.	Physically settled.	Cash Settled	Cash Settled	Cash Settled
Clearing House Fees	Futures R 1.00 Options R 0.50	Futures R 1.00 Options R 0.50	Futures R 1.00 Options R 0.50	Futures R 1.00 Options R 0.50	Futures R 1.00 Options R 0.50	Futures R 1.00 Options R 0.50	Futures R 1.00 Options R 0.50

Part 3: Individual Equity Futures.

Futures Contract	**Anglo American Corporation**	**Anglogold**	**The Board of Executors**	**De Beers Consolidated**	**Dimension Data**	**FirstRand**
Code	AACQ	ANGQ	BOEQ	DBRQ	DDTQ	FSRQ
Underlying Instrument	Anglo-American Corporation of SA Ltd	Anglo Gold Ltd.	The Board of Executors Ltd.	De Beers Consolidated Mines Ltd.	Dimension Data Holdings Ltd.	First Rand Ltd.
Contract Size	100 x the share price (e.g. share price 85.25, future price R 8525)	100 x the share price (e.g. share price 85.25, future price R 8525)	100 x the share price (e.g. share price 85.25, future price R 8525)	100 x the share price (e.g. share price 85.25, future price R 8525)	100 x the share price (e.g. share price 85.25, future price R 8525)	100 x the share price (e.g. share price 85.25, future price R 8525)
Expiry dates and times	16h00 on the third Thursday of March, June, September or December (or previous business day)	16h00 on the third Thursday of March, June, September or December (or previous business day)	16h00 on the third Thursday of March, June, September or December (or previous business day)	16h00 on the third Thursday of March, June, September or December (or previous business day)	16h00 on the third Thursday of March, June, September or December (or previous business day)	16h00 on the third Thursday of March, June, September or December (or previous business day)
Quotations	Price per underlying share to two decimals.	Price per underlying share to two decimals.	Price per underlying share to two decimals.	Price per underlying share to two decimals.	Price per underlying share to two decimals.	Price per underlying share to two decimals.
Minimum price movement (tick)	R 1 (R 0.01 in the share price)	R 1 (R 0.01 in the share price)	R 1 (R 0.01 in the share price)	R 1 (R 0.01 in the share price)	R 1 (R 0.01 in the share price)	R 1 (R 0.01 in the share price)
Expiry Valuation Method	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.
Settlement Method	Physically settled in terms of Rule 8.4.7.	Physically settled in terms of Rule 8.4.7.	Physically settled in terms of Rule 8.4.7.	Physically settled in terms of Rule 8.4.7.	Physically settled in terms of Rule 8.4.7.	Physically settled in terms of Rule 8.4.7.
Clearing House Fees	Futures R 0.30 Options R 0.15	Futures R 0.30 Options R 0.15	Futures R 0.30 Options R 0.15	Futures R 0.30 Options R 0.15	Futures R 0.30 Options R 0.15	Futures R 0.30 Options R 0.15

Part 4: Individual Equity Futures continued.

Futures Contract	Goldfields	Liberty Life	Comparex	Richemont	Sasol	SA Breweries
Code	GFLQ	LLAQ	CPXQ	RCHQ	SOLQ	SABQ
Underlying Instrument	Gold Fields Ltd	Liberty Life Association of South Africa Ltd	Comparex	Richemont	Sasol Ltd	The South African Breweries
Contract Size	100 x the share price (e.g. share price 85.25, future price R 8525)	100 x the share price (e.g. share price 85.25, future price R 8525)	100 x the share price (e.g. share price 85.25, future price R 8525)	100 x the share price (e.g. share price 85.25, future price R 8525)	100 x the share price (e.g. share price 85.25, future price R 8525)	100 x the share price (e.g. share price 85.25, future price R 8525)
Expiry dates and times	16h00 on the third Thursday of March, June, September or December (or previous business day)	16h00 on the third Thursday of March, June, September or December (or previous business day)	16h00 on the third Thursday of March, June, September or December (or previous business day)	16h00 on the third Thursday of March, June, September or December (or previous business day)	16h00 on the third Thursday of March, June, September or December (or previous business day)	16h00 on the third Thursday of March, June, September or December (or previous business day)
Quotations	Price per underlying share to two decimals.	Price per underlying share to two decimals.	Price per underlying share to two decimals.	Price per underlying share to two decimals.	Price per underlying share to two decimals.	Price per underlying share to two decimals.
Minimum price movement (tick)	R 1 (R 0.01 in the share price)	R 1 (R 0.01 in the share price)	R 1 (R 0.01 in the share price)	R 1 (R 0.01 in the share price)	R 1 (R 0.01 in the share price)	R 1 (R 0.01 in the share price)
Expiry Valuation Method	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.	Average price as calculated by the JSE between 14h00 and 16h00 on expiry date.
Settlement Method	Physically settled in terms of Rule 8.4.7.	Physically settled in terms of Rule 8.4.7.	Physically settled in terms of Rule 8.4.7.	Physically settled in terms of Rule 8.4.7.	Physically settled in terms of Rule 8.4.7.	Physically settled in terms of Rule 8.4.7.
Clearing House Fees	Futures R 0.30 Options R 0.15	Futures R 0.30 Options R 0.15	Futures R 0.30 Options R 0.15	Futures R 0.30 Options R 0.15	Futures R 0.30 Options R 0.15	Futures R 0.30 Options R 0.15

Appendix 3.2 - Sixteen SPAN Scenarios.

Number	Move in Futures Price	Change in Volatility.
1	Futures Unchanged	Volatility up.
2	Futures Unchanged	Volatility Down.
3	Futures up 1/3 range	Volatility up.
4	Futures up 1/3 range	Volatility Down.
5	Futures down 1/3 range	Volatility up.
6	Futures down 1/3 range	Volatility Down.
7	Futures up 2/3 range	Volatility up.
8	Futures up 2/3 range	Volatility Down.
9	Futures down 2/3 range	Volatility up.
10	Futures down 2/3 range	Volatility Down.
11	Futures up 3/3 range	Volatility up.
12	Futures up 3/3 range	Volatility Down.
13	Futures down 3/3 range	Volatility up.
14	Futures down 3/3 range	Volatility Down.
15	Futures up extreme move	Not Applicable
16	Futures down extreme move	Not Applicable

Appendix 8.1 - Futures / Spot Graphs

See accompanying CD - ROM.

On the CD - ROM select the "R squared" directory and you will find all the different generic contracts in the form of Excel spreadsheets. In each spreadsheet there is a covering summary page that uses hyperlinks to each contract. By clicking on a hyper link one will be taken to the contract and shown: the date, the spot and futures price on that date and the log normal changes in the future and the spot for each day. The page after the data for each contract of the graph that shows the spot and the actual futures price for the selected contract graphed against one another. The "RSQ Analysis" page shows the month-by-month r squared figures for each of the contracts in the time series.

Appendix 8.2 - Futures Fair Value Calculator.

See accompanying CD-ROM.

Fair Value Calculator Refinements.

The calculator that has been designed does not take into account brokerage, the possible movements in margin over the period that the arbitrage position is in place and the possible movements in the collateral for the securities loan over the period that the arbitrage position is in place. These could be incorporated to enable the futures trader to use it as a day-to-day tool.

To include brokerage, care must be taken to determine the method brokerage is charged. Brokerage can be charged as an invoiced fee, in which case Value Added Tax (VAT) must be taken into account. In some instances the brokerage is taken as part of the bid / offer spread. In this case VAT in not included at the brokerage forms part of trading income.

To build in margin movements, one must forecast the volatility of the future over the period of the position. It would be prudent to assume the position will be held to maturity of the futures contract. Once the volatility has been forecast the resultant futures prices will have to be compared to the margin "triggers" (see chapter 3). The extent to which the extreme prices breach the triggers will have to be quantified. This will then be translated into margin requirements. The timing of this will be difficult to determine. Either an average time period (over the maturity of the futures contract) could be used, or the extreme prices could be assumed to occur early in the contract's life. This would enable one to calculate the cost of margin movements.

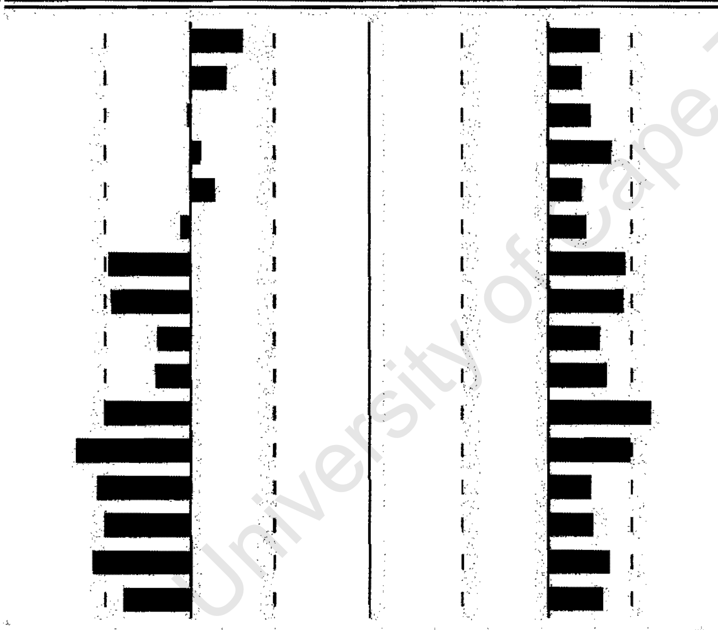
The movement in collateral on the securities loan should be dealt with in the same way as the above margin movements.

Appendix 9.1 – Correlograms for the correlations between "Traditional" ALSI volatility and the ALSI Arbitrage Gap.

Contract # 1: June 1990 ALSI Futures Contract

Sample: 5/04/1990 12/08/2000
Included observations: 17
Correlations are asymptotically consistent approximations

JUN90,VOLATILITY(-i)	JUN90,VOLATILITY(+i)	i	lag	lead
		0	0.2973	0.2973
		1	0.2072	0.1963
		2	-0.0106	0.2514
		3	0.0591	0.3674
		4	0.1473	0.1935
		5	-0.0574	0.2224
		6	-0.4736	0.4475
		7	-0.4551	0.4392
		8	-0.1849	0.2972
		9	-0.1956	0.3379
		10	-0.4898	0.5952
		11	-0.6555	0.4749
		12	-0.5270	0.2512
		13	-0.4885	0.2566
		14	-0.5583	0.3577
		15	-0.3910	0.3132



Contract # 2: September 1990 ALSI Futures Contract

Sample: 5/04/1990 12/08/2000
Included observations: 57
Correlations are asymptotically consistent approximations

SEP90,VOLATILITY(-i)	SEP90,VOLATILITY(+i)	i	lag	lead
		0	0.4812	0.4812
		1	0.4585	0.5246
		2	0.4162	0.6424
		3	0.6036	0.7059
		4	0.7880	0.4799
		5	0.5775	0.2848
		6	0.3155	0.2919
		7	0.3355	0.3290
		8	0.4320	0.3271
		9	0.3632	0.3476
		10	0.3846	0.3651
		11	0.4147	0.2160
		12	0.2844	0.0848
		13	0.0956	0.0898
		14	0.1108	0.1495
		15	0.1763	0.1179
		16	0.1507	0.0438
		17	0.0701	0.0297
		18	-0.0156	-0.0143
		19	-0.0965	-0.0610
		20	-0.1871	-0.0924
		21	-0.1520	-0.0471
		22	-0.1047	-0.0666
		23	-0.1641	-0.1947
		24	-0.3525	-0.3156
		25	-0.5472	-0.3342
		26	-0.5879	-0.3326
		27	-0.5637	-0.3520
		28	-0.4757	-0.2913
		29	-0.4160	-0.3103
		30	-0.4675	-0.5232
		31	-0.7143	-0.6848
		32	-0.9432	-0.5691
		33	-0.7417	-0.4565
		34	-0.5129	-0.4651
		35	-0.5338	-0.4372
		36	-0.5511	-0.4388
		37	-0.5108	-0.6165
		38	-0.6467	-0.7478
		39	-0.7819	-0.5308
		40	-0.5908	-0.3645
		41	-0.4032	-0.3720
		42	-0.4272	-0.3832
		43	-0.4174	-0.3729
		44	-0.3722	-0.4353
		45	-0.4371	-0.4845
		46	-0.4776	-0.3011
		47	-0.3054	-0.1895
		48	-0.1918	-0.2071
		49	-0.2375	-0.2175
		50	-0.2320	-0.1876

Contract # 3: December 1990 ALSI Futures Contract

Sample: 5/04/1990 12/08/2000
Included observations: 87
Correlations are asymptotically consistent approximations

DEC90,VOLATILITY(-i)	DEC90,VOLATILITY(+i)	i	lag	lead
		0	0.7106	0.7106
		1	0.7468	0.6988
		2	0.7039	0.9400
		3	0.8882	1.1781
		4	1.1339	0.9069
		5	0.8511	0.7021
		6	0.5850	0.7125
		7	0.6055	0.6540
		8	0.6529	0.6242
		9	0.6096	0.8351
		10	0.7328	1.0717
		11	0.8983	0.8189
		12	0.6565	0.6241
		13	0.4498	0.6462
		14	0.4627	0.6015
		15	0.4893	0.5589
		16	0.4756	0.7449
		17	0.5525	0.9556
		18	0.6574	0.7410
		19	0.4684	0.5694
		20	0.3096	0.5786
		21	0.3328	0.5435
		22	0.3469	0.4988
		23	0.3225	0.6853
		24	0.3882	0.8713
		25	0.4628	0.6676
		26	0.3264	0.5115
		27	0.2100	0.5427
		28	0.2229	0.5114
		29	0.2320	0.4704
		30	0.2319	0.6383
		31	0.2522	0.8153
		32	0.2615	0.6325
		33	0.1667	0.4982
		34	0.1104	0.5354
		35	0.1171	0.4902
		36	0.1161	0.4443
		37	0.1115	0.6076
		38	0.1134	0.7831
		39	0.1097	0.6238
		40	0.0517	0.4991
		41	0.0172	0.5440
		42	0.0272	0.4850
		43	0.0196	0.4274
		44	0.0047	0.6211
		45	-0.0180	0.8082
		46	-0.0372	0.6242
		47	-0.0553	0.4954
		48	-0.0543	0.5316
		49	-0.0523	0.4640
		50	-0.0650	0.4237

Contract # 4: March 1991 ALSI Futures Contract

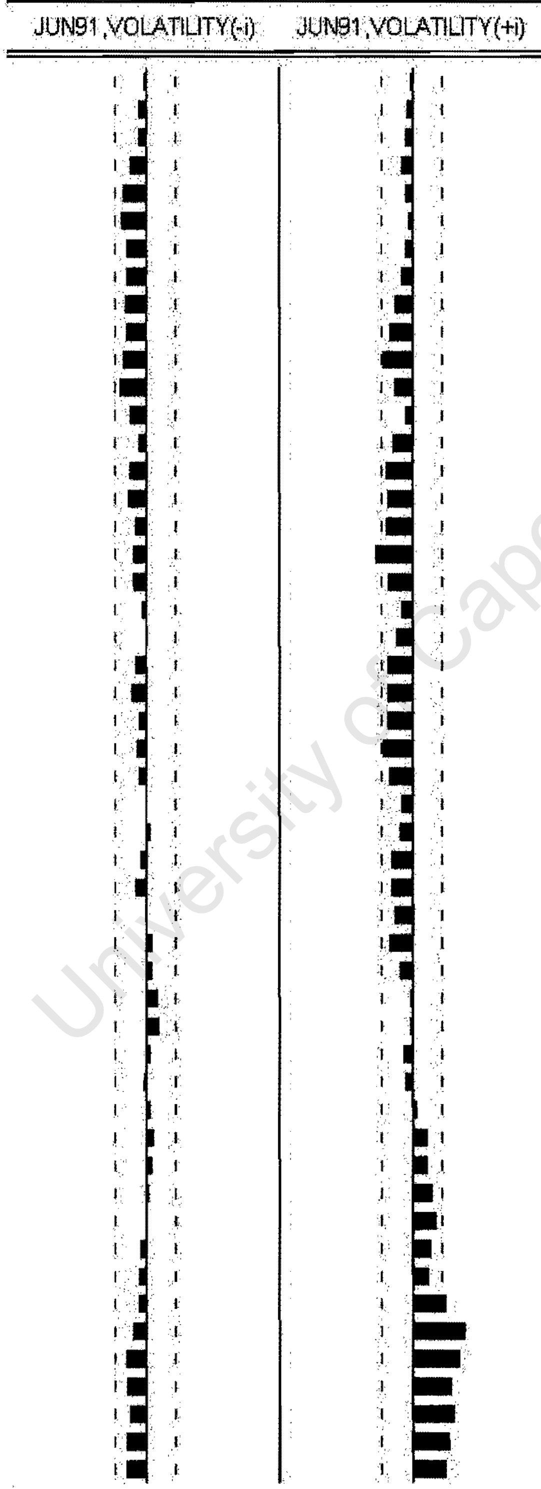
Sample: 5/04/1990 12/08/2000
Included observations: 112
Correlations are asymptotically consistent approximations

MAR91,VOLATILITY(-i) MAR91,VOLATILITY(+i)

i	lag	lead
0	0.6545	0.6545
1	0.6541	0.6587
2	0.6519	0.8748
3	0.8592	1.0967
4	1.0605	0.8744
5	0.8271	0.6662
6	0.5991	0.6790
7	0.5987	0.6783
8	0.6207	0.6724
9	0.6203	0.9005
10	0.7923	1.1474
11	0.9695	0.9110
12	0.7475	0.6854
13	0.5399	0.7032
14	0.5349	0.6996
15	0.5513	0.6910
16	0.5614	0.9177
17	0.7051	1.1431
18	0.8435	0.9041
19	0.6436	0.6915
20	0.4619	0.7193
21	0.4565	0.7098
22	0.4763	0.6821
23	0.4853	0.9247
24	0.5967	1.1664
25	0.7217	0.9109
26	0.5478	0.6840
27	0.3781	0.7154
28	0.3747	0.7089
29	0.3935	0.6812
30	0.4031	0.9136
31	0.4841	1.1526
32	0.5658	0.8892
33	0.4122	0.6387
34	0.2838	0.6636
35	0.2739	0.6822
36	0.2882	0.6604
37	0.2964	0.8375
38	0.3460	1.0196
39	0.3927	0.7766
40	0.2729	0.5451
41	0.1719	0.5768
42	0.1654	0.5943
43	0.1805	0.5696
44	0.1760	0.7159
45	0.1785	0.8583
46	0.1919	0.6353
47	0.1206	0.4297
48	0.0619	0.4567
49	0.0539	0.4820
50	0.0722	0.4625

Contract # 5: June 1991 ALSI Futures Contract

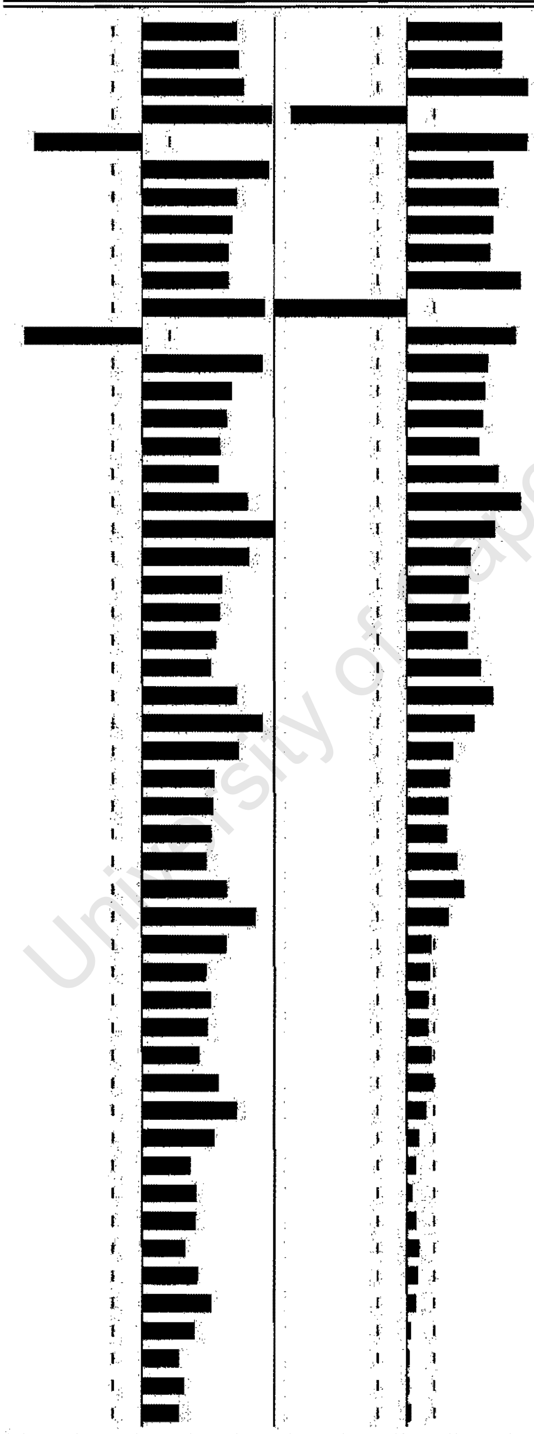
Sample: 5/04/1990 12/08/2000
Included observations: 71
Correlations are asymptotically consistent approximations



i	lag	lead
0	-0.0068	-0.0068
1	-0.0466	-0.0280
2	-0.0519	-0.0535
3	-0.1115	-0.0750
4	-0.1676	-0.0465
5	-0.1759	-0.0230
6	-0.1327	-0.0427
7	-0.1405	-0.0789
8	-0.1555	-0.1274
9	-0.1362	-0.1710
10	-0.1687	-0.2293
11	-0.1957	-0.1230
12	-0.1130	-0.0564
13	-0.0506	-0.1472
14	-0.1197	-0.1933
15	-0.1299	-0.1735
16	-0.0814	-0.2041
17	-0.0892	-0.2814
18	-0.0904	-0.1776
19	-0.0213	-0.0741
20	0.0117	-0.1148
21	-0.0722	-0.1811
22	-0.0987	-0.1752
23	-0.0487	-0.1867
24	-0.0618	-0.2223
25	-0.0484	-0.1692
26	0.0016	-0.0813
27	0.0296	-0.0829
28	-0.0406	-0.1616
29	-0.0660	-0.1547
30	0.0028	-0.1291
31	0.0510	-0.1640
32	0.0458	-0.0859
33	0.0898	-0.0002
34	0.0959	-0.0092
35	0.0261	-0.0612
36	-0.0046	-0.0534
37	0.0387	0.0254
38	0.0609	0.1112
39	0.0443	0.1211
40	0.0172	0.1491
41	0.0110	0.1831
42	-0.0364	0.1423
43	-0.0508	0.1287
44	-0.0510	0.2665
45	-0.0844	0.4043
46	-0.1475	0.3655
47	-0.1364	0.3083
48	-0.1200	0.3205
49	-0.1359	0.2825
50	-0.1462	0.2684

Contract # 6: September 1991 ALSI Futures Contract

Sample: 5/04/1990 12/08/2000
Included observations: 76
Correlations are asymptotically consistent approximations



i	lag	lead
0	0.7495	0.7495
1	0.7612	0.7433
2	0.8040	0.9491
3	1.0134	1.1836
4	1.2475	0.9524
5	1.0044	0.6882
6	0.7397	0.7140
7	0.6983	0.6751
8	0.6867	0.6551
9	0.6855	0.8955
10	0.9591	1.0681
11	1.1772	0.8537
12	0.9515	0.6331
13	0.7112	0.6146
14	0.6588	0.6059
15	0.6089	0.5693
16	0.6009	0.7290
17	0.8240	0.8968
18	1.0420	0.6887
19	0.8437	0.5013
20	0.6289	0.4887
21	0.6098	0.4856
22	0.5836	0.4682
23	0.5411	0.5895
24	0.7514	0.6864
25	0.9461	0.5282
26	0.7663	0.3674
27	0.5702	0.3463
28	0.5564	0.3355
29	0.5416	0.3176
30	0.5010	0.3995
31	0.6607	0.4526
32	0.8892	0.3207
33	0.6670	0.2048
34	0.5048	0.1853
35	0.5474	0.1706
36	0.5228	0.1641
37	0.4589	0.2035
38	0.5932	0.2128
39	0.7401	0.1529
40	0.5665	0.0920
41	0.3887	0.0763
42	0.4312	0.0548
43	0.4185	0.0757
44	0.3504	0.1004
45	0.4374	0.0879
46	0.5483	0.0731
47	0.4061	0.0353
48	0.2916	0.0240
49	0.3201	0.0229
50	0.2919	0.0334

Contract # 7: December 1991 ALSI Futures Contract

Sample: 5/04/1990 12/08/2000
Included observations: 74
Correlations are asymptotically consistent approximations

DEC91,VOLATILITY(-i)	DEC91,VOLATILITY(+i)	i	lag	lead
		0	0.3788	0.3788
		1	0.4278	0.3649
		2	0.4660	0.4564
		3	0.5423	0.5731
		4	0.6362	0.4302
		5	0.4891	0.3325
		6	0.3635	0.2677
		7	0.2124	0.2189
		8	0.2085	0.2536
		9	0.2832	0.3400
		10	0.4063	0.4807
		11	0.5416	0.4279
		12	0.5113	0.3804
		13	0.4364	0.2950
		14	0.2922	0.2078
		15	0.2102	0.1574
		16	0.2118	0.1977
		17	0.2951	0.2885
		18	0.3309	0.2363
		19	0.2956	0.2355
		20	0.2454	0.1671
		21	0.0843	0.1002
		22	-0.0244	0.0747
		23	-0.0252	0.1190
		24	-0.0129	0.1759
		25	-0.0070	0.1498
		26	0.0464	0.1392
		27	0.0753	0.0832
		28	-0.0782	0.0311
		29	-0.1544	0.0249
		30	-0.1449	0.0501
		31	-0.1500	0.0832
		32	-0.1559	0.0736
		33	-0.0522	0.0772
		34	0.0061	0.0720
		35	-0.0285	0.0635
		36	-0.0483	-0.0207
		37	-0.0190	-0.0076
		38	-0.0097	0.0322
		39	-0.0262	-0.0132
		40	-0.0067	-0.0293
		41	-0.0182	0.0633
		42	-0.0796	0.0589
		43	-0.0890	-0.0054
		44	-0.0884	0.0434
		45	-0.1657	0.0795
		46	-0.2663	0.0763
		47	-0.2011	0.0461
		48	-0.1887	0.1422
		49	-0.2639	0.1737
		50	-0.2660	0.1427

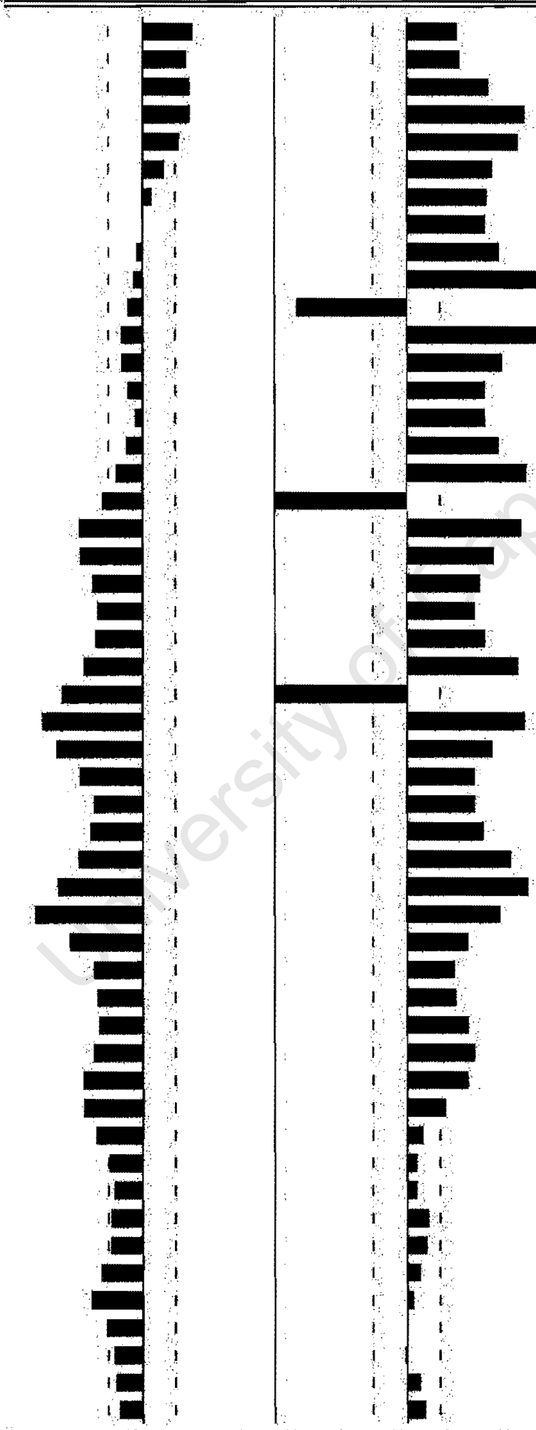
Contract # 8: March 1992 ALSI Futures Contract

Sample: 5/04/1990 12/08/2000
Included observations: 274
Correlations are asymptotically consistent approximations

MAR92,VOLATILITY(-i)	MAR92,VOLATILITY(+i)	i	lag	lead
		0	0.3200	0.3200
		1	0.3375	0.3187
		2	0.3455	0.4269
		3	0.4280	0.5485
		4	0.5251	0.4382
		5	0.4057	0.3507
		6	0.2929	0.3579
		7	0.2790	0.3319
		8	0.3001	0.3301
		9	0.3100	0.4546
		10	0.3886	0.5841
		11	0.4698	0.4653
		12	0.3659	0.3721
		13	0.2674	0.3703
		14	0.2540	0.3430
		15	0.2622	0.3400
		16	0.2715	0.4587
		17	0.3365	0.5825
		18	0.3995	0.4600
		19	0.3045	0.3646
		20	0.2219	0.3688
		21	0.2099	0.3447
		22	0.2112	0.3337
		23	0.2178	0.4592
		24	0.2698	0.5850
		25	0.3237	0.4561
		26	0.2457	0.3603
		27	0.1700	0.3653
		28	0.1637	0.3387
		29	0.1657	0.3291
		30	0.1702	0.4497
		31	0.2000	0.5706
		32	0.2286	0.4510
		33	0.1561	0.3514
		34	0.1068	0.3561
		35	0.1057	0.3334
		36	0.1075	0.3208
		37	0.1120	0.4393
		38	0.1151	0.5660
		39	0.1118	0.4483
		40	0.0647	0.3513
		41	0.0252	0.3635
		42	0.0187	0.3374
		43	0.0282	0.3255
		44	0.0250	0.4574
		45	-0.0109	0.5825
		46	-0.0373	0.4649
		47	-0.0558	0.3639
		48	-0.0651	0.3744
		49	-0.0704	0.3550
		50	-0.0592	0.3464

Contract # 9: June 1992 ALSI Futures Contract

Sample: 5/04/1990 12/08/2000
Included observations: 57
Correlations are asymptotically consistent approximations

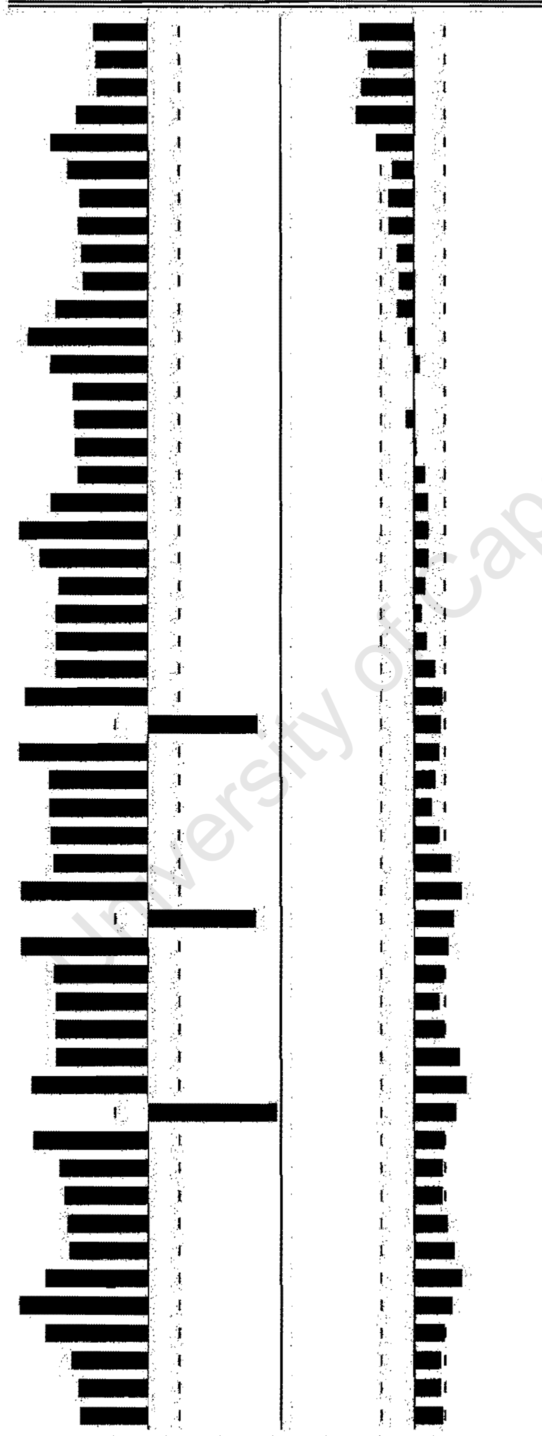


i	lag	lead
0	0.4006	0.4006
1	0.3515	0.4161
2	0.3737	0.6451
3	0.3755	0.9246
4	0.2898	0.8724
5	0.1720	0.6714
6	0.0787	0.6243
7	0.0086	0.6203
8	-0.0313	0.7136
9	-0.0580	1.0327
10	-0.1046	1.2237
11	-0.1530	1.0406
12	-0.1503	0.7524
13	-0.1058	0.6124
14	-0.0508	0.6216
15	-0.1088	0.7282
16	-0.2029	0.9337
17	-0.3091	1.0642
18	-0.4877	0.8888
19	-0.4835	0.6871
20	-0.3885	0.5801
21	-0.3443	0.5299
22	-0.3599	0.6203
23	-0.4431	0.8669
24	-0.6301	1.0604
25	-0.7755	0.9187
26	-0.6650	0.6696
27	-0.4783	0.5310
28	-0.3712	0.5407
29	-0.3984	0.5909
30	-0.4901	0.8146
31	-0.6526	0.9428
32	-0.8288	0.7362
33	-0.5648	0.4767
34	-0.3709	0.3698
35	-0.3479	0.3847
36	-0.3274	0.4803
37	-0.3769	0.5400
38	-0.4527	0.4826
39	-0.4537	0.3060
40	-0.3573	0.1264
41	-0.2482	0.0672
42	-0.2114	0.0798
43	-0.2331	0.1695
44	-0.2331	0.1530
45	-0.3143	0.0958
46	-0.4008	0.0417
47	-0.2763	0.0076
48	-0.2055	-0.0042
49	-0.1981	0.1059
50	-0.1640	0.1372

Contract # 10: September 1992 ALSI Futures Contract

Sample: 5/04/1990 12/08/2000
Included observations: 64
Correlations are asymptotically consistent approximations

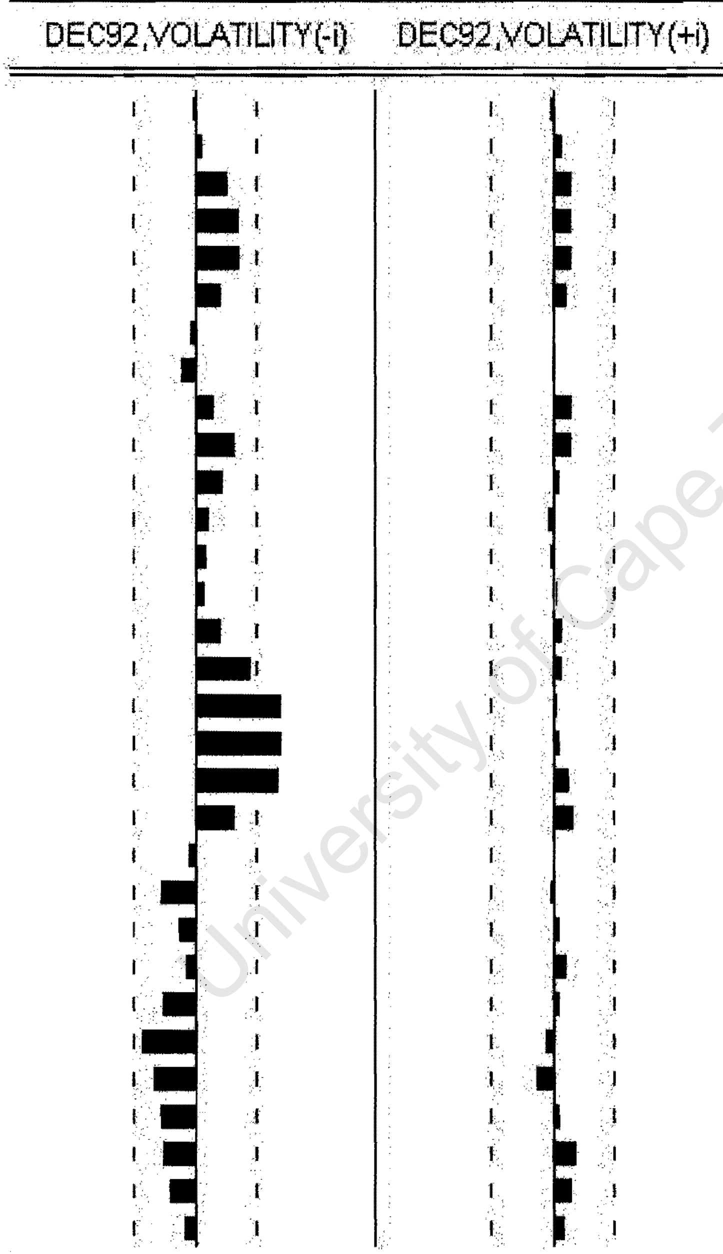
SEP92,VOLATILITY(-i) SEP92,VOLATILITY(+i)



i	lag	lead
0	-0.4033	-0.4033
1	-0.4001	-0.3515
2	-0.3815	-0.3991
3	-0.5474	-0.4394
4	-0.7405	-0.2743
5	-0.6217	-0.1553
6	-0.5118	-0.1743
7	-0.5375	-0.1835
8	-0.5069	-0.1197
9	-0.4918	-0.1062
10	-0.6978	-0.1144
11	-0.9235	-0.0316
12	-0.7481	0.0439
13	-0.5809	0.0063
14	-0.5651	-0.0426
15	-0.5510	0.0210
16	-0.5366	0.0844
17	-0.7439	0.1122
18	-0.9865	0.1120
19	-0.8349	0.1195
20	-0.6813	0.0825
21	-0.7042	0.0586
22	-0.7024	0.1002
23	-0.6999	0.1678
24	-0.9533	0.2152
25	-1.2337	0.2115
26	-0.9994	0.1918
27	-0.7672	0.1676
28	-0.7673	0.1433
29	-0.7463	0.1888
30	-0.7265	0.2888
31	-0.9741	0.3617
32	-1.2516	0.3164
33	-0.9790	0.2728
34	-0.7251	0.2348
35	-0.7017	0.2012
36	-0.7130	0.2413
37	-0.7002	0.3565
38	-0.8910	0.4109
39	-1.0975	0.3323
40	-0.8841	0.2404
41	-0.6757	0.2164
42	-0.6365	0.2209
43	-0.6186	0.2546
44	-0.6061	0.3179
45	-0.7930	0.3731
46	-0.9994	0.3045
47	-0.7918	0.2309
48	-0.5834	0.2101
49	-0.5302	0.2126
50	-0.5101	0.2249

Contract # 11: December 1992 ALSI Futures Contract

Sample: 5/04/1990 12/08/2000
Included observations: 32
Correlations are asymptotically consistent approximations



i	lag	lead
0	-0.0121	-0.0121
1	0.0405	0.0503
2	0.1862	0.0909
3	0.2539	0.0985
4	0.2519	0.0979
5	0.1463	0.0778
6	-0.0241	0.0046
7	-0.0788	0.0159
8	0.0967	0.1003
9	0.2284	0.1028
10	0.1631	0.0264
11	0.0736	-0.0182
12	0.0649	-0.0113
13	0.0413	0.0237
14	0.1354	0.0551
15	0.3132	0.0520
16	0.4873	0.0212
17	0.4901	0.0379
18	0.4753	0.0841
19	0.2252	0.1070
20	-0.0316	0.0074
21	-0.1932	-0.0125
22	-0.0917	0.0333
23	-0.0494	0.0738
24	-0.1792	0.0310
25	-0.3089	-0.0295
26	-0.2423	-0.0837
27	-0.1891	0.0320
28	-0.1881	0.1300
29	-0.1385	0.1013
30	-0.0648	0.0582

Contract # 12: March 1993 ALSI Futures Contract

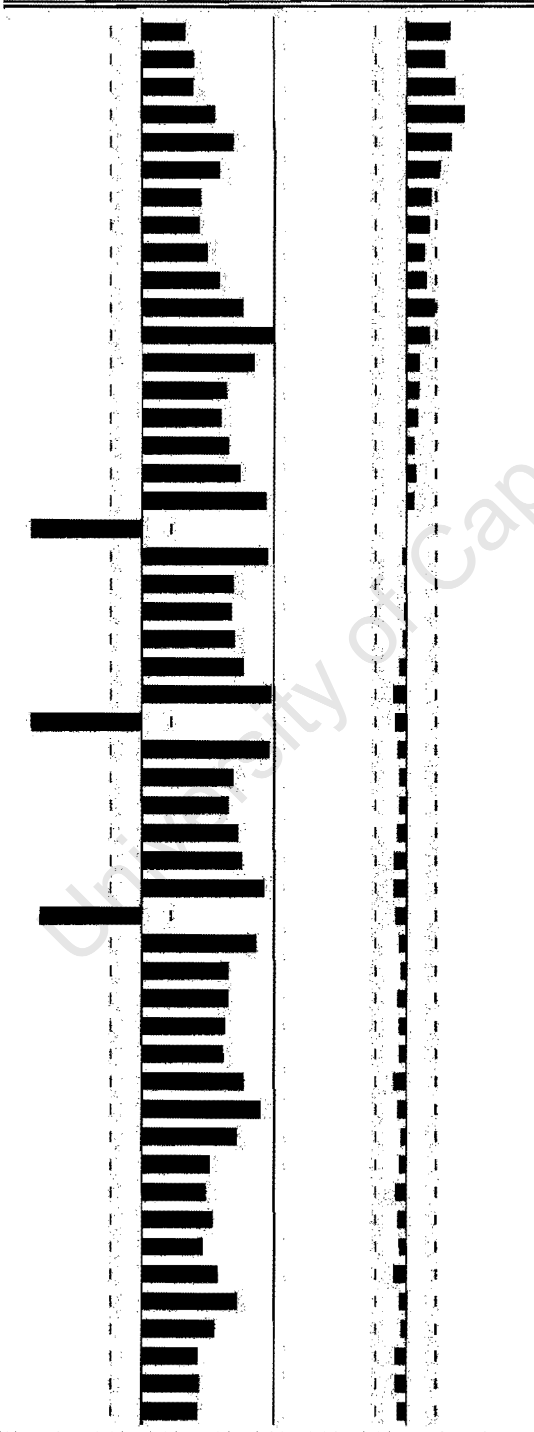
Sample: 5/04/1990 12/08/2000
Included observations: 187
Correlations are asymptotically consistent approximations

MAR93,VOLATILITY(-i)	MAR93,VOLATILITY(+i)	i	lag	lead
		0	0.0509	0.0509
		1	0.0647	0.0572
		2	0.0861	0.0814
		3	0.0988	0.1073
		4	0.1027	0.0942
		5	0.0824	0.0741
		6	0.0523	0.0500
		7	0.0183	0.0369
		8	0.0181	0.0617
		9	0.0442	0.0916
		10	0.0690	0.1063
		11	0.0790	0.1006
		12	0.0857	0.0948
		13	0.0797	0.0597
		14	0.0578	0.0266
		15	0.0425	0.0385
		16	0.0619	0.0607
		17	0.0851	0.0654
		18	0.0883	0.0526
		19	0.0644	0.0523
		20	0.0389	0.0250
		21	0.0014	-0.0010
		22	-0.0246	0.0111
		23	-0.0235	0.0204
		24	-0.0266	0.0170
		25	-0.0395	0.0227
		26	-0.0155	0.0292
		27	-0.0008	0.0000
		28	-0.0312	-0.0289
		29	-0.0496	-0.0157
		30	-0.0350	-0.0066
		31	-0.0250	-0.0169
		32	-0.0281	-0.0112
		33	-0.0047	0.0056
		34	0.0162	-0.0201
		35	0.0130	-0.0616
		36	0.0008	-0.0628
		37	0.0247	-0.0668
		38	0.0594	-0.0962
		39	0.0709	-0.0859
		40	0.0558	-0.0624
		41	0.0335	-0.0721
		42	0.0347	-0.0963
		43	0.0430	-0.1004
		44	0.0597	-0.1251
		45	0.0687	-0.1599
		46	0.0646	-0.1237
		47	0.0544	-0.0802
		48	0.0393	-0.0777
		49	0.0323	-0.1047
		50	0.0327	-0.1186

Contract # 13: June 1993 ALSI Futures Contract

Sample: 5/04/1990 12/08/2000
Included observations: 68
Correlations are asymptotically consistent approximations

JUN93,VOLATILITY(-i)	JUN93,VOLATILITY(+i)	i	lag	lead



i	lag	lead
0	0.3497	0.3497
1	0.4030	0.2958
2	0.4033	0.3881
3	0.5819	0.4520
4	0.7148	0.3605
5	0.6110	0.2615
6	0.4635	0.1999
7	0.4516	0.1768
8	0.5140	0.1392
9	0.6156	0.1634
10	0.7977	0.2205
11	1.0320	0.1832
12	0.8786	0.1032
13	0.6650	0.0993
14	0.6304	0.0876
15	0.6826	0.0591
16	0.7710	0.0724
17	0.9810	0.0582
18	1.2315	0.0103
19	0.9890	-0.0210
20	0.7146	-0.0015
21	0.7029	-0.0079
22	0.7371	-0.0186
23	0.8003	-0.0569
24	1.0131	-0.0858
25	1.2220	-0.0793
26	1.0023	-0.0641
27	0.7236	-0.0558
28	0.6723	-0.0558
29	0.7551	-0.0631
30	0.7802	-0.0845
31	0.9634	-0.0949
32	1.2937	-0.0807
33	0.8980	-0.0484
34	0.6738	-0.0368
35	0.6730	-0.0607
36	0.6497	-0.0651
37	0.6387	-0.0558
38	0.8003	-0.0837
39	0.9417	-0.0596
40	0.7418	-0.0398
41	0.5397	-0.0544
42	0.5081	-0.0704
43	0.5506	-0.0609
44	0.4711	-0.0547
45	0.5963	-0.0823
46	0.7378	-0.0507
47	0.5793	-0.0340
48	0.4354	-0.0705
49	0.4571	-0.0809
50	0.4410	-0.0615

Contract # 14: September 1993 ALSI Futures Contract

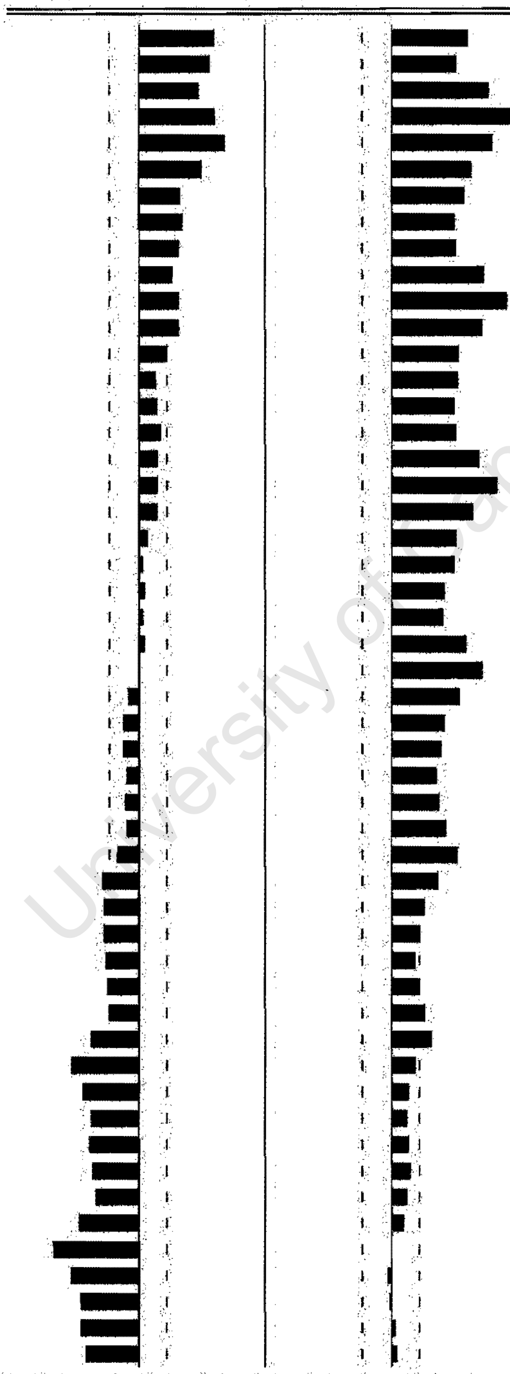
Sample: 5/04/1990 12/08/2000
Included observations: 72
Correlations are asymptotically consistent approximations

SEP93,VOLATILITY(-i)	SEP93,VOLATILITY(+i)	i	lag	lead
		0	-0.3371	-0.3371
		1	-0.3423	-0.3852
		2	-0.3879	-0.4725
		3	-0.3990	-0.6087
		4	-0.4885	-0.5179
		5	-0.3252	-0.3496
		6	-0.2137	-0.3850
		7	-0.2441	-0.3271
		8	-0.2350	-0.3323
		9	-0.1784	-0.5350
		10	-0.2338	-0.5990
		11	-0.2635	-0.4837
		12	-0.1793	-0.4485
		13	-0.1516	-0.3553
		14	-0.1670	-0.3734
		15	-0.1293	-0.3917
		16	-0.1052	-0.5509
		17	-0.1572	-0.7806
		18	-0.2325	-0.6719
		19	-0.2289	-0.4640
		20	-0.1862	-0.4702
		21	-0.2038	-0.4378
		22	-0.2055	-0.4121
		23	-0.1285	-0.5975
		24	-0.2025	-0.7113
		25	-0.2867	-0.5585
		26	-0.2032	-0.3824
		27	-0.1490	-0.2915
		28	-0.1869	-0.3035
		29	-0.1711	-0.3553
		30	-0.1332	-0.4064
		31	-0.2164	-0.4450
		32	-0.2673	-0.3661
		33	-0.2219	-0.1915
		34	-0.1385	-0.2036
		35	-0.1698	-0.2765
		36	-0.1936	-0.1440
		37	-0.1576	-0.1754
		38	-0.1853	-0.2651
		39	-0.2395	-0.1930
		40	-0.1822	-0.1037
		41	-0.1209	-0.1369
		42	-0.1394	-0.0860
		43	-0.1339	-0.0534
		44	-0.1388	-0.0445
		45	-0.1892	-0.0072
		46	-0.2036	0.0683
		47	-0.1280	0.0926
		48	-0.0746	0.0515
		49	-0.0566	0.0944
		50	-0.0540	0.2053

Contract # 15: December 1993 ALSI Futures Contract

Date: 05/29/01 Time: 01:33
Sample: 5/04/1990 12/08/2000
Included observations: 74
Correlations are asymptotically consistent approximations

DEC93,VOLATILITY(-i) DEC93,VOLATILITY(+i)



i	lag	lead
0	0.6269	0.6269
1	0.5848	0.5407
2	0.4962	0.7954
3	0.6230	1.0246
4	0.7041	0.8350
5	0.5108	0.6479
6	0.3425	0.6010
7	0.3585	0.5205
8	0.3298	0.5313
9	0.2748	0.7568
10	0.3265	0.9547
11	0.3357	0.7497
12	0.2343	0.5602
13	0.1467	0.5458
14	0.1485	0.5119
15	0.1724	0.5276
16	0.1496	0.7230
17	0.1593	0.8679
18	0.1509	0.6678
19	0.0701	0.5353
20	0.0317	0.5178
21	0.0514	0.4409
22	0.0376	0.4290
23	0.0460	0.6100
24	0.0013	0.7500
25	-0.0715	0.5608
26	-0.1106	0.4408
27	-0.1205	0.4172
28	-0.0896	0.3723
29	-0.1017	0.3961
30	-0.0870	0.4476
31	-0.1686	0.5447
32	-0.2939	0.3786
33	-0.2796	0.2758
34	-0.2726	0.2413
35	-0.2625	0.2014
36	-0.2500	0.2390
37	-0.2402	0.2785
38	-0.3878	0.3198
39	-0.5432	0.2005
40	-0.4461	0.1325
41	-0.3915	0.1276
42	-0.3939	0.1394
43	-0.3687	0.1574
44	-0.3467	0.1266
45	-0.4778	0.0912
46	-0.6892	0.0152
47	-0.5434	-0.0239
48	-0.4609	-0.0038
49	-0.4637	0.0351
50	-0.4188	0.0513

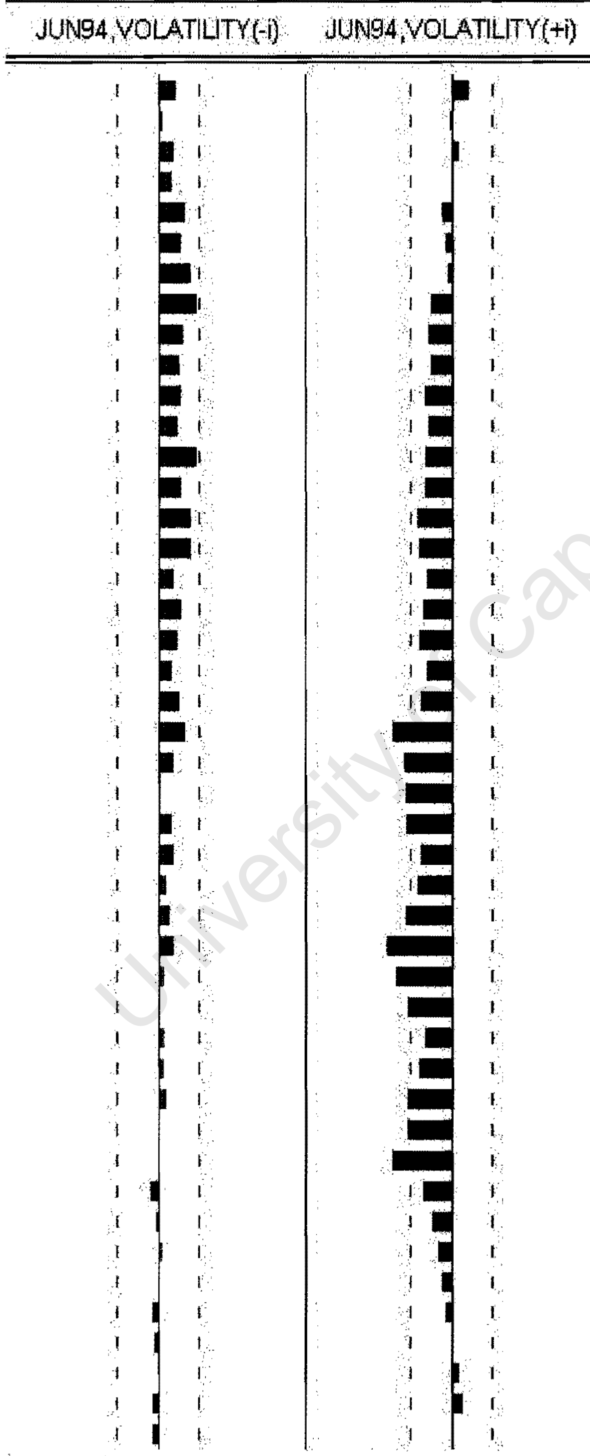
Contract # 16: March 1994 ALSI Futures Contract

Sample: 5/04/1990 12/08/2000
Included observations: 46
Correlations are asymptotically consistent approximations

MAR94,VOLATILITY(-i)	MAR94,VOLATILITY(+i)	i	lag	lead
		0	0.1141	0.1141
		1	0.0212	-0.0075
		2	0.1018	0.0496
		3	0.0874	0.0078
		4	0.1757	-0.0644
		5	0.1607	-0.0299
		6	0.2262	-0.0218
		7	0.2693	-0.1431
		8	0.1665	-0.1511
		9	0.1346	-0.1392
		10	0.1594	-0.1727
		11	0.1264	-0.1535
		12	0.2635	-0.1755
		13	0.1484	-0.1863
		14	0.2209	-0.2400
		15	0.2213	-0.2195
		16	0.1048	-0.1678
		17	0.1608	-0.2033
		18	0.1296	-0.2240
		19	0.0863	-0.1706
		20	0.1328	-0.2080
		21	0.1825	-0.4131
		22	0.1043	-0.3244
		23	0.0158	-0.3165
		24	0.0879	-0.3123
		25	0.0925	-0.2063
		26	0.0457	-0.2307
		27	0.0812	-0.3190
		28	0.0933	-0.4468
		29	0.0296	-0.3782
		30	0.0057	-0.3106
		31	0.0403	-0.1803
		32	0.0360	-0.2158
		33	0.0447	-0.3090
		34	0.0084	-0.3037
		35	0.0087	-0.4072
		36	-0.0561	-0.2019
		37	-0.0155	-0.1288
		38	0.0170	-0.0927
		39	0.0114	-0.0616
		40	-0.0298	-0.0362
		41	-0.0216	0.0012
		42	0.0000	0.0446
		43	-0.0255	0.0744
		44	-0.0248	0.0109

Contract # 17: June 1994 ALSI Futures Contract

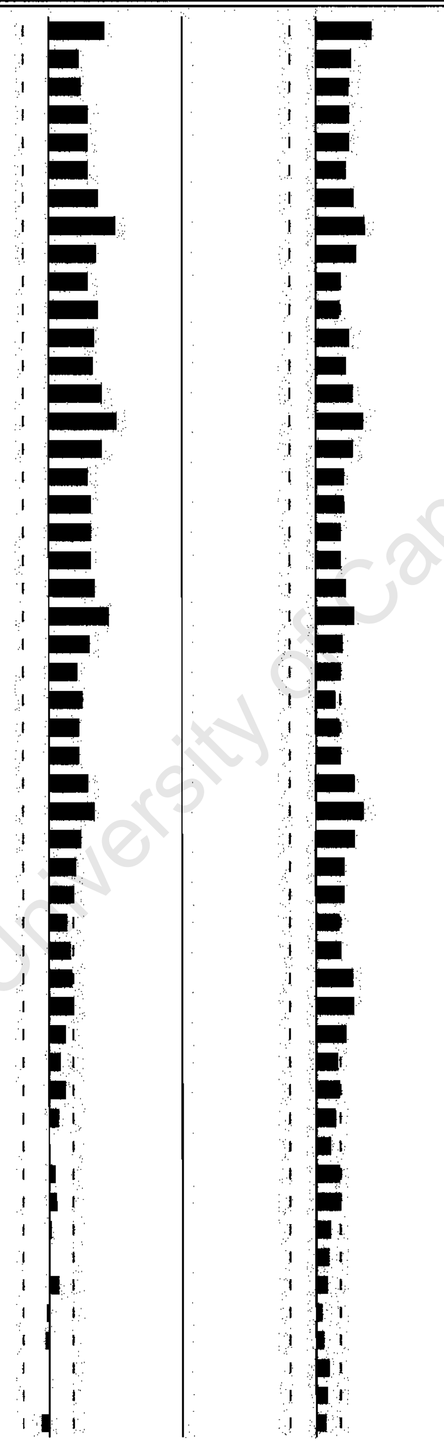
Sample: 6/05/1990 12/08/2000
Included observations: 46
Correlations are asymptotically consistent approximations



i	lag	lead
0	0.1141	0.1141
1	0.0212	-0.0075
2	0.1018	0.0496
3	0.0874	0.0078
4	0.1757	-0.0644
5	0.1607	-0.0299
6	0.2262	-0.0218
7	0.2693	-0.1431
8	0.1665	-0.1511
9	0.1346	-0.1392
10	0.1594	-0.1727
11	0.1264	-0.1535
12	0.2635	-0.1755
13	0.1484	-0.1863
14	0.2209	-0.2400
15	0.2213	-0.2195
16	0.1048	-0.1678
17	0.1608	-0.2033
18	0.1296	-0.2240
19	0.0863	-0.1706
20	0.1328	-0.2080
21	0.1825	-0.4131
22	0.1043	-0.3244
23	0.0158	-0.3165
24	0.0879	-0.3123
25	0.0925	-0.2063
26	0.0457	-0.2307
27	0.0812	-0.3190
28	0.0933	-0.4468
29	0.0296	-0.3782
30	0.0057	-0.3106
31	0.0403	-0.1803
32	0.0360	-0.2158
33	0.0447	-0.3090
34	0.0084	-0.3037
35	0.0087	-0.4072
36	-0.0561	-0.2019
37	-0.0155	-0.1288
38	0.0170	-0.0927
39	0.0114	-0.0616
40	-0.0298	-0.0362
41	-0.0216	0.0012
42	0.0000	0.0446
43	-0.0255	0.0744
44	-0.0248	0.0109

Contract # 18: September 1994 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 112
Correlations are asymptotically consistent approximations

SEP94,VOLATILITY(-i)	SEP94,VOLATILITY(+i)	i	lag	lead
		0	0.4355	0.4355
		1	0.2342	0.2706
		2	0.2480	0.2575
		3	0.3051	0.2614
		4	0.3094	0.2656
		5	0.3097	0.2384
		6	0.3785	0.2994
		7	0.5158	0.3891
		8	0.3629	0.3197
		9	0.3108	0.1900
		10	0.3829	0.1844
		11	0.3595	0.2618
		12	0.3490	0.2383
		13	0.4095	0.2904
		14	0.5273	0.3746
		15	0.4027	0.2829
		16	0.3004	0.2250
		17	0.3264	0.2258
		18	0.3211	0.1886
		19	0.3210	0.1920
		20	0.3546	0.2297
		21	0.4643	0.3112
		22	0.3130	0.2060
		23	0.2240	0.1921
		24	0.2662	0.1608
		25	0.2453	0.1764
		26	0.2313	0.2009
		27	0.3063	0.3011
		28	0.3560	0.3686
		29	0.2465	0.3015
		30	0.2104	0.2267
		31	0.1954	0.2266
		32	0.1315	0.1849
		33	0.1640	0.1996
		34	0.1858	0.2936
		35	0.1984	0.3050
		36	0.1252	0.2386
		37	0.0867	0.1646
		38	0.1246	0.1852
		39	0.0688	0.1483
		40	0.0105	0.1197
		41	0.0421	0.1743
		42	0.0635	0.1918
		43	0.0196	0.1205
		44	0.0037	0.0940
		45	0.0666	0.0886
		46	-0.0042	0.0414
		47	-0.0219	0.0619
		48	0.0146	0.0949
		49	0.0020	0.0901
		50	-0.0442	0.0795

Contract # 19: December 1994 ALSI Futures Contract

Sample: 6/05/1990 5/17/1999
Included observations: 98
Correlations are asymptotically consistent approximations

DEC94,VOLATILITY(-i)	DEC94,VOLATILITY(+i)	i	lag	lead
		0	-0.3171	-0.3171
		1	-0.2532	-0.2276
		2	-0.2102	-0.1012
		3	-0.2228	-0.1229
		4	-0.2146	-0.1741
		5	-0.1162	-0.2094
		6	-0.1523	-0.2348
		7	-0.2224	-0.2044
		8	-0.1792	-0.1334
		9	-0.1269	-0.0862
		10	-0.0267	-0.1264
		11	-0.0237	-0.1735
		12	-0.0428	-0.1585
		13	-0.0332	-0.1986
		14	0.0080	-0.2390
		15	0.0092	-0.1396
		16	0.0005	-0.0815
		17	0.0364	-0.1583
		18	0.0526	-0.1972
		19	0.0506	-0.1279
		20	0.0407	-0.0609
		21	0.0715	-0.1465
		22	0.0951	-0.0886
		23	0.1118	-0.0648
		24	0.0723	-0.0984
		25	0.0511	-0.0551
		26	0.1273	-0.0042
		27	0.2205	-0.0698
		28	0.3448	-0.1317
		29	0.2970	-0.1203
		30	0.2157	-0.0884
		31	0.2466	-0.0791
		32	0.2294	-0.0204
		33	0.1800	-0.0089
		34	0.2786	-0.0519
		35	0.3799	-0.0670
		36	0.3230	-0.0181
		37	0.2511	0.0059
		38	0.2382	-0.0367
		39	0.2306	0.0209
		40	0.2154	0.0394
		41	0.2789	0.0662
		42	0.3609	0.0723
		43	0.3178	0.0853
		44	0.2769	0.0474
		45	0.2473	0.0132
		46	0.2349	0.0808
		47	0.2004	0.0783
		48	0.2925	0.0576
		49	0.3581	0.0923
		50	0.2596	0.0969

Contract # 20: March 1995 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 237
Correlations are asymptotically consistent approximations

MAR95,VOLATILITY(-i)	MAR95,VOLATILITY(+i)	i	lag	lead
		0	-0.0270	-0.0270
		1	-0.0326	-0.0421
		2	0.0042	-0.0362
		3	0.0078	-0.0314
		4	0.0280	0.0063
		5	0.0210	0.0021
		6	0.0185	-0.0407
		7	0.0229	-0.0306
		8	0.0144	-0.0255
		9	0.0055	-0.0264
		10	0.0093	-0.0143
		11	0.0358	0.0053
		12	0.0305	0.0016
		13	0.0113	-0.0006
		14	0.0088	0.0032
		15	0.0020	-0.0021
		16	0.0058	-0.0026
		17	0.0086	-0.0151
		18	0.0017	0.0029
		19	0.0053	-0.0006
		20	-0.0268	-0.0134
		21	-0.0264	-0.0119
		22	-0.0303	-0.0190
		23	0.0057	-0.0172
		24	0.0083	0.0016
		25	-0.0301	0.0008
		26	-0.0452	-0.0020
		27	-0.0402	0.0592
		28	0.0083	0.0585
		29	-0.0688	0.0720
		30	0.0053	0.0775
		31	0.0065	0.0758
		32	-0.1188	-0.0019
		33	-0.1187	-0.0039
		34	-0.0955	0.0779
		35	-0.0911	0.0750
		36	-0.0982	0.0922
		37	0.0029	0.0913
		38	0.0050	0.0927
		39	-0.1148	-0.0038
		40	-0.1186	-0.0053
		41	-0.1171	0.0878
		42	-0.1169	0.0791
		43	-0.1192	0.0598
		44	0.0021	0.0527
		45	0.0044	0.0417
		46	-0.1300	-0.0065
		47	0.0003	-0.0069
		48	-0.1294	0.0338
		49	0.0024	0.0346
		50	-0.1395	0.0304

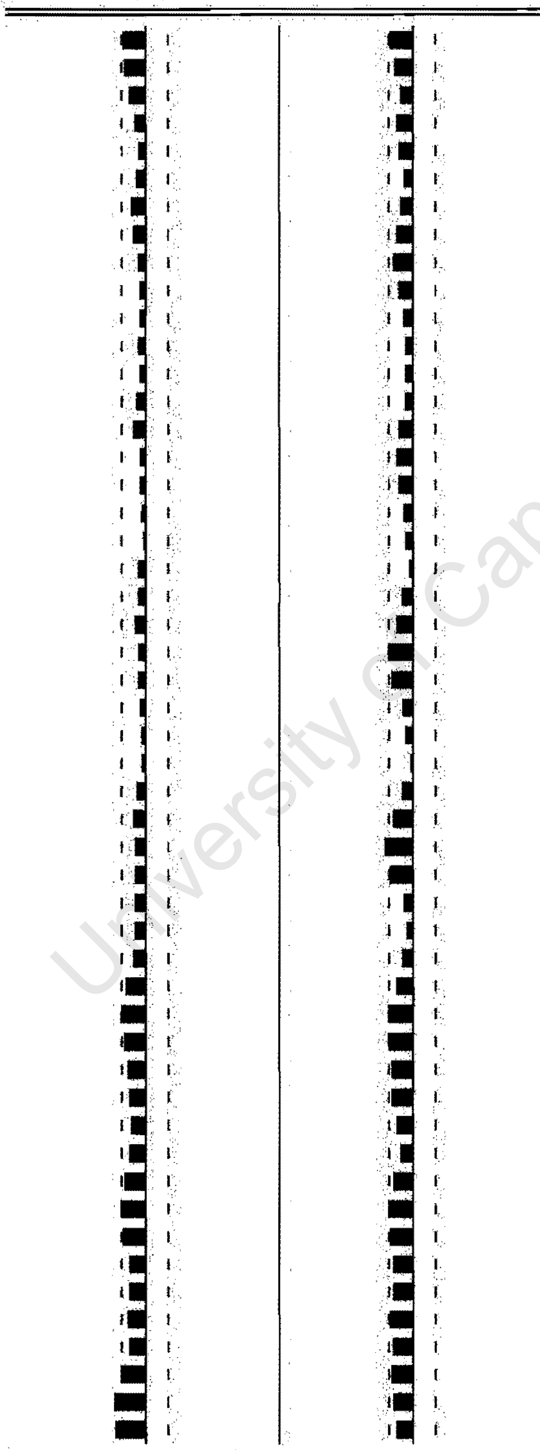
Contract # 21: June 1995 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 111
Correlations are asymptotically consistent approximations

JUN95,VOLATILITY(-i)	JUN95,VOLATILITY(+i)	i	lag	lead
		0	-0.3754	-0.3754
		1	-0.3088	-0.2313
		2	-0.2816	-0.1543
		3	-0.2516	-0.1488
		4	-0.2519	-0.1324
		5	-0.2555	-0.1037
		6	-0.3732	-0.1190
		7	-0.4482	-0.1235
		8	-0.3684	-0.0989
		9	-0.2985	-0.0788
		10	-0.2685	-0.0497
		11	-0.2516	-0.0292
		12	-0.2672	-0.0455
		13	-0.3441	-0.0694
		14	-0.4087	-0.0594
		15	-0.3147	-0.0559
		16	-0.2231	-0.0614
		17	-0.2146	-0.0366
		18	-0.2248	-0.0350
		19	-0.2288	-0.0079
		20	-0.2400	0.0012
		21	-0.3300	-0.0290
		22	-0.2421	-0.0451
		23	-0.1782	-0.0678
		24	-0.1795	-0.0488
		25	-0.1835	-0.0242
		26	-0.1233	0.0461
		27	-0.1438	-0.0002
		28	-0.1826	-0.0631
		29	-0.1502	-0.1062
		30	-0.0606	-0.1029
		31	-0.0270	-0.0954
		32	-0.0449	-0.0940
		33	-0.0147	-0.1001
		34	0.0423	-0.1309
		35	0.0629	-0.1986
		36	0.0772	-0.1535
		37	0.0933	-0.1208
		38	0.1110	-0.1492
		39	0.0499	-0.1454
		40	0.1088	-0.1119
		41	0.1540	-0.1295
		42	0.1756	-0.1728
		43	0.1293	-0.0967
		44	0.1107	-0.0614
		45	0.0951	-0.1031
		46	0.0773	-0.0788
		47	0.1215	-0.0429
		48	0.1821	-0.0681
		49	0.2345	-0.0258
		50	0.2061	-0.0226

Contract # 22: September 1995 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 113
Correlations are asymptotically consistent approximations



SEP95,VOLATILITY(-i)	SEP95,VOLATILITY(+i)	i	lag	lead
		0	-0.1693	-0.1693
		1	-0.1540	-0.1289
		2	-0.1177	-0.0926
		3	-0.0764	-0.1174
		4	-0.0414	-0.1065
		5	-0.0645	-0.0648
		6	-0.1053	-0.0874
		7	-0.0897	-0.1215
		8	-0.0476	-0.1463
		9	-0.0326	-0.1037
		10	-0.0252	-0.0581
		11	-0.0434	-0.0534
		12	-0.0399	-0.0416
		13	-0.0620	-0.0560
		14	-0.0853	-0.1032
		15	-0.0340	-0.1105
		16	-0.0332	-0.1049
		17	-0.0200	-0.0588
		18	-0.0100	-0.0450
		19	-0.0516	-0.0196
		20	-0.0528	-0.0704
		21	-0.0754	-0.1155
		22	-0.0516	-0.1816
		23	-0.0416	-0.1626
		24	-0.0381	-0.0692
		25	-0.0199	-0.0515
		26	-0.0221	-0.0103
		27	-0.0587	-0.0683
		28	-0.0830	-0.1440
		29	-0.0802	-0.2062
		30	-0.0773	-0.1666
		31	-0.0763	-0.0631
		32	-0.0674	-0.0274
		33	-0.0654	-0.0680
		34	-0.1381	-0.1153
		35	-0.1785	-0.1827
		36	-0.1590	-0.1739
		37	-0.1233	-0.1499
		38	-0.1180	-0.1502
		39	-0.1043	-0.1206
		40	-0.1212	-0.0963
		41	-0.1627	-0.1380
		42	-0.1884	-0.1828
		43	-0.1640	-0.1655
		44	-0.1194	-0.1391
		45	-0.1072	-0.1400
		46	-0.1254	-0.1713
		47	-0.1208	-0.1409
		48	-0.1843	-0.1563
		49	-0.2358	-0.1343
		50	-0.2161	-0.1155

Contract # 23: December 1995 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 138
Correlations are asymptotically consistent approximations

DEC95,VOLATILITY(-i)	DEC95,VOLATILITY(+i)	i	lag	lead
		0	-0.0205	-0.0205
		1	-0.0253	-0.0049
		2	-0.0226	0.0097
		3	-0.0067	-0.0157
		4	-0.0099	-0.0121
		5	-0.0019	0.0039
		6	-0.0079	0.0194
		7	-0.0135	0.0181
		8	-0.0247	0.0209
		9	-0.0231	0.0288
		10	-0.0111	0.0238
		11	-0.0153	0.0307
		12	-0.0338	0.0306
		13	-0.0398	0.0303
		14	-0.0529	0.0287
		15	-0.0577	0.0048
		16	-0.0667	0.0081
		17	-0.0553	0.0057
		18	-0.0427	-0.0147
		19	-0.0790	-0.0397
		20	-0.1254	-0.0647
		21	-0.1638	-0.0789
		22	-0.1356	-0.0898
		23	-0.1104	-0.0679
		24	-0.1191	-0.0611
		25	-0.1109	-0.0704
		26	-0.1141	-0.0596
		27	-0.1712	-0.0844
		28	-0.2174	-0.1189
		29	-0.1835	-0.1021
		30	-0.1403	-0.0603
		31	-0.1538	-0.0312
		32	-0.1570	-0.0321
		33	-0.1700	-0.0314
		34	-0.2334	-0.0238
		35	-0.2718	-0.0264
		36	-0.2080	-0.0414
		37	-0.1517	-0.0296
		38	-0.1618	0.0092
		39	-0.1585	-0.0098
		40	-0.1657	-0.0610
		41	-0.2257	-0.0773
		42	-0.2742	-0.0792
		43	-0.2056	-0.0687
		44	-0.1387	-0.0482
		45	-0.1558	-0.0204
		46	-0.1688	-0.0324
		47	-0.1575	-0.0347
		48	-0.2049	-0.0393
		49	-0.2438	-0.0559
		50	-0.1758	-0.0175

Contract # 24: March 1996 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 397
Correlations are asymptotically consistent approximations

MAR96,VOLATILITY(-i)	MAR96,VOLATILITY(+i)	i	lag	lead
		0	-0.2343	-0.2343
		1	-0.1803	-0.1744
		2	-0.1528	-0.1226
		3	-0.1506	-0.1275
		4	-0.1430	-0.1218
		5	-0.1273	-0.0908
		6	-0.1822	-0.1226
		7	-0.2381	-0.1529
		8	-0.2020	-0.1253
		9	-0.1628	-0.0912
		10	-0.1580	-0.0799
		11	-0.1535	-0.0747
		12	-0.1537	-0.0545
		13	-0.2070	-0.0763
		14	-0.2722	-0.1055
		15	-0.2225	-0.0815
		16	-0.1764	-0.0598
		17	-0.1645	-0.0621
		18	-0.1668	-0.0604
		19	-0.1667	-0.0238
		20	-0.2251	-0.0368
		21	-0.3079	-0.0605
		22	-0.2490	-0.0520
		23	-0.1972	-0.0426
		24	-0.1942	-0.0355
		25	-0.2033	-0.0130
		26	-0.1763	0.0154
		27	-0.2449	0.0157
		28	-0.3383	0.0061
		29	-0.2811	0.0032
		30	-0.1956	0.0036
		31	-0.1952	0.0203
		32	-0.1912	0.0414
		33	-0.1771	0.0201
		34	-0.2301	0.0258
		35	-0.2895	0.0475
		36	-0.2256	0.0525
		37	-0.1638	0.0308
		38	-0.1518	0.0258
		39	-0.1804	0.0421
		40	-0.1564	0.0357
		41	-0.2063	0.0617
		42	-0.2811	0.0914
		43	-0.2217	0.0886
		44	-0.1599	0.0605
		45	-0.1711	0.0528
		46	-0.1833	0.0494
		47	-0.1645	0.0384
		48	-0.2156	0.0616
		49	-0.2835	0.1332
		50	-0.2301	0.1194

Contract # 25: June 1996 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 189
Correlations are asymptotically consistent approximations

JUN96,VOLATILITY(-i)	JUN96,VOLATILITY(+i)	i	lag	lead
		0	0.2850	0.2850
		1	0.2384	0.2341
		2	0.2107	0.1600
		3	0.2018	0.1270
		4	0.1894	0.1225
		5	0.2142	0.1221
		6	0.3087	0.1434
		7	0.4150	0.1733
		8	0.3574	0.1386
		9	0.2914	0.1104
		10	0.2926	0.0920
		11	0.2773	0.0859
		12	0.2993	0.0802
		13	0.4294	0.1054
		14	0.5322	0.1364
		15	0.4277	0.1348
		16	0.3355	0.1163
		17	0.3499	0.0830
		18	0.3485	0.0730
		19	0.3579	0.0757
		20	0.4753	0.1183
		21	0.5769	0.1617
		22	0.4378	0.1375
		23	0.3154	0.0985
		24	0.3484	0.0717
		25	0.3529	0.0768
		26	0.3284	0.1014
		27	0.4643	0.1270
		28	0.5910	0.1615
		29	0.4857	0.1431
		30	0.3511	0.1055
		31	0.3645	0.0823
		32	0.3779	0.0855
		33	0.3482	0.1086
		34	0.4664	0.1318
		35	0.5962	0.1510
		36	0.4995	0.1191
		37	0.3605	0.0843
		38	0.3511	0.0526
		39	0.3577	0.0644
		40	0.3662	0.1012
		41	0.4941	0.0999
		42	0.5882	0.0894
		43	0.4646	0.0585
		44	0.3131	0.0381
		45	0.3242	0.0335
		46	0.3489	0.0354
		47	0.3451	0.0456
		48	0.4541	0.0439
		49	0.5555	0.0287
		50	0.4344	0.0122

Contract # 26: September 1996 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 115
Correlations are asymptotically consistent approximations

SEP96,VOLATILITY(-i)	SEP96,VOLATILITY(+i)	i	lag	lead
		0	-0.0681	-0.0681
		1	-0.0036	-0.0975
		2	-0.0389	-0.1193
		3	0.0048	-0.1132
		4	0.0986	-0.1391
		5	0.0517	-0.1544
		6	0.0435	-0.2232
		7	0.0893	-0.3148
		8	0.0878	-0.2543
		9	0.0119	-0.2071
		10	0.1378	-0.2286
		11	0.2140	-0.2631
		12	0.1059	-0.2380
		13	0.1698	-0.2996
		14	0.3018	-0.4127
		15	0.2385	-0.3266
		16	0.1821	-0.2384
		17	0.2664	-0.2601
		18	0.2435	-0.2581
		19	0.1896	-0.2322
		20	0.2874	-0.2919
		21	0.3591	-0.3811
		22	0.2756	-0.3094
		23	0.2045	-0.2273
		24	0.2296	-0.2154
		25	0.2269	-0.1911
		26	0.2453	-0.1977
		27	0.3319	-0.2591
		28	0.3426	-0.2944
		29	0.2657	-0.2269
		30	0.1933	-0.1351
		31	0.1847	-0.1144
		32	0.2035	-0.1087
		33	0.1910	-0.0889
		34	0.2706	-0.1357
		35	0.3416	-0.1507
		36	0.2673	-0.1253
		37	0.1824	-0.0835
		38	0.2105	-0.0760
		39	0.2255	-0.0049
		40	0.2558	0.0328
		41	0.2665	-0.0064
		42	0.2581	0.0196
		43	0.1506	-0.0291
		44	0.0902	-0.0483
		45	0.1016	-0.0130
		46	0.1249	0.0881
		47	0.1383	0.1068
		48	0.1096	0.0593
		49	0.1044	0.0824
		50	0.0371	0.0474

Contract # 27: December 1996 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 116
Correlations are asymptotically consistent approximations

DEC96,VOLATILITY(-i)	DEC96,VOLATILITY(+i)	i	lag	lead
		0	0.0381	0.0381
		1	0.0305	-0.0076
		2	0.0698	-0.0438
		3	0.0731	-0.0143
		4	0.0559	0.0128
		5	0.0822	0.0252
		6	0.1253	-0.0050
		7	0.1653	-0.0504
		8	0.1330	-0.1150
		9	0.0938	-0.1290
		10	0.1245	-0.0712
		11	0.1066	-0.0199
		12	0.0948	-0.0127
		13	0.1482	-0.0759
		14	0.1924	-0.1409
		15	0.1165	-0.1829
		16	0.0639	-0.1608
		17	0.1191	-0.0910
		18	0.1130	-0.0395
		19	0.0903	-0.0276
		20	0.1233	-0.0949
		21	0.1565	-0.1381
		22	0.1058	-0.1608
		23	0.0717	-0.1320
		24	0.1460	-0.0358
		25	0.1404	0.0198
		26	0.0929	0.0227
		27	0.1206	0.0094
		28	0.1712	0.0195
		29	0.1140	0.0293
		30	0.0862	0.0642
		31	0.1544	0.1230
		32	0.1451	0.0343
		33	0.0965	0.0213
		34	0.1429	0.0948
		35	0.1921	0.0725
		36	0.1404	0.0353
		37	0.1298	0.0805
		38	0.1704	0.1084
		39	0.1491	-0.0093
		40	0.1299	-0.0079
		41	0.1548	0.0576
		42	0.2126	0.0202
		43	0.1391	-0.0351
		44	0.1355	-0.0234
		45	0.1459	-0.0409
		46	0.1023	-0.0886
		47	0.0899	-0.1082
		48	0.1106	-0.0953
		49	0.1274	-0.1260
		50	0.0825	-0.0519

Contract # 30: March 1997 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 417
Correlations are asymptotically consistent approximations

MAR97,VOLATILITY(-i)	MAR97,VOLATILITY(+i)	i	lag	lead
		0	0.0903	0.0903
		1	0.0777	0.0542
		2	0.0630	0.0383
		3	0.0523	0.0434
		4	0.0417	0.0623
		5	0.0413	0.0648
		6	0.0577	0.0803
		7	0.0716	0.0952
		8	0.0644	0.0787
		9	0.0430	0.0473
		10	0.0391	0.0545
		11	0.0278	0.0834
		12	0.0225	0.0909
		13	0.0297	0.1122
		14	0.0362	0.1360
		15	0.0288	0.1170
		16	0.0108	0.0773
		17	0.0029	0.0832
		18	0.0081	0.1096
		19	0.0028	0.1223
		20	-0.0053	0.1561
		21	-0.0177	0.1895
		22	-0.0181	0.1565
		23	-0.0267	0.1095
		24	-0.0293	0.1200
		25	-0.0226	0.1508
		26	-0.0239	0.1585
		27	-0.0425	0.2055
		28	-0.0633	0.2634
		29	-0.0494	0.2204
		30	-0.0442	0.1630
		31	-0.0429	0.1717
		32	-0.0390	0.2011
		33	-0.0491	0.2021
		34	-0.0675	0.2710
		35	-0.0809	0.3455
		36	-0.0653	0.2809
		37	-0.0511	0.2063
		38	-0.0466	0.2305
		39	-0.0484	0.2508
		40	-0.0576	0.2481
		41	-0.0790	0.3364
		42	-0.0972	0.4272
		43	-0.0787	0.3420
		44	-0.0541	0.2458
		45	-0.0501	0.2677
		46	-0.0616	0.2869
		47	-0.0675	0.2884
		48	-0.0855	0.3850
		49	-0.1056	0.4784
		50	-0.0868	0.3875

Contract # 31: June 1997 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 166
Correlations are asymptotically consistent approximations

JUN97,VOLATILITY(-i)	JUN97,VOLATILITY(+i)	i	lag	lead
		0	-0.1091	-0.1091
		1	-0.0934	-0.0984
		2	-0.0360	-0.0757
		3	-0.0629	-0.1136
		4	-0.1301	-0.0408
		5	-0.0845	-0.0374
		6	-0.0807	-0.1475
		7	-0.0585	-0.1517
		8	-0.0501	-0.1244
		9	-0.0071	-0.1220
		10	-0.0304	-0.1226
		11	-0.0522	-0.0447
		12	-0.0022	-0.0435
		13	0.0024	-0.1431
		14	-0.0109	-0.1549
		15	-0.0074	-0.1400
		16	-0.0257	-0.1201
		17	-0.0366	-0.1018
		18	-0.0322	-0.0352
		19	-0.0155	-0.0346
		20	-0.0354	-0.1213
		21	-0.0666	-0.1172
		22	-0.0990	-0.1103
		23	-0.0396	-0.0819
		24	-0.0419	-0.0422
		25	-0.0583	0.0021
		26	-0.0568	0.0171
		27	-0.0938	-0.0380
		28	-0.1149	-0.0020
		29	-0.0974	0.0481
		30	-0.0662	0.0611
		31	-0.0487	0.0614
		32	-0.0774	0.0185
		33	-0.0590	0.0444
		34	-0.0943	0.0857
		35	-0.1354	0.1096
		36	-0.1168	0.0815
		37	-0.0728	0.0779
		38	-0.0737	0.0893
		39	-0.0948	0.0559
		40	-0.0936	0.0661
		41	-0.1316	0.0946
		42	-0.1639	0.1191
		43	-0.1286	0.0858
		44	-0.0760	0.0658
		45	-0.0748	0.0924
		46	-0.1080	0.0734
		47	-0.0652	0.0662
		48	-0.0770	0.0891
		49	-0.1199	0.1050
		50	-0.0527	0.0484

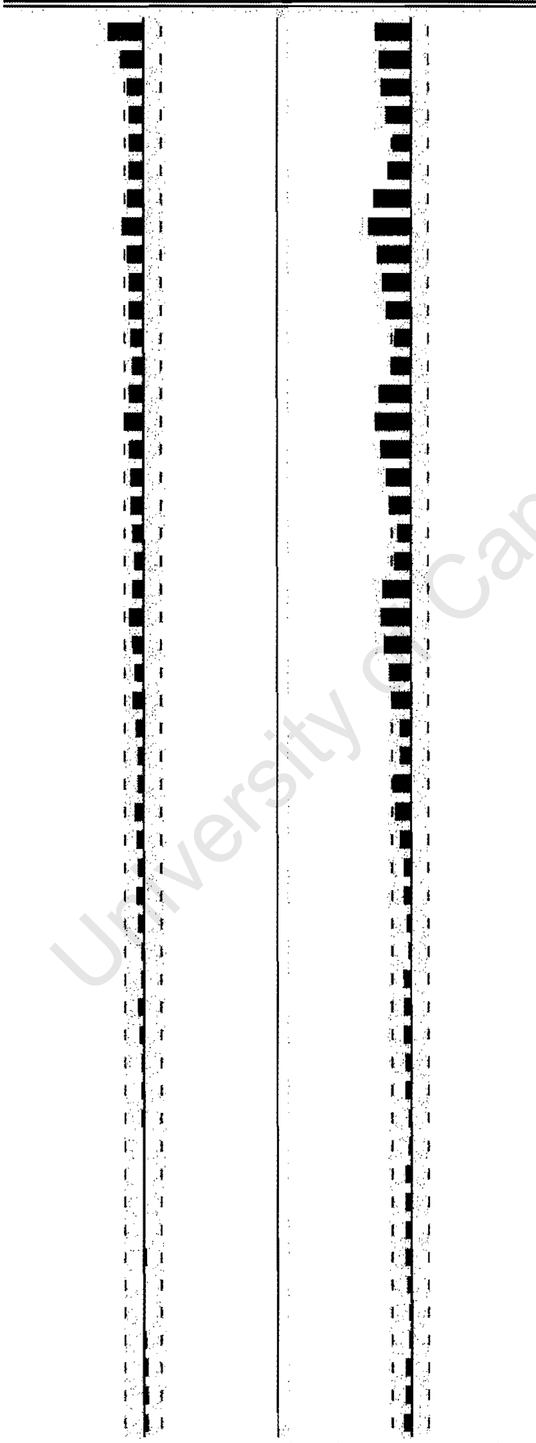
Contract # 32: September 1997 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 182
Correlations are asymptotically consistent approximations

SEP97,VOLATILITY(-i)	SEP97,VOLATILITY(+i)	i	lag	lead
		0	0.0066	0.0066
		1	0.0330	-0.0031
		2	0.0475	0.0027
		3	0.0326	-0.0316
		4	-0.0088	-0.0279
		5	-0.0055	-0.0131
		6	0.0433	-0.0639
		7	0.0968	-0.0904
		8	0.0617	-0.0571
		9	0.0556	-0.0727
		10	0.0361	-0.0938
		11	0.0124	-0.0495
		12	0.0448	-0.0347
		13	0.0681	-0.0673
		14	0.0503	-0.1045
		15	0.0704	-0.0785
		16	0.0134	-0.0581
		17	0.0136	-0.0604
		18	0.0617	-0.0330
		19	0.0523	-0.0313
		20	0.0639	-0.0645
		21	0.0837	-0.0676
		22	0.0370	-0.0511
		23	0.0180	-0.0382
		24	0.0269	-0.0386
		25	0.0821	0.0012
		26	0.0703	0.0033
		27	0.0666	-0.0312
		28	0.0604	-0.0109
		29	0.0468	0.0685
		30	0.0051	0.0708
		31	0.0158	0.0660
		32	0.0656	0.0181
		33	0.0643	0.0315
		34	0.0532	0.0911
		35	0.0352	0.1163
		36	0.0139	0.1103
		37	0.0080	0.1075
		38	0.0116	0.0890
		39	-0.0003	0.0326
		40	0.0020	0.0396
		41	-0.0050	0.1004
		42	-0.0374	0.1169
		43	-0.0540	0.1095
		44	-0.0086	0.0915
		45	-0.0012	0.0814
		46	-0.0461	0.0276
		47	-0.0026	0.0285
		48	0.0004	0.0942
		49	-0.0076	0.0873
		50	0.0781	0.0666

Contract # 33: December 1997 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 193
Correlations are asymptotically consistent approximations



i	lag	lead
0	-0.2627	-0.2627
1	-0.1677	-0.2457
2	-0.1206	-0.2136
3	-0.1029	-0.1864
4	-0.1018	-0.1301
5	-0.1004	-0.1689
6	-0.1192	-0.2758
7	-0.1509	-0.3120
8	-0.1127	-0.2519
9	-0.1003	-0.2073
10	-0.1008	-0.1833
11	-0.0875	-0.1169
12	-0.0783	-0.1468
13	-0.1045	-0.2351
14	-0.1442	-0.2604
15	-0.1009	-0.2188
16	-0.0886	-0.1821
17	-0.0948	-0.1569
18	-0.0743	-0.0923
19	-0.0634	-0.1200
20	-0.0797	-0.2061
21	-0.1036	-0.2253
22	-0.0709	-0.1900
23	-0.0600	-0.1512
24	-0.0670	-0.1315
25	-0.0549	-0.0695
26	-0.0320	-0.0752
27	-0.0379	-0.1293
28	-0.0630	-0.1104
29	-0.0462	-0.0667
30	-0.0380	-0.0438
31	-0.0423	-0.0465
32	-0.0351	-0.0191
33	-0.0120	-0.0147
34	-0.0115	-0.0453
35	-0.0307	-0.0457
36	-0.0205	-0.0413
37	-0.0124	-0.0290
38	-0.0135	-0.0283
39	-0.0145	-0.0094
40	0.0022	-0.0119
41	0.0117	-0.0398
42	0.0091	-0.0368
43	0.0141	-0.0350
44	0.0191	-0.0247
45	0.0137	-0.0238
46	0.0072	-0.0054
47	0.0219	-0.0114
48	0.0342	-0.0398
49	0.0340	-0.0383
50	0.0271	-0.0450

Contract # 34: March 1998 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 347
Correlations are asymptotically consistent approximations

MAR98,VOLATILITY(-i)	MAR98,VOLATILITY(+i)	i	lag	lead
		0	-0.1993	-0.1993
		1	-0.1487	-0.1850
		2	-0.0891	-0.1613
		3	-0.0773	-0.1411
		4	-0.1083	-0.0910
		5	-0.1073	-0.1219
		6	-0.1224	-0.2062
		7	-0.1471	-0.2282
		8	-0.1195	-0.1871
		9	-0.0860	-0.1582
		10	-0.0878	-0.1377
		11	-0.1066	-0.0803
		12	-0.0913	-0.1051
		13	-0.1188	-0.1765
		14	-0.1660	-0.1930
		15	-0.1283	-0.1649
		16	-0.0995	-0.1408
		17	-0.1081	-0.1166
		18	-0.1107	-0.0585
		19	-0.0985	-0.0851
		20	-0.1274	-0.1569
		21	-0.1676	-0.1698
		22	-0.1330	-0.1502
		23	-0.0991	-0.1254
		24	-0.1071	-0.1016
		25	-0.1050	-0.0468
		26	-0.0858	-0.0585
		27	-0.1130	-0.1050
		28	-0.1557	-0.0903
		29	-0.1253	-0.0620
		30	-0.0933	-0.0464
		31	-0.0917	-0.0393
		32	-0.0915	-0.0194
		33	-0.0756	-0.0230
		34	-0.1002	-0.0543
		35	-0.1396	-0.0595
		36	-0.1136	-0.0535
		37	-0.0792	-0.0421
		38	-0.0667	-0.0389
		39	-0.0776	-0.0264
		40	-0.0739	-0.0296
		41	-0.0838	-0.0561
		42	-0.1017	-0.0621
		43	-0.0793	-0.0482
		44	-0.0402	-0.0371
		45	-0.0331	-0.0399
		46	-0.0556	-0.0318
		47	-0.0481	-0.0381
		48	-0.0492	-0.0632
		49	-0.0663	-0.0718
		50	-0.0529	-0.0615

Contract # 35: June 1998 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 183
Correlations are asymptotically consistent approximations

JUN98,VOLATILITY(-i)	JUN98,VOLATILITY(+i)	i	lag	lead
		0	0.0092	0.0092
		1	0.0413	-0.0175
		2	0.0308	-0.0458
		3	0.0018	-0.0304
		4	-0.0255	0.0427
		5	0.0318	0.0208
		6	0.0485	-0.0251
		7	0.0217	0.0278
		8	0.0247	0.0485
		9	0.0011	0.0417
		10	-0.0249	0.0489
		11	-0.0137	0.0970
		12	0.0515	0.0827
		13	0.0577	0.1006
		14	0.0295	0.1692
		15	0.0501	0.1356
		16	0.0116	0.0972
		17	-0.0116	0.1131
		18	0.0116	0.1524
		19	0.0637	0.1333
		20	0.0971	0.1669
		21	0.0868	0.2177
		22	0.0779	0.1848
		23	0.0568	0.1463
		24	0.0308	0.1705
		25	0.0374	0.2064
		26	0.1099	0.1839
		27	0.1570	0.2829
		28	0.1483	0.4280
		29	0.1151	0.3788
		30	0.0801	0.3031
		31	0.0887	0.3051
		32	0.0979	0.2910
		33	0.1365	0.2991
		34	0.1865	0.3994
		35	0.1841	0.4828
		36	0.1289	0.3427
		37	0.0783	0.2596
		38	0.1079	0.2911
		39	0.0831	0.2709
		40	0.0900	0.2447
		41	0.1411	0.3105
		42	0.1526	0.3760
		43	0.1085	0.2820
		44	0.0795	0.2027
		45	0.0983	0.2157
		46	0.0704	0.2099
		47	0.0813	0.1828
		48	0.1092	0.2244
		49	0.0945	0.2705
		50	0.0412	0.1706

Contract # 36: September 1998 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 246
Correlations are asymptotically consistent approximations

i	lag	lead
0	0.1369	0.1369
1	0.1095	0.1032
2	0.0873	0.0819
3	0.0963	0.0867
4	0.0839	0.0914
5	0.0906	0.0887
6	0.1172	0.1198
7	0.1397	0.1789
8	0.1033	0.1620
9	0.0800	0.1361
10	0.0751	0.1268
11	0.0767	0.1297
12	0.0963	0.1385
13	0.1166	0.1865
14	0.1373	0.2426
15	0.1192	0.1927
16	0.0920	0.1443
17	0.0769	0.1388
18	0.0758	0.1266
19	0.1021	0.1358
20	0.1456	0.1979
21	0.1787	0.2356
22	0.1445	0.1970
23	0.1355	0.1632
24	0.1201	0.1469
25	0.0925	0.1495
26	0.1389	0.1860
27	0.1965	0.2807
28	0.2152	0.3520
29	0.1575	0.3067
30	0.1333	0.2337
31	0.1261	0.2173
32	0.0948	0.2274
33	0.1274	0.2534
34	0.1787	0.3217
35	0.1908	0.3767
36	0.1384	0.2741
37	0.1114	0.1964
38	0.1056	0.2206
39	0.0544	0.2187
40	0.0673	0.2095
41	0.1101	0.2684
42	0.1086	0.3232
43	0.0748	0.2464
44	0.0580	0.1701
45	0.0567	0.1813
46	0.0213	0.1961
47	0.0228	0.1744
48	0.0402	0.2243
49	0.0248	0.2699
50	0.0016	0.1839

Contract # 37: December 1998 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 262
Correlations are asymptotically consistent approximations

DEC98,VOLATILITY(-i)	DEC98,VOLATILITY(+i)	i	lag	lead
		0	0.0854	0.0854
		1	0.1015	0.0829
		2	0.0840	0.0421
		3	0.0504	-0.0027
		4	0.0420	0.0045
		5	0.1039	0.0305
		6	0.1593	0.0338
		7	0.1780	0.0356
		8	0.1521	0.0507
		9	0.1220	0.0266
		10	0.0953	-0.0187
		11	0.0969	-0.0008
		12	0.1584	0.0181
		13	0.2213	0.0139
		14	0.2555	0.0039
		15	0.2223	0.0253
		16	0.1705	0.0066
		17	0.1437	-0.0283
		18	0.1382	-0.0192
		19	0.1841	-0.0128
		20	0.2567	-0.0139
		21	0.3024	-0.0327
		22	0.2482	-0.0159
		23	0.1935	-0.0220
		24	0.1638	-0.0507
		25	0.1598	-0.0451
		26	0.2240	-0.0437
		27	0.3129	-0.0445
		28	0.3513	-0.0702
		29	0.2728	-0.0605
		30	0.2094	-0.0478
		31	0.2013	-0.0645
		32	0.2077	-0.0532
		33	0.2674	-0.0543
		34	0.3588	-0.0854
		35	0.4123	-0.1117
		36	0.3391	-0.0989
		37	0.2575	-0.0846
		38	0.2345	-0.0884
		39	0.2214	-0.0715
		40	0.2807	-0.0734
		41	0.3917	-0.1148
		42	0.4531	-0.1478
		43	0.3766	-0.1224
		44	0.2818	-0.1039
		45	0.2606	-0.1101
		46	0.2524	-0.0849
		47	0.3080	-0.0852
		48	0.4279	-0.1192
		49	0.5123	-0.1613
		50	0.4205	-0.1408

Contract # 38: March 1999 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 513
Correlations are asymptotically consistent approximations

MAR99,VOLATILITY(-i)	MAR99,VOLATILITY(+i)	i	lag	lead
		0	-0.1373	-0.1373
		1	-0.1124	-0.1151
		2	-0.0560	-0.0950
		3	-0.0567	-0.0973
		4	-0.0973	-0.0627
		5	-0.0947	-0.0628
		6	-0.1062	-0.1202
		7	-0.0872	-0.1383
		8	-0.0684	-0.1143
		9	-0.0492	-0.0968
		10	-0.0496	-0.0995
		11	-0.0514	-0.0609
		12	-0.0469	-0.0620
		13	-0.0580	-0.1203
		14	-0.0727	-0.1411
		15	-0.0569	-0.1194
		16	-0.0428	-0.1002
		17	-0.0424	-0.1015
		18	-0.0442	-0.0646
		19	-0.0411	-0.0668
		20	-0.0506	-0.1260
		21	-0.0640	-0.1503
		22	-0.0500	-0.1278
		23	-0.0341	-0.1076
		24	-0.0344	-0.1087
		25	-0.0399	-0.0698
		26	-0.0333	-0.0727
		27	-0.0368	-0.1334
		28	-0.0485	-0.1577
		29	-0.0412	-0.1287
		30	-0.0296	-0.1075
		31	-0.0250	-0.1053
		32	-0.0274	-0.0705
		33	-0.0219	-0.0753
		34	-0.0263	-0.1370
		35	-0.0371	-0.1653
		36	-0.0296	-0.1424
		37	-0.0219	-0.1189
		38	-0.0202	-0.1165
		39	-0.0247	-0.0824
		40	-0.0180	-0.0882
		41	-0.0191	-0.1531
		42	-0.0290	-0.1837
		43	-0.0233	-0.1543
		44	-0.0189	-0.1260
		45	-0.0149	-0.1231
		46	-0.0162	-0.0894
		47	-0.0105	-0.0937
		48	-0.0109	-0.1545
		49	-0.0197	-0.1848
		50	-0.0183	-0.1565

Contract # 39: June 1999 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 229
Correlations are asymptotically consistent approximations

JUN99,VOLATILITY(-i)	JUN99,VOLATILITY(+i)	i	lag	lead
		0	-0.1042	-0.1042
		1	-0.0610	-0.0592
		2	-0.0390	-0.0339
		3	-0.0509	-0.0397
		4	-0.0534	-0.0526
		5	-0.0394	-0.0479
		6	-0.0471	-0.0536
		7	-0.0486	-0.0596
		8	-0.0376	-0.0478
		9	-0.0155	-0.0413
		10	-0.0277	-0.0298
		11	-0.0409	-0.0255
		12	-0.0232	-0.0553
		13	-0.0188	-0.0837
		14	-0.0324	-0.1069
		15	-0.0104	-0.0900
		16	0.0009	-0.0909
		17	0.0009	-0.0807
		18	-0.0233	-0.0734
		19	-0.0137	-0.1042
		20	0.0006	-0.1586
		21	0.0030	-0.1954
		22	0.0021	-0.1651
		23	0.0177	-0.1566
		24	0.0095	-0.1631
		25	-0.0127	-0.1404
		26	-0.0054	-0.1652
		27	0.0205	-0.2465
		28	0.0305	-0.3202
		29	0.0266	-0.2570
		30	0.0396	-0.2228
		31	0.0494	-0.2317
		32	0.0256	-0.2196
		33	0.0210	-0.2311
		34	0.0565	-0.3341
		35	0.0770	-0.4319
		36	0.0603	-0.3508
		37	0.0519	-0.2875
		38	0.0440	-0.3120
		39	0.0326	-0.3023
		40	0.0403	-0.3038
		41	0.0573	-0.4234
		42	0.0660	-0.5530
		43	0.0638	-0.4318
		44	0.0538	-0.3413
		45	0.0556	-0.3738
		46	0.0329	-0.3647
		47	0.0444	-0.3437
		48	0.0788	-0.4674
		49	0.0972	-0.5962
		50	0.0852	-0.4661

Contract # 40: September 1999 ALSI Futures Contract

Sample: 6/05/1990 12/08/2000
Included observations: 150
Correlations are asymptotically consistent approximations

SEP99,VOLATILITY(-i)	SEP99,VOLATILITY(+i)	i	lag	lead
		0	-0.3624	-0.3624
		1	-0.2635	-0.2635
		2	-0.2160	-0.1374
		3	-0.2565	-0.1458
		4	-0.2251	-0.1734
		5	-0.1920	-0.1477
		6	-0.2094	-0.1621
		7	-0.2011	-0.1934
		8	-0.0364	-0.1506
		9	-0.0173	-0.1156
		10	0.0053	-0.0854
		11	-0.0334	-0.0744
		12	-0.0204	-0.0783
		13	0.0422	-0.1585
		14	0.0908	-0.1750
		15	0.1118	-0.1333
		16	0.0950	-0.0477
		17	0.0696	-0.0425
		18	0.0686	-0.0716
		19	0.0479	-0.0794
		20	0.1205	-0.0869
		21	0.1510	-0.0864
		22	0.1440	-0.0511
		23	0.0929	-0.0261
		24	0.0801	-0.0781
		25	0.0640	-0.0989
		26	0.0356	-0.0739
		27	0.0857	-0.1384
		28	0.1317	-0.1810
		29	0.1477	-0.1411
		30	0.1324	-0.0836
		31	0.1336	-0.0852
		32	0.0867	-0.1177
		33	0.0294	-0.1351
		34	0.0761	-0.1405
		35	0.1361	-0.1591
		36	0.1370	-0.1307
		37	0.0710	-0.0587
		38	0.0537	-0.0500
		39	0.0721	-0.0881
		40	0.0423	-0.1174
		41	0.0473	-0.1455
		42	0.0856	-0.1273
		43	0.0893	-0.1058
		44	0.0927	-0.0611
		45	0.0771	-0.0552
		46	0.0980	-0.0621
		47	0.0697	-0.0855
		48	0.1409	-0.1224
		49	0.2145	-0.1353
		50	0.2098	-0.1017

Appendix 9.2 – Correlograms for the correlations between "GARCH(1,1)" ALSI volatility and the ALSI Arbitrage Gap.

See accompanying CD – Rom.

Appendix 9.3 – Legislative Environment Analysis.

A9.3.1 SAFEX internal regulation

On the 29 November 1995 the rules of SAFEX replaced the original constitution adopted by SAFEX on 14 February 1990. The new rules adopted all the articles of the constitution and have since evolved into the current set. In the SAFEX rules, the objectives of SAFEX are defined as "to establish, operate and regulate a financial exchange where trading in the financial instruments listed by SAFEX will be conducted in a fair and orderly manner and in accordance with the provisions of the Act" (SAFEX Rules, 1999 : 2-1). In the rules, SAFEX is recognised as a juristic person with all the associated succession rights.

The rules set out the executive committee of SAFEX. This being no less than seven and no more than eleven representatives of the members of SAFEX (who the rules are to govern). The requirements for membership of SAFEX are set out in the rules (see table A9.1 below) as well as the conditions for on going membership and capital requirements. SAFEX has two classes of members, namely the clearing and non-clearing members. These also break down into two further categories, namely: broking and non-broking members. A clearing member is defined as "a person admitted by the executive committee as a clearing member of SAFEX and who has entered into a clearing house agreement with the clearing house" (SAFEX Rules, 1999 : 1-7). A non-Clearing member is defined as "any person admitted by the executive committee to membership of SAFEX and who is not a clearing member but who is either a broking member or a non-broking member " (SAFEX Rules, 1999 : 1-15). A Broking member is defined as "a member who is a financial instrument trader" (SAFEX Rules, 1999 : 1-4). A non-broking member is defined as "a member who may trade with members for his own account but not with clients" (SAFEX Rules, 1999 : 1-14).

Table A9.1 - Requirements for Membership of SAFEX.

Natural Persons	Requirements
	Members who are natural persons and affiliated officers of members shall, in the opinion of the executive committee, be of good character and high business integrity and shall not in the five years or whatever longer period the executive committee may decide, prior to the date on which the membership is considered by the executive committee have been -
	convicted of a criminal offence;
	expelled, whether as a member or otherwise, from any financial exchange as defined in the Act or stock exchange as defined in the Stock Exchanges Control Act, 1985 (Act No 1 of 1985), or

	from any similar institution or association in the Republic of South Africa or elsewhere;
	employed by or associated with a member of any financial exchange as defined in the Act or stock exchange as defined in the Stock Exchanges Control Act, 1985 (Act No 1 of 1985), or similar institution or association in the Republic of South Africa or elsewhere who was expelled as a member of that exchange and where the person or affiliated officer has, in the opinion of the executive committee, contributed to the act which led to the expulsion of such member;
	dismissed from the employment of any member of any financial exchange as defined in the Act or stock exchange as defined in the Stock Exchanges Control Act, 1985 (Act No 1 of 1985), or similar institution or association whether in the Republic of South Africa or elsewhere where, in the opinion of the executive committee, the act or omission that led to such dismissal would exclude such person as a member or affiliated officer under the rules of SAFEX.
	A member who is a natural person shall be at least twenty-one years of age and of full legal capacity and a citizen or permanent resident of the Republic of South Africa.
Corporate Entities	**Requirements**
	A member which is a body corporate, external company or partnership shall -
	not employ, register or permit an affiliated officer to be in any way associated with it without the prior approval of the executive committee;
	have, in the opinion of the executive committee, a good reputation and high business standing.
	the external company shall, when submitting its application for membership, submit proof of compliance with the requirements of Section 322 of the Companies Act, 1973 (Act No. 61 of 1973) by furnishing the membership committee with the certificate of registration as provided for in Section 322(2) of the said Companies Act;
	the own funds of the local branch of the external company shall at all times exceed the liabilities of the said local branch of the external company in the Republic by an amount equal to or greater than that provided for in rule 4.2.5, 4.2.6, 4.2.7 or 4.2.8 (of the SAFEX rules) as the case may be;
	the foreign parent of the local branch of the external company shall confirm to the exchange that it is required to comply with capital adequacy requirements similar to those in the Republic, and that they are reporting such as required to a foreign regulator;
	the thirteen weeks operating costs requirement I rule 4.2.4.2 (of the SAFEX rules) shall relate to the operating costs of the local branch of the external company in the Republic; and
	an external company which operates as a branch by means of which a foreign institution conducts the business of a bank, shall submit its capital adequacy returns in terms of rules 4.6.6 and 4.6.7 (of the SAFEX rules) to the Registrar of Banks, and shall at all times comply with the Banks Act, 1990 (Act No. 94 of 1990) and any Conditions published in terms of the said Banks Act.

(Source: SAFEX Rules, 1999 : 4-1 to 4-3)

The SAFEX rules also outline the need for a compliance officer to ensure compliance of the member with the rules of SAFEX. The compliance section of the rules extend to the monitoring of who the member is able to trade with and which of the member's staff are able to do so. Junior dealers are only able to trade for the member's account. Senior dealers are able to trade for the member's account as well as client accounts.

In order for one to become a member of SAFEX, one must purchase a seat on SAFEX. The registration of one seat, whether owned or leased, confers membership on the person in whose name the seat is registered. (SAFEX Rules, 1999 : 6-1). Seats can be bought and sold as well as leased. This would occur where membership ceases (either voluntarily or through the actions of SAFEX). The withdrawing member is able to sell a seat in the open market as long as the purchaser complies with all the requirements of becoming a member. The price of seats on an exchange often reflect the health of the financial sector. If the demand for seats increases along with the price one usually experiences buoyant markets. Members, who own more than one seat, are able to lease their surplus seats to other members, as long as, in the event the lessee's membership is terminated, the lease terminates. The acquisition (and leasing) of seats on the exchange is subject to the 10% rule. No member is able to hold more than 10% of the seats on SAFEX whether through ownership or leasing arrangements. This is to guard against undue influencing of the exchange by individual members.

The rules of SAFEX also govern the actual trading practices of the members. This is primarily driven through ATS (Automated Trading System) - SAFEX's electronic trading platform. SAFEX does allow Off-ATS trading, but this is determined by the executive committee of SAFEX. If a trade is Off-ATS, the trade will either be telephonic or written. In this case the precise requirements for what constitutes a valid offer or bid are outlined in the SAFEX rules. If a trade is conducted through ATS the member is bound by the trade, regardless of whether the trade was authorised by the member or not. In this way SAFEX passes on the responsibility to ensure that only authorised trades are conducted, to the members of the exchange. The members thus become responsible for all application controls over their ATS terminals. The time of ATS trading is from 07h30 to 17h30 each business day with 30 minutes allowed after trading for administrative purposes.

Off-ATS trades need to be reported to maintain market transparency. The SAFEX rules thus dictate that in the event of an Off-ATS trade having taken place, the trade must be reported to the clearing house within 10 minutes of the trade having taken place. Off-ATS trades concluded after trading hours are to be reported the following morning.

Another issue that concerns trading practices is that of order priority. The basic rule in this case is "A member shall not trade with another member if the trade could satisfy an order from a client" (SAFEX

Rules, 1999 : 7-6). The rule is designed to ensure all clients are treated equally. During times of market turbulence brokers have been accused of favoring larger clients over smaller ones and executing their orders first. This is not specific to SAFEX and is more of a general financial market issue. Further to the above rule, a member shall not trade with a client if the trade could satisfy a previously received order from another client (SAFEX Rules, 1999 : 7-6). This is also extended to include the protection of other members "a member shall not trade with another member, if the trade could satisfy a previously received order from another member" (SAFEX Rules, 1999 : 7-6).

The basic rule when trading with clients and other members is that the member shall be liable to ensure due fulfillment of all obligations arising out of the trade. Members may trade as both agents and principals with clients and other members. If a member has two clients with corresponding buy and sell offers the member may net them off as an Off-ATS transaction, but may only do so as a principal and after complying with certain SAFEX rules. In order to be able to trade with clients, members have to enter into client agreements. These agreements set out the terms within which the client can trade with and through the member. The client must also register with the member before being able to trade. The required registration details are set out in the SAFEX rules. The member will also be required to send advice notes to the client from time to time. The format of these are determined by SAFEX.

Clearing of trades by the clearing house are also governed by the SAFEX rules. Trades are cleared by the clearing house when, in the case of Off-ATS trades, the trade is either reported to the clearing house or matched as allowed by the SAFEX rules. In the case of ATS based trades, the clearing occurs as soon as the trade is concluded on ATS. The way in which the actual trade is cleared is through a process called Novation. Novation is where, in the case of the buyer, SAFEX replaces the seller and becomes the new seller to the buyer. In the case of the seller, SAFEX replaces the buyer and becomes the buyer to the seller. In the event the price of the trade is substantially different to the current market price the clearing house can refuse to clear the trade.

The trade is treated as an open position if the participant has not entered into a trade involving the same contract prior to the trade taking place. If the participant has entered into a trade in the contract prior to the trade taking place the participant is faced with two possible situations. The first case is where the previous trade was in the same direction as the current trade. In this case the open position of the participant is increased. In the second case the participant would have entered into an opposite trade to the original trade. In this case the open position would be reduced. This can be illustrated by means of an example: suppose a participant entered into 10 ALSI futures September 1997 contracts to buy the ALSI on 1 July 1997. If on the 10 July the participant entered into 10 more ALSI futures September 1997 contracts, to sell the ALSI, the open position on the 10 July would be nil. If the second trade was to buy the ALSI (rather than sell it) the open position would be +20. See table A9.2 below.

Table A9.2 - Open Positions Example.

Date	Movements in Contracts	Open Position
Scenario 1: 10 July sell ALSI.		
1 July 1997	+10	+10
10 July 1997	-10	0
Scenario 2: 10 July buy ALSI.		
1 July 1997	+10	+10
10 July 1997	+10	+20

The SAFEX rules make provision for the acceptance of margin from clients. This covers maintenance margin, variation margin and initial margin. The broker is also empowered to keep the margin in an account even if the client has not entered into any trades. This is allowed in anticipation of future trades. SAFEX invests all the margin it receives and pays out interest on this margin.

Market participants are limited, in terms of the SAFEX rules, to the size of the positions they can take. This limit is set at the worth of the participant added to any suretyships it may have. This limit is applicable to clearing members. For non clearing members the limits are set by the clearing members. In calculating the size of the positions that can be taken, the positions of the clients of the clearing member are taken into account. This is because, in the event of a client of the clearing member defaulting, the clearing member takes responsibility for the trading liabilities of the defaulting client. As the clearing member carries the risk of its clients in the event of their default, the clearing member is able to set any limits that may be deemed necessary.

Market participants who have clients are not restricted to simply transact for their clients. The SAFEX rules make provision for the market participants to actively manage the clients' investments. This may only be done, however, if the participant has a discretionary client agreement in place between itself and the client. The reporting requirements are subject to the same rules as the participant would be for normal client reporting activities.
Members of SAFEX are subject to a code of Ethics. These are also established in the SAFEX rules. The broad underlying principle that the member must adhere to is: the member must not engage in any activity that could bring SAFEX into disrepute. A number of bad practices are identified as being not acceptable. These include price manipulation, cheating, defrauding, and the supplying of misleading information, dishonesty and the creating of fictitious trades. Advertising by the members is also regulated by the Ethics section of the SAFEX rules. Members are not allowed to advertise to the general public by only advertising

the potential for profit from futures trading without a statement warning of the possibility for loss. No statements are allowed to be made that suggest trading on SAFEX is appropriate for all individuals.

The Ethics section of the SAFEX rules also govern the issue of insider trading. Members may not enter into trades if the member knows that the "information was obtained by virtue of a relationship of trust or contract, whether or not the person is a party to that relationship, or through espionage, theft, bribery, fraud, misrepresentation or any other wrongful method" (SAFEX Rules, 1999 : 16-3). The information must also not be "generally available to the reasonable investor and includes information that some other person intends to trade in the exchange contract or a related exchange contract or the underlying instrument of the exchange contract or related exchange contract or any component of such underlying instrument on SAFEX or on any other exchange or market" (SAFEX Rules, 1999 : 16-3).

In the event of disciplinary hearings and investigations a set of procedures need to be followed by SAFEX. Disciplinary procedures come into action when a member fails to comply with the provisions of the rules. The first step involves an executive officer investigating the circumstances of the contravention. This will result in either the member being found innocent in which case the disciplinary procedures are terminated, or the member will be found guilty. On being found guilty, if the contravention is a minor offence the executive officer may issue a warning to the accused. If the contravention is not a minor offence the matter is referred to a disciplinary tribunal. This results in the accused being summonsed to a hearing where the evidence is heard before the disciplinary tribunal. The executive officer may suspend the member from trading for a period the officer deems necessary. On being found guilty the accused may be subject to the following penalties: a reprimand; a censure; a suspension; a termination of membership; a fine not exceeding one million Rands (to be paid into the Fidelity Fund) or the member being forced to terminate the employment of a registered officer in the employ of the member.

The details of the contravention, the findings and the penalty imposed must be published for the other members. The decisions of the tribunal are final unless provisions are made to appeal the findings to an appeal tribunal.

A9.3.1.1 Fidelity Fund

In accordance with the SAFEX rules, a Fidelity Fund has been set up to guarantee members' claims against one another. The fidelity fund is called the " SAFEX Fidelity Fund Trust" and has as its trustees the executive committee of SAFEX. The members contribute to the fidelity fund on the basis of the number of contracts they trade. The actual amount is determined by the trustees. The contributions are payable by the clearing members who are empowered to collect them from their respective clients for the trades entered into by their clients.

The funds within the Fidelity Fund are managed by the fund's trustees. The rules governing the management of the margin deposits by the clearing house also apply to the management of the Fidelity Fund. The fund itself is divided into two parts - a general fund and a member's fund. The member's fund is to settle claims of members against other members. In certain circumstances the settlement of this claim can be extended and paid out of the general fund. The general fund is for general claims and any claims made by non-members.

A person may recover from the fidelity fund the amount of the outstanding liabilities of a member due to him arising out of dealings in financial instruments. This is provided the amount of the claim has been determined by way of arbitration and has become final and the award of the arbitrator has not been satisfied by the member. A clearing member or the clearing house shall be entitled to apply any such balance towards a claim by a person against a member and, if after the application of such balance, any part of the award remains unpaid, the trustees shall consider a payment from the fidelity fund (SAFEX Rules, 1999 : 18-3).

A9.3.1.2 Safcom

As part of the normal exchange activities SAFEX provides a clearing facility of all its trades through Safcom. Safcom is a wholly owned subsidiary of SAFEX. Safcom (Pty) Ltd (Safcom Clearing Company) provides clearing and margining facilities for SAFEX (Lambrechts, 1990 : 117). Safcom is a private company (not for profit) that administers and manages the clearing house. The actual clearing of the trades is done by the clearing members of the exchange as outlined in the rules. Safcom also provides SAFEX with compliance, surveillance and other exchange services (SAFEX, 1999 : 15). Safcom provides the service to both the agricultural and financial arms of SAFEX.

SAFEX pays Safcom a management fee for the services it provides. This is the primary form of income other than the interest spread earned on the margin accounts it manages on behalf of SAFEX. This will usually not amount to anything as Safcom passes on all interest earned from the margin accounts to the margin account holders. This does differ, however, in the case of a loss, where Safcom will absorb this loss. An example of this occurred in 1999 when Safcom placed margin funds with a bank that was subsequently placed under curatorship. Safcom had to make good the losses. In this case SAFEX reimbursed Safcom for the losses made. Safcom also provides SAFEX with ATS (Automated Trading System). ATS is managed and maintained by Safcom, which developed ATS in house for SAFEX. As at the end of 1999 the number of clearing members who performed the clearing of the trades put through SAFEX was 7. These 7 members cleared the trades through the Safcom clearing company.

Safcom, according to Patrick Birley (2000), the Chief Executive of SAFEX has one of the lowest clearing costs in the world. This enables SAFEX to charge amongst the lowest transaction costs of the world's futures exchanges. It is important that Safcom performs its duties without any problems or delay. The clearing house serves to remove the credit risk from the transaction through the process of novation. One must remember, however, that the credit risk is not entirely removed, Safcom becomes the guarantor of the trade. For this reason the market has to have confidence in Safcom, from both a credit and operational perspective. The credit perspective is covered by the fact that the clearing members essentially "underwrite" the trades being cleared through Safcom. For this reason the credit risk profile of Safcom is the credit risk profile of the clearing members. It is for this reason that the requirements to become a clearing member are so onerous. The operational confidence is needed for market participants to ensure that they can rely on trades being cleared and recorded correctly. The goals of Safcom are thus to "provide its services to the members of SAFEX as efficiently and economically as possible" (Lambrechts, 1990 : 117). Safcom thus plays an important role in the successful functioning of the market.

A9.3.2 Legislation

Besides the SAFEX rules, the only other piece of legislation governing the futures market is the Financial Markets Control Act of 1989. This ignores other non specific pieces of legislation such as the labour legislation. This piece of legislation directly refers to the definition of a futures contract and thus governs the futures market in South Africa.

A9.3.2.1 The Financial Markets Control Act 1989

The financial markets control act 55 of 1989 (the act) governs exchanges. Specifically it is the governing legislation over the South African Futures Exchange. The act defines a number of key financial terms. These can be seen in table A4.3 below. The act defines the controlling body of exchanges in South Africa. The controlling body is made up of a registrar and deputy registrar of financial markets as well as a financial markets advisory board. The individuals who fill these posts are appointed by the Finance Minister.

Table A9.3 - Definition of Key Financial Terms According to the Financial Markets Control Act

Term	Definition
Clearing house	in relation to a financial exchange, means a body corporate or unincorporated association providing services or facilities in respect of the buying and selling

	of financial instruments on the financial market in question;
Financial exchange	means an association contemplated in section 7 to which a financial market license has been issued;
Financial instrument	means:- *(a)* a futures contract; *(b)* an option contract; *(c)* loan stock; or *(d)* any other instrument declared by the Registrar by notice in the *Government Gazette* to be a financial instrument;
Financial instrument principal	means any person who is a member of a financial exchange, but not a financial instrument trader, and who is authorised in terms of the rules thereof to carry on the business of buying and selling listed financial instruments on his own account;
Financial instrument trader	means any person who is a member of a financial exchange and is authorised in terms of the rules thereof to carry on the business of buying and selling listed financial instruments on behalf of other persons or on his own account;
Financial market	means a market for the carrying on of the business of buying and selling financial instruments, taking place:- *(a)* on an exchange or at any other place; or *(b)* by means of any system or facility;
Futures contract	means a standardised contract the effect of which is that:- *(a)* a person agrees to deliver to or receive from another person a certain quantity of corporeal or incorporeal things on a future date at a pre-arranged price; or *(b)* a person will pay to or receive from another person an amount of money on a future date according to whether the pre-arranged value or price of an asset, index as referred to in the definition of "securities" in section 1 of the Stock Exchanges Control Act, 1985 (Act No.1 of 1985), currency, rate of interest or any other factor is higher or lower on that future date than the pre-arranged value or price;
Listed financial instruments	means financial instruments included in the list of financial instruments kept by an executive committee in terms of section 14;
Option contract	means a standardised contract the effect of which is that a person acquires the option

	(a) to buy from or sell to another person a certain quantity of corporeal or incorporeal things before or on a future date at a pre-arranged price; or *(b)* that an amount of money will be paid to or received from another person before or on a future date according to whether the pre-arranged value or price of an asset, index as referred to in the definition of "securities" in section 1 of the Stock Exchanges Control Act, 1985 (Act No.1 of 1985), currency, rate of interest or any other factor is higher or lower before or on that future date than the pre-arranged value or price;
Standardised contract	means a contract that complies with the formal requirements applying on a financial market to a contract of the kind in question and in respect of which dealings take place on that market;

(Source: Financial Markets Control Act, 1999 : 6 to 9)

The Financial Markets Advisory Board (the board) is empowered by the act to perform various functions. This includes any investigations that may need to be performed by the Registrar concerning financial markets. In this case the board is empowered to investigate and report on its findings to the registrar as well as make recommendations on the investigation. With regards to the administrative issues concerning the board, these are the responsibility of the registrar. The advisory board is empowered to appoint sub committees to achieve its goals.

The act seeks to regulate the buying and selling of financial instruments (as defined above) and the business of being a financial market. The overriding rule is that no person may carry on the business of a financial market without a license. More specifically this means that no person may engage in the business of buying and selling of unlisted or listed financial instruments (whether it be on that individual's own behalf or on behalf of other people) unless the following requirements are met. The individual is a financial instrument trader or works through a financial instrument trader. The term financial instrument trader is defined in table A4.3 above. The registrar determines an individual to be carrying on the business of buying and selling financial instruments as contemplated above if that person does so as a regular feature of his or her business. The registrar also determines this to be the case if "he holds himself out as a person who carries on the business of buying and selling financial instruments" (Financial Markets Control Act 1999: 11). As part of this restriction to deal in securities the act also restricts individuals to manage investments on behalf of others unless the manager is approved by the registrar.

The act regulates the procedure for applying for a license to run an exchange. Briefly, ten or more people can carry on the business of an exchange and must apply to the registrar for a license for the exchange. The application must be made in a manner prescribed by the registrar, a fee must accompany the application along with the proposed rules of the exchange. As part of the application procedures the registrar will advertise the application for the exchange in the national newspapers.

In issuing the license the registrar has to ensure the association has sufficient financial resources to carry on the business of an exchange. This includes having sufficient resources to meet the day-to-day requirements imposed on the exchange by the registrar. The proposed rules of the exchange will have to comply with the act and the interests of the public would have to be served by the issuance of the license. To ensure the market is sustainable the exchange will have to comprise of at least ten members who will carry on the business of being buyers and sellers on the exchange.

Once the license has been issued it will expire on the 31st December of each year to be renewed the following year. As part of this renewal process there will be a renewal fee. The registrar may refuse to renew the license if the registrar is of the opinion the rules of the exchange were not properly enforced during the previous year. The registrar may also choose not to renew the license if the financial exchange not complying with the act. Along with being allowed to refuse renewal of a license the registrar is empowered by the act to cancel or suspend a license. The three primary reasons for this are if the exchange is carrying on business that is not in the public interest, the license was obtained fraudulently, or the exchange has ceased the business of being a financial market. Once the license has been issued the financial exchange takes on a juristic personality such as a company would which enables it to be sue or be sued.

As part of the license granting procedures, the registrar will assess the financial standing of the exchange. The registrar to empowered by the act to require the members of the exchange to contribute funds to the exchange to allow it to carry on the business of being a financial exchange. In the case where the exchange has surplus assets it is allowed to distribute this to the members under certain conditions decided by the registrar. Before the registrar can rule on whether the surplus may be transferred to the members the surplus must first be net of any liabilities. Once this has been established, the members must approve the disbursement in terms of the written constitution of the exchange. It is at this stage that the registrar can decide to distribute the surplus to the members. Another way of accessing the surplus is where the exchange is dissolved.

With regards the instruments, the executive committee of the Financial Markets Advisory board must maintain a register of the instruments that are allowed to be traded on the exchange. No dealings may take place in instruments that are not on this list. The executive committee also reserves the right to remove instruments from the list if it sees fit to do so. In removing a financial instrument the committee must allow the exchange to make representations defending the listing of the instrument.

Each exchange must have a set of rules and an executive committee to manage it. The rules must include parameters on how delivery and settlement should take place, how members are to deal in the financial instruments and how they disclose their dealings. The way in which credit is granted by a member to a client as well as the types of individuals the exchange should allow to become members need to be defined in the rules.

The rules need to outline how one is able to become a member and must set out the expected qualifications an individual needs to have in order to achieve this. On becoming a member the disciplinary procedures are also necessary in terms of the act and should form part of the rules as well. The act also requires the rules to make provisions for a fidelity type fund such as in the case of SAFEX.

The day-to-day activities of members are also required to be established in the rules, by the act. This includes the way in which a trader must separate clients' funds from his or her own. This is further expanded to include the manner in which fees are charged and advertising takes place by the different members. A key feature of the act's requirements regarding the rules is that the rules should take into account the public interest in all the dealings of the exchange.

The exchange must establish a board to hear appeals. The appeals that are to be heard are appeals against the executive committee of the Financial Markets Advisory Board. This is primarily for the case where the exchange's executive committee rejects an application for membership, terminates a membership, imposes a penalty, includes or removes financial instruments from the active list that are traded. The board may decide on whether it is able to hear the appeal and whether the appeal should be granted or not. Once the board has decided on an appeal, the decision will be binding upon the executive committee of the exchange and shall be deemed to have come from the executive committee.

The act outlaws false trading and market manipulation. This includes direct and indirect action and fictitious and artificial transactions, where the intended effect is to create artificial prices, fluctuations, or maintain, inflate or depress prices. The act widens its scope to include the making of false statements and disseminating of false information to induce other individuals to trade on the basis of the statements or information, or create artificial prices.

Individuals are not allowed to advertise the transacting on an exchange that has not been approved by the registrar in terms on the act. This includes foreign-based exchanges and would include foreign-based futures exchanges. As part of these advertising requirements no one is allowed to fraudulently induce individuals to engage in the trade of financial instruments. This includes the making of statements that contain forecasts that are known to be false or misleading and the withholding or concealment of information that would be material to the decision of whether or not to engage in trading.

The act makes provisions for the case where an individual contravenes the rules of an exchange. In this case the individual may be liable for damages suffered by another who has suffered as a result of the contravention. This is explicitly the case in the above situation where an individual is falsely induced into engaging in trading on the exchange. The damages are limited, however, to twice the amount the contravening individual gained from the infringement.

With regards public notices affecting the instruments listed on the exchange, no person may circulate news that may affect the price of the instrument unless that person's name accompanies the announcement. IN the case where the announcement is based on information that has been disclosed the source of the information must be disclosed with the announcement.

In the case where the registrar detects undesirable practices the registrar is empowered to require the exchange to begin voluntary winding up procedures, or direct the exchange, the clearing house, or a member to refrain from continuing with the undesirable practice. In the case where the exchange wishes to dissolve voluntarily, the act governs the manner in which this should be done. An alternative course of action is to obtain a court order ordering the winding up of the financial exchange. The court order may be brought by either the exchange itself, a member, a creditor, the registrar, or a judicial manager.

The act's scope governs more than SAFEX. However, its provisions apply to SAFEX. SAFEX's rules comply with the requirements of the act. The detailed nature of SAFEX's rules ensure there is little need to rely on the Financial Markets Control Act for guidance. The act is thus only brought into consideration when the relationship between the different parties and SAFEX is concerned. After the review of SAFEX's rules in the earlier part of the chapter, one can see that they take into consideration all the issues raised in the act. Other than the non-specific legislation governing areas such as labour relations, the SAFEX rules and the Financial Markets Control Act are the only areas of compliance when one is looking to participate in SAFEX. As most of the provisions of the act govern the running of an exchange and not necessarily the individual rules and regulations of each exchange, the primary area of compliance that a market participant should be concerned with is compliance with the SAFEX rules. Further to this would be any special regulatory notices issued to market participants by SAFEX.

A9.3.3 External Bodies

The only external regulatory bodies to SAFEX are the Financial Markets Advisory Board and the Financial Services Board. As mentioned above the Financial Markets Advisory Board is a body that does not only cover SAFEX, but all exchanges approved by the registrar. The reasoning behind the board is that it is supposed to assist the finance minister and the registrar in their policy-making duties (Lambrechts, 1990 :

108). According to Lambrechts (1990 : 108) the board has the added responsibility (over those dictated in the Financial Markets Control Act) to create a research center to study market developments both locally and overseas as well as coordinate developments between different financial sectors under their supervision.

Like the Financial Markets Advisory Board, the Financial Services Board (FSB) overseas financial exchanges (both the stock, futures and bond exchanges). The financial markets department within the FSB has a mission of "Striving to ensure sound and efficient markets and related services for the exchange of relevant securities and financial instruments, together with mechanisms for investor protection." (FSB, 2000, mission.html). It vision is "To be a professional and efficient regulator and supervisor of financial markets and related services. " (FSB, 2000, mission.html). The difference between the FSB and the Financial Markets Advisory Board is the focus of the regulation. The FSB is not focused on the day-to-day activities of exchanges; it is focused on investor protection. It is for this reason that the FSB has a scope wider than the financial markets and covers insurance companies, pensions and unit trusts as well.

The FSB regulates the granting of approval to become investment managers and marketing of ones services within South Africa in the area of financial markets. In this area the FSB implements the rules defined by the Financial Markets Control Act regarding these issues. The FSB also administers the collection of the fees payable in terms of the Financial Markets Control act. In this regard the FSB is not another regulatory body but a facilitator of the rules outlined in the Financial Markets Control Act. The financial services board was established as " in terms of the Financial Services Board Act, 1990, to exercise supervision over the business of financial institutions." (FSB, 2000, mission.html).

A9.3.4 Conclusion.

The goal of a futures exchange should be to provide liquidity, transparency and accessibility (Young & Theys, 1999 : 20) and deliver this using a secure and cheap delivery mechanism. According to Lambrechts (1990, 111) the goals of the clearing house should be to match buy and sell trades, assure the financial integrity of the contracts traded and provide the necessary mechanism for delivery. Through the course of this chapter one can see that through regulatory efforts and the efforts of SAFEX itself the above goals have been achieved or have structures put in place, which allow for them to be achieved.

In the case of liquidity, the only way this can be ensured is if SAFEX actively intervenes in the market to ensure the instruments are traded. This is not prevalent amongst the world's futures exchanges. What SAFEX can do is put in place structures that ensure liquidity. This is provided by mechanisms such as the automated trading system that allows for immediate and efficient price discovery that will allow for more advanced trading strategies such as arbitrage that rely on this.

Liquidity is further provided by the main market participants who are active in the market. This is further enforced in the act that requires at least 10 members to provide both buy and sell quotations in the market. Finally, liquidity is helped through the existence of an efficient clearing house. This creates confidence in the market by allowing the participants to rely on the fact that trades entered into will be settled timeously and accurately. This confidence, in turn, will have a positive impact on market liquidity as it will encourage more trades.

Accessibility is provided by a combination of the SAFEX rules and the Financial Markets Control Act. Both of these documents outline the requirements of becoming a member of the exchange and how one can engage in trading on SAFEX. As the rules have been outlined clearly, compliance with them becomes easier to achieve. This, in turn, increases accessibility. The rules and the act are explicit in how one may become a member of the exchange - this makes the requirements clear. Whether the requirements are biased and exclusionary is a different matter. In the case of SAFEX, this can be tested by comparing the requirements of becoming a member of another significant futures exchange with the requirements of becoming a member of SAFEX. According to Kolb (1997, 4) the Chicago Board of Trade is the oldest and largest futures exchange and it requires members to purchase seats on the exchange. The way in which these seats are bought and sold are similar to the methodology the SAFEX regulations outline. The requirements to become a member of the exchange are similar between the Chicago Board of Trade and SAFEX.

Accessibility does not only revolve around the membership requirements of an exchange, it includes the ability to trade. In this regard the comparison needs to be drawn between the rules and the margin requirements of SAFEX and the Chicago Board of Trade. In terms of the SAFEX rules any member of the public can trade through a broker if they meet the credit requirements of the broker and were not falsely induced to trade futures. They are able to trade directly (i.e. not through a broker) if they become a member of the exchange and pass the prerequisite exams. A similar situation exists at the Chicago Board of Trade.

The margining system devised by SAFEX is based, in part, on the margining system employed by the Chicago Board of Trade. SAFEX determines the margins that are dependant on the underlying spot instrument and the contract specifications, to which each broker adds their own required margin. This depends on the creditworthiness of the market participant applying for an account to trade futures. According to Kolb (1997: 4), this is the same as the margining system employed by the Chicago Board of Trade. One could conclude from this that as the accessibility to SAFEX is similar to that of the Chicago Board of Trade, SAFEX is an accessible futures exchange.

Transparency, according to Young & Theys (1999 : 20) is the third key element of a successful exchange. This is achieved, as in the case of liquidity, through a combination of the SAFEX rules and the Automated Trading System. The rules ensure transparency by specifically disallowing market manipulation that includes the withholding of information and insider trading (which would be based on information not distributed to the general public). The rules and the Financial Markets Control Act provide for penalties in the event this rule is contravened.

The ATS increases transparency by allowing for a real time feed of market data and bids and offers. This allows participants to determine the market levels and current trading prices. The making available of the real time market data ensures that market participants are able to make informed decisions based on the current state of the market. Unlike in the case of the Johannesburg Stock Exchange (JSE), there is little evidence of the real time SAFEX market data being made available to the general public through popular mediums such as financial web sites. In the case of the JSE, equity prices are made available on line through on line brokers, financial web sites and, on occasion, through the web sites of the listed companies themselves. This does point to lower market transparency, however, SAFEX does not wish to entice participants into the market who do not understand futures due to the possible loss they may face and thus the level of transparency is set to cater to the needs of specialist market participants. This attitude of SAFEX can be seen throughout the SAFEX rules as well as through the Financial Markets Control Act. In light of this attitude one can conclude the transparency is adequate. Transparency is provided to the general public through publications as the Business Day, however, this is not real time data and would not be sufficient for an active futures trader.

The requirements of Young & Theys for a successful market have been met in the case of SAFEX. The roles outlined by Lambrechts (1990, 111) are also met; as described above, the first role of a futures exchange is to match trades. The ATS system does exactly this; trades are matched on a real time basis. For trades concluded outside the ATS, there is an elaborate set of rules governing them (see above - Rules of SAFEX). In this case the exchange does not actively match the trades but allows the match to take place and records the match and deals with the post trade management.

The second role of the exchange (according to Lambrechts 1990 : 111) - to assure financial integrity is covered by the SAFEX rules and the Financial Markets Control Act. The integrity issue is broad and covers the actual integrity of the trade to the integrity of the market participants. The integrity of the trade is taken care of by the ATS. ATS, in conjunction with the clearing house, ensures each trade is successfully processed, thereby achieving integrity. The integrity of the market is covered by the rules such as the anti market manipulation rule mentioned above. The integrity of the market participants is achieved by requiring them to conform to the ethics section of the rules.

The final role of an exchange - to provide a mechanism for delivery - is provided by Safcom and the clearing house of SAFEX. In this case delivery must be considered as both the settlement of the trades and the delivery of any necessary cash. Safcom undertakes this delivery. In the case of the cash, the margin mechanism ensures that any cash that needs to be delivered against any contract will be. The final settlement of the positions is also undertaken by Safcom through the clearing members who each have the financial resources to ensure all trades are settled. The platform for this is provided by a combination of the SAFEX rules and the Financial Markets Control Act.

In conclusion, the act and the SAFEX rules ensure an efficient exchange that allows the market to operate normally. Both the act and the rules need bodies to enforce them. This is done by the Financial Services Board in the case of the act and the SAFEX executive in the case of the SAFEX rules. Without these two documents and their respective enforcement bodies the efficient functioning of SAFEX could be jeopardised.

Appendix 9.4 – Discussion of the development of the ARCH model

ARCH takes into account the time effect and long-term trends in variance. The next step is to look closer at the actual weighting of the data. This leads on to the next model: exponentially weighted moving average (EWMA). In this case the individual weights that are assigned to the observations decrease exponentially as the data points move backward through time. This can be represented as follows:

$$\alpha_{i+1} = \lambda \alpha_i \qquad (22)$$

Where:

λ = a constant between zero and one.

Applying this to formula 17 above and separating today's volatility, the following formula results:

$$\sigma_n^2 = \lambda \sigma_{n-1}^2 + (1-\lambda) u_{n-1}^2 \qquad (23)$$

This allows one to estimate today's volatility from the previous day's volatility and the most recent observation of the changes in the returns from the instrument (or market variable). This equation was constructed by substituting the original volatility estimate (formula 17) with the volatility estimate from the previous day added to the market variable for the current day, with both being adjusted respectively for their weightings. If one repeats the substitution for the previous day b y substituting it for the day before (σ_{n-2}^2), the following formula results:

$$\sigma_n^2 = \lambda \left[\lambda \sigma_{n-2}^2 + (1-\lambda) u_{n-2}^2 \right] + (1-\lambda) u_{n-1}^2 \qquad (24)$$

This type of substitution can be repeated until a pattern emerges. The resultant formula is as follows:

$$\sigma_n^2 = (1-\lambda) \sum_{i=1}^{m} \lambda^{i=1} u_{n-i}^2 + \lambda^m \sigma_0^2 \qquad (25)$$

According to Hull (1999, 371) the above formula can be simplified even further: for large m, the term $\lambda^m \sigma_0^2$ is sufficiently small to be ignored so that equation 23 becomes the same as equation 17 with $(1-\lambda)\lambda^{i-1} = \alpha_i$. This means that the u_i's decline at a rate of λ as one moves back through time. Each weight becomes λ times the previous weight. This result is called the EWMA model and can be used to estimate today's variance using only the previous day's variance estimate and the most recent observation of the movement in the market variable. This can be illustrated by the following example in table A9.4:

Table A9.4 - Example of the Exponentially Weighted Moving Average Model.

Suppose that λ is 0.9, the volatility estimated from the previous day (n-1) is 1% per day and the proportional change in the market variable during the previous day (n-1) is 2%. This means that $\sigma_{n-1}^2 = 0.01^2 = 0.0001$ and $u_{n-1}^2 = 0.02^2 = 0.0004$. Equation 23 gives the following result:
$$\sigma_n^2 = 0.9 \times 0.0001 + 0.1 \times 0.0004 = 0.00013$$
The estimate of the volatility for day n, σ_n, is therefore, $\sqrt{0.00013}$ or 1.14% per day. Note that the expected value of u_{n-1}^2 is σ_{n-1}^2 or 0.0001. In this example, the realised value of u_{n-1}^2 is greater than the expected value, and as a result, the volatility estimate increases. If the realised value of u_{n-1}^2 had been less than its expected value, the estimate of the volatility would have decreased.

Source (Hull, 1999 : 371)

The EWMA formula allows one to track changes in volatility. If there is a big movement in the market variable on the previous day (n-1) so that u_{n-1}^2 is large, one will note an increase in volatility. The variable λ governs how sensitive the volatility is to the most recent observations of the market variable. A low value of λ leads to a higher weighting being given to the market variable. A high value of λ produces estimates of the daily volatility that responds slowly to new information on the market variables. (Hull, 1999 : 372).

One should note that the above EWMA formula does not take into account any weighting being given to the long run average variance. By adding this to the equation one gets a new model called GARCH - General Autoregressive Conditional Heteroscedasticity. GARCH was first introduced by Bollerslev in 1986 (Engle, 1995 : 42). It expands on the EWMA model by bringing long run variance into the equation. The EWMA model is a specific form of the GARCH model, this can be seen in the series of equations below. The equation for GARCH (1,1) is:

$$\sigma_n^2 = \gamma V + \alpha u_{n-1}^2 + \beta \sigma_{n-1}^2 \qquad (26)$$

Where:

γ	=	the weight assigned to V.
V	=	the long run variance rate.
α	=	the weight assigned to u_{n-1}^2.
β	=	the weight assigned to σ_{n-1}^2.

As in the case with formula 18 above the weights must sum to one:

$$\gamma + \alpha + \beta = 1 \qquad (27)$$

To derive the EWMA model from the GARCH model one needs to set $\gamma = 0$, $\alpha = 1 - \lambda$ and $\beta = \lambda$. The notation (1,1) in the GARCH model refers to the data being used to estimate the volatility. The (1,1) indicates that σ_{n-1}^2 is the most recent observation of u^2 and the most recent estimate of the variance rate. The more general GARCH (p,q) model calculates the σ_n^2 from the most recent p observations on u^2 and the most recent q estimates of the variance rate. (Hull, 1999 : 372). According to Hull (1999 : 372) GARCH (1,1) is the most popular of the GARCH models. Similar to equation 21, the GARCH model can be rewritten as follows:

$$\sigma_n^2 = \omega + \alpha u_{n-1}^2 + \beta\sigma_{n-1}^2 \qquad (28)$$

This is the form of the model that is usually used to estimate the parameters. The process is to first estimate the parameters ω, α and β. Once this has been done γ can be derived as follows: $1 - \alpha - \beta$. Upon deriving γ, the long-term variance can be calculated by performing the following calculation: ω/γ. According to Hull (1999 : 373), in order for the weight to be applied to the long term variance to be positive and hence a stable GARCH (1,1) process, the following is required: $\alpha + \beta < 1$. If this is not the case the weighting that will be applied to the long-term variance will be negative. The application of the GARCH(1,1) model can best be seen on the following example in table A9.5 below:

Table A9.5 - Example of the GARCH (1,1) Model.

Suppose the GARCH (1,1) model is estimated from daily data as:

$$\sigma_n^2 = 0.000002 + 0.13u_{n-1}^2 + 0.86\sigma_{n-1}^2$$

This corresponds to α = 0.13, β = 0.86 and ω = 0.000002. Because γ = 1 - α - β, it follows that γ = 0.01. Because ω = γ*V*, it follows that *V* = 0.0002. In other words, the long run average variance per day implied by the model is 0.0002. This corresponds to a volatility of $\sqrt{0.0002} = 0.014$ or 1.4% per day.

Suppose that the estimate and the volatility on day n - 1 is 1.6% per day so that $\sigma_{n-1}^2 = 0.016^2 = 0.000256$ and that the proportional change in the market variable on day n - 1 is 1% so that $u_{n-1}^2 = 0.01^2 = 0.0001$. Then:

$$\sigma_n^2 = 0.000002 + 0.13 \times 0.0001 + 0.86 \times 0.000256 = 0.00023516$$

The new estimate of the volatility is therefore $\sqrt{0.00023516} = 0.0153$ or 1.53% per day.

Source: Hull (1999 : 373).

As was done to formula 23, one can undertake a substitution process with the GARCH formula. Taking equation 28 as a starting point, one can substitute σ_{n-1}^2 with the previous day's GARCH equation:

$$\sigma_n^2 = \omega + \alpha u_{n-1}^2 + \beta\left[\omega + \alpha u_{n-2}^2 + \beta\sigma_{n-2}^2\right] \qquad (29)$$

One can continue this substitution process by substituting the σ_{n-2}^2 in the previous day's GARCH equation for $\omega + \alpha u_{n-3}^2 + \beta\sigma_{n-3}^2$. If one continues this process an infinite number of times the u_{n-1}^2 term becomes affected as follows. The weight that is applied to it becomes $\alpha\beta^{i-1}$. The weight thus declines at an exponential rate β. Comparing this to the EWMA model the GARCH β parameter is similar to the EWMA's λ parameter. The β parameter determines the sensitivity of the GARCH volatility estimate to the u terms. If one had the situation where β was set at 0.8, u_{n-2}^2 is only 80% as important as u_{n-1}^2 and u_{n-3}^2 is only 64% as u_{n-1}^2. In this case u_{n-3}^2 is only 80% as important as u_{n-2}^2.

The GARCH (1,1) model is similar to the EWMA model in that it takes into account the exponential decay of the importance of individual variance observations over time, in the estimation of current variance. The difference lies in the fact that the GARCH (1,1) model explicitly takes long run volatility trends into account, where the EWMA model does not.

Hull (1999 : 374) is of the opinion that the GARCH (1,1) model is the theoretically more appealing model if one has to decide between using it or the EWMA model. This is because the GARCH (1,1) model takes into account long run volatility estimates, and as mentioned earlier in the chapter, variance exhibits mean reversion, which is brought into account through the inclusion of the long run average volatility parameter.

For the purposes of the thesis the GARCH (1,1) model will be used in determining the advanced volatility estimates. The ARCH model and the traditional model will be used to show the difference in determining volatility when not taking into account the exponential decay of the effect of earlier observations and the long run average volatility level. With regards the GARCH (1,1) model, work needs to be done on the estimation of the different weightings of the variables. The theory behind this will be dealt with chapter 7 and the actual measurement of the weightings will be done in chapter 9.