Managing Pure and Statistical Equity Arbitrage Opportunities
Within The South African Environment

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Prepared by Peter John Cronje

Promoter
Prof J.J.L. Cronje

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Declaration

Student number 7427115

I declare that Managing Pure and Statistical Equity Arbitrage Opportunities Within The South African Environment is my own work and that all sources that I have used or quoted have been indicated and acknowledged by means of complete references.

_________________________  ________________________

Peter John Cronje  Date
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Summary

The analysis undertaken, firstly aims to identify the extent to which equities, their indexes and their derivatives priced in accordance with their fair value. Secondly, presuming that the traded values of the instruments do not in all instances equate to the fair value, the research aims to develop an effective means to identify and manage profitable opportunities arising from the mispricing.

General concepts relating to profitability, trade identification, risk and continuous improvement of the processes are addressed. This includes recommendations on the management of the risks through a structured reporting process.

The research looks at arbitrage trading in the South African market from the perspective of an empirical review into the market’s participation in equity and equity derivative arbitrage. In addition to this empirical analysis, a time series analysis into various arbitrage strategies is conducted with the view to determining their relative profitability.

The first component of the empirical research focuses on the arbitrage trading strategies adopted by a sample of 80 institutions. Where the institutions trade arbitrage strategies, the research undertook to establish what methods are used to identify, trade and manage the index arbitrage, single stock futures arbitrage, risk arbitrage, statistical arbitrage and volatility arbitrage trading opportunities that present themselves within the South African Market.

Information gathered did not only focus on the actual trading strategies but also determined the relative cost structures, profitability and risk management processes that are employed to support these trading initiatives.

The time series analysis focused on index futures, single stock futures, risk, dual listed and statistical arbitrage methods, and reflects the results before and after transaction costs. These arbitrage strategies were applied to the ALSI Top 40 index or its associated shares and generally spanned a period of about four years.

Finally the research presents an arbitrage business model that is aimed at providing a blue print for arbitrage trading which covers:
• new arbitrage strategy implementation,
• market risk,
• execution,
• profit,
• traders,
• cost,

Finally, the research provides a multiple regression method for application in identifying further arbitrage trading opportunities within the South African environment.
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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The concepts which underpin derivative contracts have been used for centuries and can be traced back to articles relating to the Tulip futures market, which developed in Holland in the 17th century. In the 20th century, the global financial markets have undergone dramatic changes and shocks, as a direct result of the proliferation of derivative instruments. The general acceptance of derivative instruments into the financial structures of the global marketplace started in the mid nineteen hundreds, through the introduction of currency futures markets. These futures markets were followed by the development of interest rate products such as forward rate agreements (FRAs) and swaps. The trading of options was formally introduced with the creation of a standardised means to price these instruments, which was provided by Fisher Black and Myron Scholes (1973) through the Black Scholes Model. Equity derivatives were the next phase in the derivative evolution and were followed by the most current derivative paradigms, namely credit derivatives and exotic derivatives.

Miller (1997:4-7) ascribes the “derivative revolution” to one or a combination of the following factors:

- The move to floating exchange rate systems from the Bretton Woods financial system allowed currencies to better reflect their true value and provided impetus for larger currency futures markets.
- The development of computers and information technology allowed for improved communication and the ability to easily price derivative structures within the global market place.
- The regulation and in some cases the deregulation of derivative instruments, provided further impetus to the derivative evolution.

In the South African context, the introduction of financial derivatives was only partially inhibited by the country’s global isolation resulting from the United Nations sanctions, which ended in 1994. Following South Africa’s formal reintroduction into the global economy, product developments by financial institutions in the field of financial derivatives have allowed them to effectively integrate into the global environment. The economy does, however, still suffer from certain regulatory constraints, which
impede its ability to effectively compete with other economies in the world. These constraints include exchange control regulations, which inhibit the market from freely competing in a true market type environment. This interventionist approach also impacts on the product ranges, which the institutions may put forward to their clients.

The South African economy is categorised as a developing economy and a developing country by rating agencies such as Moody’s and Standard and Poor’s. On the 25 February 2000 South Africa’s country rating was upgraded by Standard and Poor’s to a BBB and was then again upgraded to a BBB “Stable” rating in May 2003 according to Bloomberg sources. While these upgrades were considered to be extremely positive for the country, the essence of this developing country status is, however, still indicative of the fact that South Africa suffers from the dilemmas that usually burden the developing nations.

Inflation and currency instability are examples of factors that negatively affect the South African economy and its financial markets, according to the South African Reserve Bank (2002). More specifically, traders in the South African financial markets often cite the lack of liquidity as a cause of the market’s inefficiency. This lack of liquidity directly affects market depth and is combined with high levels of volatility within the equity trading environment. Additional complications which are often cited are that the exogenous factors which influence the economy are not in the government’s direct control. The emerging market economies, which are going through a period of economic instability, may therefore be the cause of South Africa’s economic instability. Recent examples of these regional exogenous factors would include the controversial land reform programmes adopted by Zimbabwe, which destabilise the Southern African Development Community (SADEC). Further afield the economic instability seen in Argentina and Brazil in the period May to June 2002 affected the South African Rand and had a detrimental impact on the bond markets, with the Emerging Bond Market index spreads widening from about 800 to about 1200 during this period, according to Bloomberg’s data. This widening of the spreads was due to bonds from emerging markets being sold off by international investors during the emerging market crises. These and many other factors affect the way the developed world views developing countries and their inherent risks.

Developing nations are considered more risky than their developed nation counterparts; therefore, when dealing in developing countries, it is standard practice for traders to deal at a risk-adjusted level, which aims to compensate investors for
the greater levels of risk they face within such environments. These increased returns are visible in the larger trading spreads observed in developing countries and therefore where prices are quoted at the incorrect levels, this mispricing could result in extremely profitable arbitrage opportunities.

Developed markets have adapted to take advantage of these situations by exploiting these price disparities, which in turn help the markets to remain efficient. These arbitrage operations therefore help to create a market that tends towards a form of market efficiency as described by the Efficient Market Hypothesis discussed by Rielly and Brown (1997:208). Research has shown that the international arbitrage funds, such as Royal Bank of Canada ARC Fund Limited, and specialist companies, such as GIB Inc., are providing returns in excess of those provided by the market in general as a result of arbitrage trading. This has resulted in global institutions writing systems that would enable them to automate some portions of their arbitrage trading operations.

The South African financial market has developed the ability to deal with the common types of pure arbitrage situations that are present within the market. As with the international markets, the exploitation of the arbitrage opportunities helps to bring about a greater degree of efficiency within the South African market. In preliminary discussions and interviews held with South African banking groups and risk consulting institutions, it was however determined that the systems that are used in South African arbitrage operations are rather crude and the processes are manual in their identification and execution.

1.2 Problem Statement

The South African financial market is classified as an emerging market within the global economy. Global trends have shown that these types of environments tend to provide excess returns through market inefficiencies, which may be capitalised upon through arbitrage operations. These opportunities have remained topical since the late nineteen eighties, as is reflected in an article in the Economist of 21 July 1990 (1990:16) and they are still topical, as is visible in current articles like that of Siew (2003) which covers.

Initiatives to improve the equity market's efficiency are visible in the automation that has been introduced through the introduction of the Share Transactions Totally
Electronic (STRATE) settlement system and the replacement of the Johannesburg Equities Trading System (JETS) with the Sequence Electronic Trading System (SETS), according to www.STRATE.co.za [2000?] and www.JSE.co.za [1999?]. Despite these initiatives currency instability combined with liquidity and volatility factors continue to affect the pricing of South African equities and their associated derivative instruments. Given the above arguments, the South African financial market may display a greater degree of disparity between the quoted prices of the equities and their related derivative instruments. The size of the price disparities should therefore allow for profitable and sustainable arbitrage operations within the market in the same manner as those reflected in research relating to the international markets.

The most effective manner in which to harness these price distortions with the view to generating a profit while providing adequate risk, profitability and general management structures are therefore scrutinised. In preliminary interviews with South African financial institutions, auditing institutions and a risk-consulting firm, it became apparent that not one of the South African institutions has formally identified an end-to-end methodology to identify and maximise the profitability of these arbitrage opportunities over time. In addition to this fact there is currently no known formal systems development in progress to attempt to provide such an arbitrage solution which will assist in the management of the arbitrage process.

It seems that the existing models used in the South African environment are rudimentary and based on quantitative models embedded in spreadsheets which link to live data sources. The results generated from these spreadsheets are used by the traders in conjunction with their view of the market prior to entering into the trade. The validity of the assumptions and the position’s performance is then driven through the mark to market performance of the desks. No mechanisms are in place to measure the potential profits or losses that may result by trading all or certain trade types, and there are only limited mechanisms that can be used to maximise the returns that are generated through the arbitrage opportunities that may be exploited.

Formal research that has been undertaken in the South African environment does not cover “Equity Derivative Arbitrage”, and searches of the National Research Foundation’s (NRF) database netted no results of studies that approach arbitrage from the perspective that this research will follow. The current and completed studies do in some cases reference arbitrage, but only through the Arbitrage Pricing Theory.
or through dividend arbitrage processes. The formal management process of arbitrage trading within a treasury environment has not received any research focus to date.

Within the international environment, discussions with representatives of multinational investment banks highlighted the fact that they are developing limited treasury structures and systems capabilities usually referred to as *programme trading*, that are aimed at capitalising on pure arbitrage concepts and to a limited degree statistical arbitrage concepts. In these cases the system can follow a rigid pricing process, which allows it to act without human supervision (Business Week. 1989:186; Board & Sutcliffe (1996:29). These arbitrage strategies are generally fairly simple and generic in nature and include index, single stock futures and dual listed arbitrage opportunities.

These preliminary interviews also highlighted the fact that the automation of processes by international companies do not span the entire range of arbitrage opportunities and do not provide an intelligent and efficient manner in which the business could analyse the relative profitability of arbitrage opportunities or the trader’s effectiveness. This situation is aggravated by a tendency to segment the arbitrage trading into specialist areas within the business. The rebate arbitrage, for example, was generally managed out of the structured finance areas and is not grouped with the general arbitrage processes. This implies that the profits from these operations are separated from the mainstream arbitrage operations and there is no structured manner to ensure that all opportunities are being capitalised upon by the business.

The shortcomings encountered in the international processes are even more pronounced in the South African environment, where the arbitrage operations are often totally removed from one another and the methodology used to manage the profitability, risks and trading opportunities are even more unstructured due to the dispersion of the functions. Furthermore, the more risky types of arbitrage, such as statistical and volatility arbitrage, may have received some attention internationally but this information is considered proprietary in most cases and has therefore not received the research attention that it may deserve.
1.3 **PURPOSE OF THE RESEARCH**

The analysis undertaken, firstly aims to identify the extent to which equities, their indexes and equity derivatives such as futures and options are priced in accordance with their fair value. Secondly, presuming that the traded values of the instruments do not in all instances equate to the fair value, the research aims to develop an effective means to identify and manage profitable opportunities arising from the mispricing.

While the research is focused on the South African environment, this structured approach to the management of arbitrage, as proposed by this research, will find application in both the developed and developing markets of the world. This is due to the fact that the extent of the management techniques will stretch beyond those that have been covered in existing studies and systems developments that have been initiated within the global market.

The broader focus of this research will therefore include the business structures that would most effectively enable the management, control and improvement of the arbitrage opportunities. General concepts relating to profitability, trade identification, risk and a continuous improvement of the process will be addressed. This will include recommendations on a management process, which provides a methodology for managing the trading and resulting risks through a structured reporting process, which will allow a clear view on the positions that make up the arbitrage book.

This holistic approach to managing arbitrage trading appears to be unique within the existing literature, systems developments and trading structures that are visible globally. Furthermore, the analysis into statistical and volatility arbitrage opportunities is currently embryonic in the global market place, resulting either in a lack of research, systems and methodologies or in such research, systems and methodologies being proprietary and therefore not part of the existing literature.

The methodology described to manage and maximise the returns of the more complex statistical arbitrage types will also provide the fundamental first steps needed to bring the management of these opportunities to the research forefront for equity and equity derivatives trading businesses in all markets.

The enhanced ability to manage the arbitrage business will allow the business to apply better governance to its arbitrage trading practice due to the fact that the
inherent risks associated with these trading strategies can be clearly understood and managed according to the risk profile associated with each arbitrage type. This is in contrast with the common methodology, which simply adds these risks to the general equity risk positions. The improved risk processes in addition to cost savings, generated through automation and the effective management of the profit generation and human resources, assists in the greater aims of the businesses as it provides a methodology for long term profit maximisation and therefore shareholder wealth maximisation.

1.4 Methodology

The research will firstly consist of a literature review that provides the arbitrage pricing and process principles that are followed in both the international and South African financial markets. This section is crucial in providing the practical and quantitative methodologies that will be applied in the time series research that will be conducted. The literature will also provide details of studies relating to research and trends in treasury management that have been published globally.

The literature will also focus on the arbitrage types that will be analysed. The core arbitrage types that are analysed are index arbitrage, single stock futures arbitrage, risk arbitrage, statistical arbitrage, volatility and dual listed arbitrage.

In addition to the literature study, the research will consist of empirical research that will consider two aspects. Firstly, the methodologies that are followed by the South African financial institutions that have an interest in this type of operation will be researched. This information will be gathered through research questionnaires sent to banks, investment institutions, pension funds and stockbrokers that were surveyed. The commonality and extent of their arbitrage processes are discussed against the backdrop of the published approaches to exploiting price disparities.

Secondly, a time series analysis is undertaken to establish the frequency and magnitude of equity arbitrage opportunities that present themselves in the South African environment. For the purpose of this research, only equities within the ALSI Top 40 are analysed, thereby reducing the scope of the research. The underlying reasoning relates mainly to liquidity constraints and the fact that these are mainly the counters that have established derivative instruments associated with them. Furthermore, securities lending will be more likely to cover short positions on these
shares and the lending pool of many of the TOP 40 securities is extended to the dual listed securities. The fact that the dual listed securities are primarily included in the ALSI Top 40 Index, also aids the analysis of the dual listed securities in this research.

Finally, an end-to-end process for the management of equity arbitrage opportunities will be proposed. This process will aim to consolidate the most effective way to integrate and manage business inception, product and business feasibility, profitability, risk, trade identification and trading structures.

1.5 **STRUCTURE OF THE RESEARCH**

Chapter 2 discusses the theory relating to known arbitrage situations in their pure and statistical forms. This arbitrage theory is viewed in conjunction with the treasury management structures that relate to equity derivatives and the quantitative theory as reflected in published literature. The literature discussed is therefore a reflection of the globally accepted quantitative and trading concepts and processes, that allow for the successful analysis and utilisation of arbitrage opportunities. This chapter therefore does not simply serve to highlight derivative theory, but its function is also to outline the management processes, valuation principles, trading ideas and risk management concepts that are applied to arbitrage opportunities.

Chapter 3 sets out the research methodology that will apply to the gathering and interpretation of information in this research. The empirical data will cover the existing profit control, risk and trading processes and the systems that institutions use in their efforts to execute arbitrage-trading operations. Therefore the target population, sampling method and research design applied to conducting the time-series analysis for the identification of arbitrage opportunities is also explained in this chapter.

Chapter 4 firstly deals with the research findings that relate to the arbitrage management structures and the actual arbitrage trading processes obtained through the empirical research. The chapter also reviews the findings of the time series analysis into the existence of equity arbitrage trading opportunities in the South African context. This information is expressed as the extent to which the South African equity and equity derivative instruments are mispriced relative to the underlying instruments and relative to one another. The chapter goes on to determine the extent to which these practical trading factors will impair the ability of the traders to capitalise on the mis-priced instrument sets. The analysis then sets
about using the information gathered in the research findings and compares this information to the arbitrage management processes that are currently used in the South African market place. This process allows the research to identify opportunities which have been overlooked in the market, in addition to identifying the means to improve the performance of the South African arbitrage paradigm as defined by the South African institutions which are involved in arbitrage.

Chapter 5 has the objective of delivering an end-to-end approach to the management of equity arbitrage opportunities in the South African market place. This approach is based on the findings of both the empirical research and time series analysis. The recommendations are aimed at improving the manner in which institutions manage the arbitrage trading processes through the introduction of a management model. This model can be used as a comprehensive tool to manage the arbitrage opportunities and assist the institutions in managing risks and maximising the profit potential of the identified opportunities.

Chapter 6 provides a summary of the overall research findings in terms of the actual theory, and the practical application of the theory in the South African trading environment. The chapter then provides an overview of the improvement proposal set out in chapter 5. Further areas of research are proposed in the conclusion of this chapter, with the emphasis being on the development of new and more effective methods of identifying and managing arbitrage opportunities.
CHAPTER 2

AN OVERVIEW OF EQUITY ARBITRAGE
MANAGEMENT TECHNIQUES AND PROCESSES

2.1 INTRODUCTION

The current global market environment has recently been laced with corporate failures and scandals such as WorldCom and Enron. These setbacks faced by the markets were further aggravated by the poor company results and global economic uncertainty, which have driven investors to accept lower returns from their investments while also reducing the investor and corporate demand for initial public offerings (IPO’s) in the early 2000s. The review that follows also highlights the fact that markets do not always behave rationally and that in reality there are market inefficiencies that are present for finite periods of time within the equity markets.

This chapter draws on extracts from various articles, journals and books to show that in the early 2000s institutions trading equities and equity derivatives have been improving their ability to take advantage of the market inefficiencies which exist in the global marketplace and in particular in the equity derivative arena. This chapter shows that the changes facing investment institutions, banks and corporate treasuries are partially met through the structural and procedural re-engineering initiatives that are undertaken by the leaders of these investment institutions. The view held by this research is that such re-engineering initiatives have resulted in the institutions seeking alternative sources of income to supplement their revenue through an increase in the amount of proprietary trading undertaken by them. It stands to reason that these institutions prefer to trade in a manner that provides the maximum return for the lowest level of risk, and it is this very aspect of their proprietary trading that is causing them to focus on the exploitation of inefficiencies within the global equity markets.

The afore-mentioned market inefficiencies allow for a particular type of equity trading, called equity arbitrage, which will be considered in this chapter. This analysis is split into two sub-components, namely pure and statistical arbitrage. These broad categories will be divided into the various arbitrage types that may occur within these sub-categories. The various types of arbitrage that occur in the market are discussed
in detail with the view to establishing the current level of development of this field within the global market.

The basic concept surrounding all equity arbitrage literature relies on the mathematical value of the derivative not equating to the current market valuation of the instrument. For this reason a large portion of the literature that is covered in this research is focused on the accepted means of calculating the theoretical value of the derivative instruments and the approaches used to identify pricing mismatches. It is only with this background that the foundation of the research into the mispricing of financial instruments can be determined, as these pricing fundamentals are used in the realisation of the equity derivative structures and strategies.

The focus then shifts to the application of equity arbitrage in practice. The organisational structures that house the equity derivative and equity arbitrage business activities, are a function of organisational strategy, and can be considered a reflection of an organisations view on how best to manage the equity derivative process. Very little has, however, been published on the strategies and the management of arbitrage business activities. For this reason chapter 4 and 5 will supplement the existing literature with empirical findings, which aim to cover specific issues that are relevant to the effective management of arbitrage opportunities.

### 2.2 Categories of Arbitrage

The general concept surrounding arbitrage relate to the fact that the trader will realise a riskless profit within a specified period of time due to a derivative instrument being mispriced in one or different markets. As time progressed and the financial products became more diverse and advanced, this definition was applied to more and more products, which resulted in the actual use of the arbitrage term deviating from the original narrow focus and it is now also used to describe a statistical and probability-based opportunity, which should result in an indeterminable profit in an undeterminable period of time.

More formally, investor dictionaries such as [www.Investorwords.com](http://www.Investorwords.com) [2000?] describe arbitrage as “attempting to profit by exploiting price differences of identical or similar financial instruments, on different markets or in different forms. The ideal version is riskless arbitrage.” In the case of riskless or pure arbitrage, the trader can determine the amount of profit that will be made in advance, given the fact that the
trader can determine the level at which the trade will be entered into and also the level at which the trade will be closed at a specified future date.

In cases where the prices are not guaranteed to converge, the trader will be forced to rely on a mathematical probability to determine the potential for the trade to expire in the money. In these cases there is no clearly identifiable time or level of profitability, as the trader is in principle taking a bet that the trade will end up in the money due to the behaviour of the instruments over time. This fact becomes obvious later, when the definitions and research into statistical arbitrage is reviewed.

2.2.1 Pure Arbitrage Defined

The concept pure arbitrage, which is underpinned by the law of one price, has been covered in countless works on derivative instruments and their pricing. While the same idea is restated on countless occasions, the following three definitions highlight the general view shared by authors and investor dictionaries on the concept of pure arbitrage.

Pure arbitrage is defined by www.Investorwords.com [2000?] as “a risk-free transaction consisting of purchasing an asset at one price and simultaneously selling that same asset at a higher price, generating a profit on the difference.” Hull (2000:14) defines arbitrage as “locking in a profit by simultaneously entering into transactions in two or more markets,” while Jarrow & Turnbull (1996:33) define arbitrage as any trading strategy requiring no cash input that has some probability of making profits without any risk of loss.” In these definitions it is assumed that the proceeds from the sale of one instrument will completely offset the cost associated with the purchase of the other asset. For this reason the definition implies that no cash outlay will be required in the execution of the arbitrage.

2.2.2 Types of Pure Arbitrage

Pure arbitrage can theoretically occur between any two types of related instruments, and for this reason it is necessary to define each arbitrage type in relation to the instruments, which will be used to measure the pricing relationships. From this understanding, the situations that will result in pure arbitrage opportunities within the market can be defined.
2.2.2.1 SINGLE STOCK AND INDEX FUTURES ARBITRAGE

Where futures and forwards on shares and indices are traded, the pricing inputs are applied to identify the situations where such prices are mispriced relative to the underlying shares. Research on futures and forwards arbitrage on shares and indices has been mainly focused on Index arbitrage and for this reason the following discussion relates mainly to share indices. The application of these concepts can easily be extended to single stock futures, due to the similarity in the pricing procedures and the trading and settlement processes. The definition of a single stock future, according to www.investorwords.com [2000?], is “a single transaction equivalent to the simultaneous sale of a put and purchase of a call for a given stock. Single stock futures essentially allow investors to sell a stock short without waiting for a downtick as would otherwise be required.”

The process of Single Stock Arbitrage works in exactly the same way as Index Arbitrage, which is defined by www.investorwords.com [2000?] as: “A strategy designed to profit from temporary discrepancies between the prices of the shares comprising an index and the price of a futures contract on that index. By buying either the shares or the futures contract and selling the other, an investor can sometimes exploit market inefficiencies for a profit.” Index arbitrage opportunities should disappear rapidly once the opportunity becomes well known and many investors act on these opportunities.

Reverre (2001:371) defines index arbitrage as the simultaneous sale and purchase of an index future and of a portfolio which replicates the same index. At a given time, an opportunity exists if the futures price is different from its theoretical value computed from a cost of carry model used to price the futures. In practice this implies an absolute difference in price which is captured now, and which can be secured until maturity. These opportunities are profitable if the transaction costs and hedging costs are lower than price discrepancies in the market.

Index futures arbitrage is extremely common and cases of this type of arbitrage have been cited in most financial markets in the world. Articles relating to this practice date back to the 1987 (see for instance Wall Street Journal (1987) and Economist (1990: 16)). The index arbitrage process has become so developed and structured that programme trading systems have been developed to execute the orders when the
system identifies opportunities. www.investorwords.com [2000?] offers the following formal definition of *programme trading*: “computer-driven, automatically-executed securities trades, usually in large volumes of a set (basket) of 15 or more stocks.”

Chung (1991:1792) shows that previous research into index arbitrage is not comprehensive, as the general research usually focuses on the frequency and violations of no arbitrage boundaries and does not look at the size and frequency of arbitrage profits. An example which Chung (1991:1792) highlights is that in the case of research into United States indices, the indices close about 15 minutes after the share market closes, which results in the comparison of non-synchronous market data. MacKinlay & Ramaswamy (1988:137-158) and Stoll & Whaley (1990:391-412) used intraday prices in an effort to resolve the problem of non-simultaneous data by using the intraday returns of shares and their indices. In their research it is shown that the index is not a perfect measure of the true value of the index, as the component parts do not trade continuously.

Chung (1991:1793) also shows that most studies do not include the up-tick rule for short sales of the constituent shares of the index in their findings and therefore these findings are not totally correct. This up-tick rule, which is enforced by the exchanges, specifies that a short sale may only occur on the market after the share price has ticked up or has had two successive trades at the same price. This rule will apply to all market participants who wish to sell a share that they do not own.

Chung (1991:1800) then goes on to show that over the period 1984 to 1986 arbitrage opportunities and profits have become smaller after taking into account trading costs. Despite the decline in profitability his study also showed that programme trading is still a profitable trading strategy despite the fact that profitable opportunities, when using a transaction cost of 0.75% and 1%, had declined to less than 50% of the opportunities that are identified. The cases of long arbitrage opportunities on an ex post and ex ante basis were significantly greater than the short arbitrage opportunities, i.e. for ex ante long arbitrage violations. This implies that there were more cases where the arbitrageur would be required to purchase shares relative to the cases where the arbitrageur would be required to sell shares. His findings showed 26,086 occurrences of arbitrage on the American markets for the period 1984-1986. These were reduced to 1,985 occurrences when transaction cost of 0.5% were applied. The research also goes on to point out that in Chung’s (1991:1799-
view the American market had matured and that excess profits such as those reflected in previous studies would not be available in the future.

Research into the behaviour of the futures prices relative to the underlying share prices was conducted by Harris et al. (1995:563-579), who showed that generally the futures prices lead the spot price. This implies that the futures prices on the Standard and Poors (S&P) Index are in fact price leaders to the spot prices. This research has the implication that when the futures prices move in a specific direction, the share prices will tend to follow the move shortly thereafter. As arbitrageurs use models which are usually based on calculation of futures prices using the spot price as the starting point of their calculations, the causation is in fact reversed according to this research. Despite this difference the processes used to establish the spot-futures price discrepancies would remain unaltered, as will the pure or statistical arbitrage process that is applied to realising the profit that is inherent in the opportunity.

Transaction costs can become large when exploiting these opportunities because of the need to simultaneously buy and sell many different shares and futures, so only the larger institutions are usually able to profit from index arbitrage. In addition to this fact, sophisticated computer programmes are needed to keep track of the large number of shares and futures involved, which makes this a difficult trading strategy for individuals.

The point should also be made that while the general index arbitrage concept assumes that the arbitrageur will hold the position until convergence, this assumption does not hold in all cases, as Kempf (1996:367-368) shows. In his work he shows that the arbitrageurs often unwind the trades prior to maturity and that these early unwind options have an effect on the futures-spot relationship, as the unwind option may move the share and futures prices in the process of unwinding the arbitrage positions. In a similar manner this work also shows that the mean reversion (conversion) of the mispriced futures and spot prices is arbitrage induced, as the arbitrage process affects the demand and supply relationships, thereby driving the prices to reversion. The basis of this research really implies that once the convergence has occurred, there is no further need for the position to be maintained and the arbitrageur can close out the position and realise the profits that were anticipated when the deal was entered into.
2.2.2.2 Covered Arbitrage on Dual Listed Securities

Covered arbitrage is defined by www.investorwords.com [2000?] as “arbitrage involving investments denominated in different currencies, using forward cover to reduce or eliminate currency risk.”

As institutions expand their global presence, it has become commonplace for them to require funding in the countries in which they have a presence. To this end the institutions issue shares on exchanges in different countries, in an effort to increase the liquidity of the shares and also to reduce the cost of trading the share (Baker 1992:23-29).

Where securities that relate to the same underlying firm are traded on more than one exchange, and in some cases in more than one country, this type of trading may allow for price discrepancies to occur on the same instrument between the different exchanges. Hanousek & Nemec (2002:49-69) consider the co-existing parallel markets and their efficiency in the Czech Republic. Due to different market mechanisms that are used in the price determination and the settlement of the two markets, the prices of these securities often differ. It is this fact that led Hanousek & Nemec (2002:46-69) to investigate the opportunities that are presented to arbitrageurs over time and also allowed them to study the increase in the markets’ efficiency over time.

The approach that was adopted in this analysis was based on Wang & Yau (1994:457-474) “market linkage test”, which used the Dickey & Fuller (1979:427-431) test to estimate the level of arbitrage activity between two markets. Wang & Yau’s approach was modified to take account of transaction costs within the market. This resulted in a modified autoregressive AR(1) process with transaction costs as an additional explanatory variable which is used to evaluate the behaviour of 95 of the most liquid securities that are traded on the two exchanges.

It is likely that there will be greater price disparities between dual listed securities that are not liquid according to Hanousek & Nemec (2002:55). This is due to the fact that the demand and supply curves of the shares are not affected by the arbitrageur operations because the arbitrageur cannot execute the arbitrage due to the lack of liquidity in the market. This results in securities that are not liquid, reflecting greater price differences for greater periods of time than those that are liquid.
Wang & Yau's (1994:457-474) research went on to show that over time the market participants became more effective in creating mechanisms that could be used to capture the price discrepancies in the more transparent and liquid securities, which resulted in stronger co-movements in the share prices between the two parallel markets in the Czech Republic.

2.2.3 **Statistical Arbitrage Defined**

The definition of *statistical arbitrage*, according to [www.Investorwords.com](http://www.Investorwords.com) [2000?], is “an attempt to profit from pricing inefficiencies that are identified through the use of mathematical models”. From the perspective of this research the fundamental difference between pure and statistical arbitrage lies in the fact that in pure arbitrage the likelihood of the profit being realised is considered to be 100%, while in the case of statistical arbitrage the price convergence is not guaranteed and there is therefore only a probability that a profit will be realised. Statistical arbitrage attempts to profit from the likelihood that prices will tend toward their historical norms, and unlike pure arbitrage, statistical arbitrage is not riskless.” [www.investopedia.com](http://www.investopedia.com) [2000?] defines this arbitrage in the following manner: “Statistical arbitrage is not without risk; it depends heavily on the ability of market prices to return to a historical or predicted normal.”

The types of instruments that are used within statistical arbitrage can span the entire range of financial instruments including the underlying securities, futures, forwards, options, warrants and synthetics. The behaviour of the derivative instruments to opportunities that presented themselves in the underlying markets should mirror the effects of those opportunities in the underlying markets. Therefore, if the underlying security is predicted to go up, then so should the derivative instrument and vice versa.

2.2.4 **Types of Statistical Arbitrage**

The different types of statistical arbitrage will be discussed in the sub-sections below.
2.2.4.1 STATISTICAL ARBITRAGE IN THE UNDERLYING SHARES AND THEIR DERIVATIVES

Reverre (2001:459) describes statistical arbitrage as the matching of shares with similar behaviour as a result of their levels of correlation. The relationships usually relate to shares in similar industries and this strategy relies on trading the changes in the price divergences between the two shares. Amman and Herriger (2002:42) describe the statistical arbitrage as “… not based on theoretically precise relationships but rather, on empirical, statistically established relationships. Consequently statistical arbitrage involves risk”.

The opportunities for these types of arbitrages tend to avail themselves for longer periods in the market, as they are not clearly visible to all market participants. However, the risks in this strategy are great and one loss may remove all historical profits in this type of trading. This is due to the fact that the fundamentals often change, which will alter the statistical relationships between the underlying securities, and this will alter the buy and sell signals on the shares or indices.

This approach contradicts the Efficient Market Hypothesis (EMH) discussed by Reilly & Brown (1997:208), as it implies that markets are predictable, and that none of the three variants of this hypothesis always holds true. In general, liquidity may affect the EMH, but for the most part, markets price correctly and many of the observable arbitrages are due to non-simultaneous prices (where the observed price of the underlying and its related security or instrument do not occur at the same time) or the extent of the arbitrage opportunities is of such a scale that it cannot be profitably exploited, given transaction costs (MacKinlay & Ramaswamy, 1988:137-158).

However, Chorafas (1995:222) is of the opinion that the EMH is wrong, as “even if the market is quick to digest earnings data, it can be grossly inefficient in valuing everything else”. Furthermore, Chorafas (1995:223) points out that on a “national stock exchange, forward thinking investment bankers and traders start from the premise that a market system is inherently inefficient and know that this inefficiency can be exploited to their advantage.”

The definition of pairs trading, which is the most common form of statistical trading as offered by www.investorwords.com [2000?], is: “The establishment of a long position in one share and a short position in another share at the same time. A pairs trade
minimizes the effect of larger market trends and emphasizes the performance of one share relative to another … ” An analysis of pairs trading is covered in the work of Froot & Perold (1997:1-19) which covered the pairs relationship that exists between Royal Dutch and Shell. These related sister companies are considered in this study, as they share the revenue and expense allocations from the holding company in a fixed ratio. The relationship of income and expense allocation is publicly known to follow a 60%:40% allocation. This implies that if the relationships of the share prices diverge from one another, arbitrageurs would be able to sell the one share and purchase the other due to the relationship that exists between these shares and their earnings. The fact that the profit allocation will follow a rigid distribution mechanism as described above, implies that there is a high probability of the convergence of the share prices to their normalised price levels. This arbitrage type does not, however, provide a time period in which the convergence will occur and therefore relies on the market mechanism to correct the prices over time.

In statistical pairs trading, a very similar process to the one described above is used by the traders to unlock profit from shares which have over time tended to react to the market in a highly correlated manner. These situations are identified through the creation of correlation matrixes, using the instrument price movements over time. Statistical arbitrage then requires the trader to sell the one share or derivative and purchase the other share or derivative in the event that the correlation relationship between the two shares is above or falls below a given distribution threshold. In the case of statistical arbitrage, there is no guarantee that there will be convergence through a return to the previous degree of correlation of the share prices. The causes of the non-convergence of the share prices are often due to changes in the fundamentals relating to the security or sector and may break or alter the relationship between the securities.

Reverre (2001:475-486) describes a process that can be used for the identification of pairs and statistical arbitrage opportunities. The process is firstly reliant on the identification of shares that have a high correlation in their share price movements. To this end he suggests using a three-month correlation of the change in the share prices to identify those that have a high correlation. While Reverre (2001:475-486) does not specify a threshold at which level the share combinations should be included, he seems to include shares that have positive or negative three month correlations from 84% and above in his analysis.
Using the above statistical approach over a time series spanning a specified period, the trader can calculate the potential profitability of the trading strategy and calculate the percentage of time that the strategy is successful. The trader can also alter the value of the threshold in an attempt to determine the change in profitability that stems from a change in the specific threshold.

Meissner et al. (2002: 1-11) researched the behaviour of the global financial markets to determine if the correlation between markets is high enough to trade on a statistical basis given these relationships. The trading strategy used was a simple unidirectional trade based on the probability that the index that is being traded would tend in the direction in which the leading exchange closed. In this research it is noted that the correlation of price behaviour between indices in different time zones increased during the ten-year period of the study.

This finding corresponds to that published by Joen & Von Furstenburg (1990:15-30) who studied the relationships between the US Dow Jones Industrial Average, the English FTSE 100, the French CAC 40, German DAX, the Japanese Nikkie 225, the Hong Kong Hang Seng Index, and the Singapore Straits Times Index. The results of this research showed that the correlations were significant and that a trading strategy that relied on this inference of performance should generally make money. The findings also showed that the greater the move in the leading index, the greater would be the probability that the lagging index would follow that direction and the greater the move in the lagging index.

In their work on maximising the predictability of share and bond markets, Lo & MacKinlay (1995:1-60) utilise statistical inference gained through the use of autocorrelation processes applied to principle components to set the bounds within which the prices of shares and bonds should trade. Where these bounds are exceeded, a statistical arbitrage has presented itself.

Lo and Mackinley (1995:4) point out that predictability in asset returns is increasingly following a two step approach, which relies firstly on the creation of a linear factor model which has cross-sectional explanatory power, for example factor analysis or principle components decomposition. Once these factors have been identified, the predictability of these factors is analysed. To this end a model which predicts the returns of assets, is created and applied to various asset groups, including components of the S&P 500, a ten-asset group consisting of deciles of size sorted
portfolios, and an eleven-asset group sector sorted portfolio. The research into the performance of these indices, shares and sectors spans the period from 1947 to 1993.

The conditional factors that are used in the forecasting models are reliant on literature documenting the time variation in expected share returns. Sources such as Keim & Stambaugh (1986:357-390), and Fearson & Harvey (1993:289-317) are relied upon to show that variables such as dividend yield and term spreads have forecast power.

2.2.4.2 Option Arbitrage

In all cases where the traders wish to benefit from arbitrage on an option due to a price difference between that option’s relative value to that of another option, on the same or similar security, they are in fact taking a view on the volatility of the option, given a particular price and maturity. Option arbitrage is quite diverse and extends across both pure and statistical arbitrage.

The case of pure arbitrage refers to the put call parity relationships that should exist between the call and put prices of the options. Another case that should be considered is dual listed options struck at the same price and maturity, as these also present pure arbitrage opportunities.

With normal statistical arbitrage the primary task is to identify shares that are highly correlated to one another, and in so doing to create a pairs relationship between the underlying shares and their related derivatives on these instruments. From correlated shares and indices a relationship can be created which may be used to determine which share options should be sold and which should be bought in terms of the historical relationships that exist between the shares, the indices and their options.

Available research on the mispricing of index call and put options in the United States spans nearly two decades, with Ervine & Rudd (1985:743-756) publishing their work as early as 1985. Ackert & Tian (1999:1-19) describe how these opportunities arise and how they can be exploited on the S&P 500, where index options were found to be priced incorrectly in both the call and put options over a long period of time.
Ackert & Tian (1999:1-19) analysed the frequency with which index options are mispriced on the S&P 500 index in the US. The research showed that the option market inefficiencies are reduced over time, but that the introduction of depository receipts, restrictions on short sales and transaction costs which are incurred do affect the profitability of index option arbitrage negatively. This research may be considered complementary to the work of Ervine & Rudd (1985:743-756), Chance (1987:47-64) and Kumara & Miller (1995:519-539), which all showed similar findings in their research into the mispricing of index options.

On the statistical side the pricing reliance again reverts to the degrees of correlation between the share or index prices. Where the share or index prices are highly correlated, the relationship between their volatility levels can be calculated according to (Ammann & Herriger, 2002:43). In light of that fact, Ammann & Herriger (2002:42-55) show that the price relationship that is created through the correlation of the underlying share prices can be extended to the volatilities and therefore to the behaviour of the prices of the options on the underlying shares.

Ammann & Herriger (2002:42-54) researched the statistical arbitrage relationship that exists between 11 share indices in the United States. The approach that was used was to remove stationarity using standard stationarity tests. This removed one index from the 11 tested. The next test was to identify indices that were correlated to a degree greater than 0.95, this removed a further 5 indices. Of the five remaining indices the three most liquid were used in their analysis. Using a period spanning from January 1995 to February 2000, they used Ordinary Least Squared (OLS) regression to determine the relationship of the daily returns of indexes with each of the other.

The findings of the research showed their trading strategy to be effective, with profitable trades being in the 90% levels for all indexes traded. The risks that this study faced were that the volatility deviation would persist until maturity and that the delta or gamma of the options would change. The option positions were constructed to be delta and gamma neutral, as implied through the high correlation ratios. In instances where the trades were not profitable, it was found that the underlying deltas of the indices had changed and this resulted in the fact that the prices and/or volatilities did not converge as expected.
An observation that can be made about this research is that the simulation of the trading environment may show that deals were closed out as per the model, but in reality there was insufficient liquidity to allow the deals to be closed out in the market. In addition, the test data relied on the closing of business price levels, which also calls into question some of the findings due to the fact that these closing levels are usually determined through auction processes which may alter the closing price from the last traded price and non-synchronous data where there are timing differences between the price observations.

2.2.4.3 Risk Arbitrage

The definition of risk arbitrage according to www.investorwords.com [2000?] is, “the simultaneous purchase of shares in a company being acquired and the sale of shares of the acquirer. Modern risk arbitrage focuses on capturing the spreads between the market value of an announced takeover target and the eventual price at which the acquirer will buy the target's shares”. Reverre (2001:423) concludes that it “… refers almost unequivocally to the systematic arbitrage of corporate events, most notably mergers and acquisitions.”

A definition put forward by www.macroanalytics.com/html/risk_arbitrage.html [1999?] explains the concept as: “Risk Arbitrage” or “merger arbitrage”, which attempts to profit from selling short the stock of an acquiring company and buying the stock of the acquiree. This is coined arbitrage due to the fact that companies will often finance takeovers through the issuance of more stock, thus diluting the value of the existing float, and offer a premium over the current share price of the firm they are acquiring, based upon expected future revenues and profits. In addition, shareholders of the takeover candidate face little risk, as they typically receive a premium for the shares they hold, while the acquiring company faces the operational and business risk of having to integrate the business acquired. While this strategy appears attractive, it is reliant upon an active mergers and acquisitions environment and thus is exposed to economic cyclicality, with economic downturns and prolonged bear markets often-impeding returns. The risk that should be considered is that should the merger fall apart, whether due to regulatory or other obstacles, the takeover candidate’s share prices often plummet while the acquiring company’s shares may rise, thus exposing a merger arbitrage trade to high losses.
This type of trading is reliant on merger and acquisition activity, as it is in these situations where companies set out to purchase institutions at levels where investors may decide that the current offer will be accepted as it currently stands or that the current offer will be revised in a specific direction and therefore the theoretical value of the share price is greater or less than the current market value. Risk Arbitrage is an attractive investment strategy for many because it is viewed as a market neutral trading strategy, as there is no correlation to the share market’s overall direction.

The overall profitability of the risk arbitrageur is a function of the number of mergers and acquisitions that occur in the specified period. In times of high corporate activity like in the mid 1990s the profits that these types of opportunities generate, may exceed the market’s return (Fortune, 1993:38).

In 1995 there were 880 mergers and acquisitions on American exchanges, which was a 16% increase over the 1994 figure (Money, 1995:181). Fund managers interviewed in this article were using a risk arbitrage strategy to “profit from the difference between the market price of the target’s shares and the higher price the acquirer is offering”. The mechanism used to hedge is to purchase put options on the company in being taken the takeover so that in the event that the buy out fails and the share price falls to the levels at which they traded prior to the offer, the fund would not have lost money.

There is more than one level to the risk arbitrage concept, as is discussed by (Raynor, 1995:15). He indicates that the shares may trade at a discount to the value of the proposed takeover due to the fact that there is a risk that the deal may fail and cause the share price to fall. The case in point was the takeover of Lotus by IBM in June 1995. Firstly, speculation that Lotus would be able to reduce costs and thereby improve performance circulated the market and resulted in the share price rising with $3. There was also talk of a takeover of Lotus by another firm. When IBM announced its intention to make an offer for Lotus at $60 a share for all shares in issue, the share price jumped from $32.25 to $61.5. At this point most investors who held the share sold their holding with the view that they were being paid more than the offer price. The investors who purchased the shares were risk arbitrageurs that were of the opinion that the price offered for Lotus would be revised upwards. Later in June of that year IBM did indeed revise the offer upwards to $64 a share, and the share then traded to $63 a share by the end of that day.
The $1 differential was left for another set of risk arbitrageurs who had their corporate and regulation lawyers scrutinising the possibility that the government would block the deal, which would cause the share price to fall back to its original level. When the deal was finally concluded, the risk arbitrageurs made the $1 profit they had anticipated when the deal was concluded.

While the literature differs with regard to the expected return that should be anticipated when employing the risk arbitrage strategy, the common idea is that the level of performance of this type of trading is a function of the merger and acquisition activity that is visible in the market.

Horwitz & Rodrigues (1996:1-7) discuss the findings of The Zurich Hedge Fund Indices, which reported merger arbitrage hedge funds realised attractive returns with little variance. On a risk adjusted return basis, merger arbitrage funds outperformed all other major categories of funds that Zurich analysed. The study also showed that the majority of the merger arbitrage managers achieved their returns by drifting away from the “pure” strategy and taking on significant equity risk. The pure form did indeed provide risk return performances, which were attractive and provided low volatilities. The most profitable types of transactions were found to be smaller deals that were presumably less efficiently valued. The study spanned the period 1996 to 2001 and examined about 27000 merger transactions.

Studies into the types of excess returns that are generated by risk arbitrage are not in short supply, as is evident from the number of research articles published on their profitability, such as that by Karolyi & Shannon (1998:2-10), who showed that the annualised returns were around 26%, and Baker & Savasoglo (2002:1-44), who found the annual excess returns to be in the order of 12.5%.

According to (www.wealtheffect.com/stocksb8f.asp) [2001?] the opportunities are partly caused by the “weak science of valuation” combined with attempts to read the direction of the market in cases of risk arbitrage. The largest losses on these types of trades were found to have occurred during the October 1989 crash when arbitrageurs lost hundreds of millions of dollars. This risk arbitrage strategy returned to an “extremely profitable” level following this event.

Jindra & Walking (1999:1-45) show that the percentage difference in price between the offer price and the market price of the shares after the announcement depends
on variables like the probability of the shareholders acceptance for the takeover. Cornelli & Li (2000:17-98), who studied the impact of post-offer trading, point out that the arbitrageurs will continue to buy shares in a firm for as long as the expected profits remain positive. Once they have started trading, the knowledge of their position becomes endogenous information and the more shares that arbitrageurs manage to purchase, the greater the influence that they will have on the outcome of the offer, due to the voting rights that are associated with the shares. This hypothesis is also put forward by Larcker & Lys (1987:111-126), who found that the success rates of risk arbitrageurs are greater than that reflected in the implied probability of success based on the price of the securities.

Mitchell & Pulvino (2001:2135-2175) point out that potential reasons for the excess returns are due to the risk that the deal will fail and thereby result in a loss for the trader. Their study led them to the conclusion that the risk arbitrage opportunities had payoffs that resembled that of an uncovered put option and that the payoff was therefore non-linear in nature. Their analysis also points out that two common types of risk arbitrage “cash mergers” and “stock mergers” occur. In the case of “cash mergers” the owner of the shares will receive cash for the shares on the relevant pay date.

The risk arbitrageurs will receive their profit payoff in the form of the difference between the price at which they bought the shares and the price that the acquiring company buys them from the arbitrageur. In addition to this profit, dividend income will also add to the profitability of the risk arbitrage. In the case of “stock mergers” the arbitrageur will sell the shares of the acquiring company and buy the shares of the company that is being acquired. As the deal reaches the point where money will be exchanged, the spread between the two shares would have narrowed, i.e. the acquirer’s share price will be lower, while the company being purchased will show a gain in the share price. It can be noted the dividend income will supplement the profitability of the strategy. Figure 2.1 below reflects the findings of the research in terms of arbitrage spreads. The figure shows that as the number of days to the deal completion approaches, the spreads either narrows to remove arbitrage opportunities, or if the deal is not going to be successful, the spreads increase dramatically close to the merger termination date.
The research then goes on to examine the validity of the findings, which are reported in other works when their returns are viewed after considering trading cost and the returns are not annualised, as is often the case in such research. The reason for not annualising the returns is that the opportunities may not be repeatable in the future and their general duration is usually about a month, which provides returns that appear inflated due to the effects of annualisation. The research uses 4,750 cash and stock mergers over the period 1963 to 1998. The approach for calculating returns is to begin by calculating daily returns. All transactions within the sample were traded on the basis that returns are calculated on the day after the merger announcement and the returns are calculated up to and including the resolution day. For successful deals the resolution day is the day on which the target’s stock is delisted, and for failed deals this would be the day following the deal failure. In terms of a summary of the duration of the opportunities, there does not appear to be a pattern over time in terms of the average duration of transactions. For the sample, the average time from bid announcement to transaction resolution is 59.3 trading days, while deals that fail generally do so within 39.2 days.

Two different means were used to measure the return on the trades. The first is a Value Weighted Average Return Series (VWRA), whereby the portfolios’ monthly

![Figure 2.1 Median arbitrage spread](image_url)
returns are obtained by calculating a weighted average of the transaction returns for each month. These returns are weighted through the total market equity value of the target company that is used, thereby mitigating the bias introduced by calculating monthly returns using equally weighted daily returns (Cannina et al., 1998).

The second measure is the Risk Arbitrage Index Manager Returns (RAIM). This method aims to simulate a risk arbitrage portfolio, which generates a time series of returns. An initial investment is allowed which must be apportioned along the lines of “not more than 10% may be invested in any one risk arbitrage opportunity and the liquidity of the securities must be adequate to allow for active trading”. The results of the research show that using the RAIM methodology will on average only realise a 4% excess return over the period after taking into account the effect of transaction costs.

In another study, Gomes (2001:1-48) researched the effects of arbitrageurs in takeover situations and the manner in which the arbitrageurs accumulated shares in the company being taken over with the view to affecting the price at which the takeover would take place. In his research he found that the acquirer needs to reach a level equal to \( f \), which equals a freeze-out level that the acquirer requires, in order to buy out the minority shareholders. In so doing the dynamics of the tender offer are considered through the systematic concentration of ownership in the hands of the risk arbitrageurs. This concentrated ownership allows target shareholders to leverage their rights and thereby increase their bargaining power to get the bidder to increase the takeover premium.

Despite the fact that the arbitrageurs have veto power, they have a vested interest in ensuring the deal will go through. They may strategically delay the takeover and thereby force a revised offer for the company. The research applies this game type approach to the risk arbitrage concept, and shows how the risk arbitrageurs utilise their consolidated holding to better the terms of the offer that is made by the acquiring firm.
2.3 **Occurrences Of Equity Arbitrage Types And Their Duration**

The arbitrage concept relies heavily on the ability of traders to short sell either the stock or the derivative instruments that are used in setting up the arbitrage according to (Chew, 2003:8-11). While these actions were initially perceived to be negative by governments, national treasuries and stock exchange bodies, Chew's (2003) research shows that these short sales assist the market in being more efficient.

While the reasoning behind the price disparities in markets are numerous, they are usually attributed to differences in market structures, inefficient markets, or according to Rashes (2001:1911-1914), stocks with similar ticker symbols which are used as abbreviations for the actual share name are sometimes traded in error, which causes large movements in either the underlying share price or in the derivative instruments that are related to that share. In this research, which focuses on unrelated securities that have similar ticker (alpha) codes, it is pointed out that the effectiveness of the current processes used to identify arbitrage opportunities is questionable due to the fact that the existing processes are not eliminating something as obvious as “ticker symbol confusion”. The research shows that the degrees of the co-movement of these share prices and the volumes traded are extremely high despite the fact that the shares are in different sectors, have different market capitalisations, and trade at different prices.

Ganley & Trebeshi. ([2000?]435:461), find that the quality of different market structures also affects arbitrage in the stock futures basis markets. In this research it is shown how the global equity markets react differently in times of stress, and how effectively the markets in London, New York, Toronto, and Frankfurt managed the arbitrage opportunities that were presented during the October 1997 stock market crash. Within the basis trading process the trader would not buy the one side and sell the other, as is common in the normal arbitrages, as in principle the trader would be taking a view on the difference between the future and the spot price. Hence, if the share price is too low relative to the futures price, one would expect the spot price to increase or the futures price to decrease or both. In all of these cases the basis difference between the two would decrease, and the arbitrage opportunity would be realised in this manner.
2.4 INSTRUMENTS USED IN THE EXPLOITATION OF EQUITY ARBITRAGE OPPORTUNITIES

In the subsections below, the following instruments and their arbitrage processes will be discussed: underlying securities, futures and forwards, equity futures, arbitrage on futures, shares futures arbitrage, stock indices, futures prices of stock indices, index arbitrage and options and warrants.

2.4.1 UNDERLYING SECURITIES

The underlying securities to which the study will refer are ordinary shares that Reilly & Brown (1997:82) describe as a token which represents ownership of a firm through its issued shares: “Owners of the common stock (ordinary shares) of a firm share in the company’s success and problems.” While there are different classes of shares, this study will focus on ordinary shares only. Preferred stock (preference shares) are classified as fixed interest securities, according to Reilly & Brown (1997:81), due to the fact that the dividend is stipulated in the terms of their issue, and they can therefore not be classified as true equity.

There are numerous models which have been developed for the valuation of shares, for example the Capital Asset Pricing Model (CAPM) and the Dividend Discount Model. The CAPM analysis is expressed by Brigham & Gapenski (1997) as:

\[ k_s = k_{RF} + (k_M - k_{RF})b_i \]

where

- \( k_s \) is the required return on the security,
- \( k_{RF} \) is the risk free rate of interest,
- \( k_M \) is the expected return of the market, and
- \( b_i \) is the estimated beta or the measure of the shares volatility relative to that of the average share.

According to the dividend discounted model, the share price is calculated using the following formula (Reilly & Brown, 1997:438):

\[ V_j = \frac{D_1}{(1+k)^1} \]
where
\[ V_j = \text{value of the ordinary share}, \]
\[ D_t = \text{dividend during the period } t, \text{ and} \]
\[ k = \text{the required rate of return on share } j. \]

As all derivative instruments rely on the traded value of the underlying securities, the relationship that exists between the underlying share valuation models, as reflected above, and the derivative price can be established. The expression above allows the market to express its view on the fundamentals of the firm through the inputs to the valuation process and these inputs affect both statistical arbitrage and pure arbitrage opportunities. In the statistical arbitrage trading processes, these changes in the inputs alter the fundamentals of the company and this impacts on the statistical relationships upon which the trading strategy is based.

Price changes of the underlying will directly affect the prices of derivatives based on the underlying shares. Notwithstanding the effect of altered fundamentals, the traders could exploit pure arbitrage opportunities, due to mispricing of the underlying instruments by trading in accordance with the dual listed securities example explained below:

Where securities that relate to the same firm are traded on more than one exchange and in some cases in more than one country, this type of trading may allow for price discrepancies to occur on the same instrument between the different exchanges. As discussed in section 2.2.2.2 of this chapter, Hanousek & Nemecek (2002:49-69) considered the co-existing parallel markets and their efficiency in the Czech Republic.

The approach that was adopted in Hanousek & Nemecek (2002:49-69), analysis was based on the Wang & Yau’s (1994:457-474) “market linkage test”, which used the Dickey & Fuller (1979:427-431) test to estimate the level of arbitrage activity between the two markets. Wang & Yau’s (1994:457-474) approach was modified to take account of transaction costs within the market. This resulted in a modified first order autoregressive AR(1) process with transaction costs as an additional explanatory variable which is used to evaluate the behaviour of 95 of the most liquid securities that are traded on the two exchanges.
The actual methodology that is applied is that the transaction costs in the two markets are given by:

$$TC(P^A_t, P^B_t) = tc_A P^A_t + tc_B P^B_t$$

where the transaction costs that are incurred $TC(P^A_t, P^B_t)$ are given by the function of the transaction costs associated with trading the same security:

- $tc_A$ is the transaction cost incurred in market A,
- $tc_B$ is the transaction cost incurred in market B,
- $P^A_t$ at price level in market A at time $t$, and
- $P^B_t$ at price level in market B at time $t$.

This will allow the creation of an upper limit at which arbitrageurs will enter the market, as the price will exceed the theoretical price at which the security is being traded on market B. The theoretical price of market A implied by the price on market B, for price $P^*_t^A$ is:

$$P^*_t^A = P^B_t (1 + tc (P^*_t^A, P^B_t))$$

where

- $P^*_t^A$ is the theoretical price of the share in market A,
- $P^B_t$ is the price of the security in market B, and
- $tc(P^*_t^A, P^B_t)$ is the expression defining the expected transaction costs in market A and actual transactions costs in market B.

After substitution the upper limits for transaction costs in market A can be rewritten as:

$$P^*_t^A = P^B_t \frac{(1 + tc_B)}{(1 - tc_A)}$$

In a similar way the upper limit of the theoretical price on market B as implied by the price on market A is given by:

$$P^*_t^B = P^A_t \frac{(1 + tc_A)}{(1 - tc_B)}$$
Hanousek & Nemecek (2002:49) show that when the observed price $P_{A,t}$ exceeds the theoretical price $P^*_A$, then the price discrepancy can be exploited by simultaneously buying one share on market B and selling one share on market A, thereby increasing the demand and prices on market B while increasing the supply and depressing the prices on market A.

The study then uses Garbade & Silber (1983:289-297) to model the dynamic price relationship between cash and futures assuming arbitrage and zero cost. In this study, it is asserted that the convergence is dependant on the supply elasticity of arbitrage, as the greater the supply elasticity, the faster the price differences will be arbitraged away. This provides the formulae:

$$P_{A,t} = P_{t-1}^A - \beta_1 (P_{t-1}^A - P^*_{t-1}A)^+ + \beta_2 (P_{t-1}^B - P^*_{t-1}B)^+ + \epsilon_{t}^A$$

$$P_{B,t} = P_{t-1}^B - \beta_1 (P_{t-1}^B - P^*_{t-1}B)^+ + \beta_2 (P_{t-1}^A - P^*_{t-1}A)^+ + \epsilon_{t}^B$$

where

$x^+$ is the max $(x,o)$ and $x^+$ is given by $(P_{t-1}^A - P^*_{t-1}A)^+ + (P_{t-1}^B - P^*_{t-1}B)^+$,

$\beta_1$ and $\beta_2$ are elasticities of the arbitrage supply in market A and B, and

$\epsilon_{t}^A$ and $\epsilon_{t}^B$ are error terms.

When $\beta_1 = \beta_2 = 0$, there is no relationship between the securities.

As an alternative to estimating $\beta_1$ and $\beta_2$ individually, the top equation can be subtracted from the bottom equation, to give:

$$P_{A,t} - P_{B,t} = (P_{t-1}^A - P^*_{t-1}A)^+ - (P_{t-1}^B - P^*_{t-1}B)^+$$

These relationships can be manipulated further to give:

$$(P^A_{t-1} - P^*_{t-1}A)^+ = (P^B_{t-1} - P^*_{t-1}B)^+$$

$$= \left\{ \begin{array}{ll} P_{t-1}^A - P^B_{t-1} + \frac{tc_A + tc_B}{1 - tc_A} P^B_{t-1} \\ 1 - tc_A \end{array} \right\}^+ + \left\{ \begin{array}{ll} P^B_{t-1} - P_{t-1}^A + \frac{tc_A + tc_B}{1 - tc_A} P^A_{t-1} \\ 1 - tc_A \end{array} \right\}^+$$
\[ P^t_A - P^t_B = (1 - \beta_1 - \beta_2)\left( P^t_A - P^t_B \right) - (\beta_1 + \beta_2) F_t + (\epsilon^A_t - \epsilon^B_t) \]

or

\[ P^t_A - P^t_B = (1 - \beta)\left( P^t_A - P^t_B \right) - \beta F_t + \epsilon_t \]

where:

\[ \beta = \beta_1 + \beta_2 \text{ and } \epsilon_t = \epsilon^A_t - \epsilon^B_t \]

\( F_t \) is a transaction cost term.

From the above, the effects of transaction costs are then depicted in Figure 2.2 below. In Figure 2.2 the X axis represents the price of the share in market A at time \( t-1 \) while the Y axis represents the price of the share in market B. The dashed 45 degree line represents instances at time \( t-1 \) where no arbitrage opportunities exist due to transaction costs. If the price difference is large enough to cover the costs of the arbitrage trade, the price difference at time \( t \) is also determined by the supply of arbitrage activities \( \beta \) and the price difference at time \( t-1 \) is greater than the transaction costs.
As discussed in section 2.2.4.1, Reverre (2001:475-486) describes a process that can be used for the identification of pairs and statistical arbitrage opportunities. The process is firstly reliant on the identification of shares that have a high correlation in their share price movements. To this end he suggests using a three-month correlation of the change in the share prices to identify shares that have a high correlation. While Reverre (2001) does not specify a threshold at which level the share combinations should be included, he seems to include shares that have positive or negative correlations from 84% and up in his analysis.

Once the shares that are highly correlated to one another have been identified, Reverre (2001:475-476) proposes firstly that the ratios of the share prices in relation to one another should be calculated, from these ratios, a 30-day moving average of the ratio of the share prices should be calculated. The ratio’s moving average is used to stabilise the value of the share price over time. Through the use of this 30 day moving average of the ratio the model can predict the proposed price of the share given this smoothing method. Basically the denominator used in the calculation of the daily share price ratio is multiplied by the smoothed ratio to provide a projected price of the share, which acts as the numerator in the ratio calculation.

Source: (Hanousek & Nemecek, 2002:51)
This theoretical value is then deducted from the actual market price of the share, which enables a view of whether the share price is currently under or overvalued. This should allow the trader to buy or sell the share if the share price is mispriced by a certain amount, which should be enough to compensate for transaction costs. This is, however, a rather crude manner of identifying price differences and Reverre (2001:476) indicates that it can be improved by normalising the value of the difference by subtracting the price difference from the 30 day moving average of the price difference and then dividing this calculated number by the standard deviation of the price difference. The above description can be expressed as:

$$\Delta_{\text{norm}} = \frac{\Delta - \text{MA}_{30}(\Delta)}{\theta_{30}(\Delta)}$$

where:

- $\Delta_{\text{norm}}$ is the normalised change in the price of the share,
- $\Delta$ is the actual change in the share price,
- $\text{MA}_{30}(\Delta)$ is the 30 day moving average of the change, and
- $\theta_{30}(\Delta)$ is the 30 day standard deviation of the change.

The benefit of using the $\Delta_{\text{norm}}$ is that it is normally distributed which means that there is, for example, a 15% chance that $\Delta_{\text{norm}}$ will be above or below 1, while there is a 2.34 percent chance that it will be above or below 2 or -2. For that reason, when the $\Delta_{\text{norm}}$ is greater or less than 2, that market event is rare from a statistical perspective.

Reverre (2001:477) suggests that as $\Delta_{\text{norm}}$ oscillates around zero, the trader should act in all cases where the threshold of 1.5 standard deviations has been breached. If the $\Delta_{\text{norm}}$ is greater than 1.5 then the recommendation is therefore to buy one of the shares, that acts as the numerator while selling a quantity equal to the $\text{MA}_{30}$ ratio of the shares acting as the denominator. If the $\Delta_{\text{norm}}$ is less than one, the opposite positions to those suggested above should be traded.

Using the above statistical approach over a time series the trader can calculate the potential profitability of the trading strategy and calculate the percentage of time that the strategy is successful. The trader can also alter the value of the threshold in an attempt to determine the change in profitability that stems from a change in the specific threshold.
As discussed in section 2.2.4.3, where risk arbitrage is considered, Mitchell & Pulvino (2001: 2135-2175) point out that potential reasons for the excess returns are due to the risk that the deal will fail and thereby result in a loss for the trader. All transactions within the sample were traded on the basis that returns are calculated on the day after the merger announcement and the returns are calculated up to and including the resolution day. For successful deals the resolution day is the day on which, the targets stock is delisted and for failed deals, this would be the day following the deal failure. The method of return calculation in cash offers is:

\[
R_{it} = \frac{P_{iT} + D_{iT} - P_{iT-1}}{P_{iT-1}}
\]

where:
- \( R_{it} \) is the daily return of the share,
- \( P_{iT} \) is the targets stock price at the close of market on day \( t \),
- \( D_{iT} \) is the dividend paid on the share, and
- \( P_{iT-1} \) is the targets closing price.

In the case of share offers the return is calculated using:

\[
R_{it} = \frac{P_{iT} + D_{iT} - P_{iT-1} - \Delta(P_{Ait} + D_{Ait} - P_{Ait-1} - r_iP_{Ait-1})}{\text{Position Value}_{t-1}}
\]

where:
- Superscript \( T \) refers to the target company,
- Superscript \( A \) refers to the acquiring company,
- \( \Delta \) is the hedge ratio (equal to the number of the acquirer’s shares to be paid for each of the outstanding target shares),
- \( r_i \) is the appropriate risk free rate, and
- \( P_{Ait} \) is the acquirer’s stock price at the close of business on the day following the merger announcement.

In terms of a summary of the duration of the opportunities, there does not appear to be a pattern over time in the average duration of transactions. For the sample, the average time from bid announcement to transaction resolution is 59.3 trading days, while deals that fail generally do so within 39.2 days.
2.4.2 Futures and Forwards

Prebon Training Services SA (2001:8-9) defines a forward as “an agreement between two parties to exchange a specific quantity, of a specified security at a specified price on a specified date”, while they define a future as “a standardised contract between two parties to exchange a standard quantity of a specified underlying asset on a predetermined future date at a price agreed today, traded on an organised exchange”. As an example the buyer of 1 Dimension Data (DDT) futures contract will receive 100 DDT shares at the maturity date of the future; therefore 1 futures contract = 100 times the underlying.

The risk profile of buying a future or a forward is the same as buying the share outright. Figure 2.3 taken from Prebon Training Services SA (2001:10) depicts this linear behaviour.

Figure 2.3 Behaviour of the price of a futures contract

![Figure 2.3 Behaviour of the price of a futures contract](source: Prebon Training Services SA (2001:10))
2.4.3 EQUITY FUTURES

Equity futures are futures on the individual shares where, settlement of these futures will occur through the physical delivery of the underlying shares. Table 2.1, taken from Prebon Training Services SA (2001:39), outlines the specifications of an equity futures contract.

Table 2-1 Equity futures specification in the South African market

<table>
<thead>
<tr>
<th>Underlying instrument</th>
<th>Specified individual equities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract Size</td>
<td>100 times the share price (i.e. the value of 100 shares).</td>
</tr>
<tr>
<td>Expiry date</td>
<td>Third Tuesday of March, June, September and December or the previous business day if it is a public holiday.</td>
</tr>
<tr>
<td>Settlement Method</td>
<td>Physically settled. Position holders must elect a stockbroker to facilitate the physical settlement.</td>
</tr>
<tr>
<td>Tick Value</td>
<td>R1 (1 ctpar share). One index point (R10).</td>
</tr>
<tr>
<td>Expiry valuation</td>
<td>Based on the average share price as calculated by the JSE between the market hours of 14H00 and 16H00 on the expiry date</td>
</tr>
</tbody>
</table>

Source: Prebon Training Services SA (2001:39)

Presuming that the contract specifications are the same, the value of a forward and a futures contract may differ as a result of the margin calls that may be required by the futures clearing house. As margin calls are not applied to Over The Counter (OTC) forward transactions the values will be different due to the carry cost on the futures margin calls (Hull, 2000:85). However, as the actual price difference will be negligible, this study will treat futures and forwards as though they were priced in the same manner. For this reason, further conventions in this discussion will refer to the futures, which imply both futures, and forwards on the underlying share or index.

2.4.4 ARBITRAGE ON FUTURES

Looking at the inputs that determine the price of a future, the basic variables are the spot price, interest rates and the dividends, which may be received. Table 2.2 below shows hypothetical inputs used to calculate a futures price. In this example the market’s futures price is too high and the future can therefore be sold while the underlying security can be purchased for delivery at the time of the futures maturity
date. If this approach was followed, the trader would realize a risk free profit of R1.84 for every share forming part of the contract that was entered into.

**Table 2-2 Futures contract where the futures price is too high**

<table>
<thead>
<tr>
<th>Spot Price (So)</th>
<th>30.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Futures Price (Fo)</td>
<td>35.00</td>
</tr>
<tr>
<td>Risk Free Interest Rate</td>
<td>5%</td>
</tr>
<tr>
<td>Time (in years)</td>
<td>2</td>
</tr>
<tr>
<td>Theoretical Futures Price</td>
<td>33.16</td>
</tr>
<tr>
<td>Difference between the future and the theoretical value</td>
<td><strong>1.84</strong></td>
</tr>
</tbody>
</table>

*Source: Adapted from (Hull, 2000:55)*

If the futures price is too low relative to the spot price and interest rate, as is the case in Table 2.3 below, two scenarios can play themselves out. If the trader already holds the shares, the future can be bought while delivering the shares to the market. At maturity the futures contract will be settled with shares which can be converted to cash. If the trader does not hold the shares in his portfolio, the trader should buy the future, while selling the shares in the spot market and borrowing the shares from securities lending desks to facilitate delivery to the market. At maturity, the shares will be received when the future matures, and these can then be delivered back to the securities lending desk. In this case the arbitrageur will receive a riskless profit of R2.16 per share traded in the arbitrage.

**Table 2-3 Futures contract where the futures price is too low**

<table>
<thead>
<tr>
<th>Spot Price (So)</th>
<th>30.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Futures Price (Fo)</td>
<td>31.00</td>
</tr>
<tr>
<td>Risk Free Interest Rate</td>
<td>5%</td>
</tr>
<tr>
<td>Time in years</td>
<td>2</td>
</tr>
<tr>
<td>Theoretical futures price</td>
<td>33.16</td>
</tr>
<tr>
<td>Difference between the future and theoretical value</td>
<td><strong>- 2.16</strong></td>
</tr>
</tbody>
</table>

*Source Adapted from (Hull, 2000:55)*
2.4.5 **SHARE FUTURES ARBITRAGE**

The calculation of the theoretical or fair price of a share future is, as in the example above, reliant on the current share price of the underlying security expressed as a function of the time until maturity, the dividend, and the risk free interest rate. The expression can be written in a manner that excludes dividends where there is no dividend yield, or in a manner where the dividend yield is subtracted from the risk free interest rate. In all cases it should be ensured that the compounding frequencies of the dividend yield and the risk free interest rate are the same.

The futures price for an investment asset producing no income, is given by Hull (2000: 55):

\[ F_0 = S_0 e^{rT} \]

The futures price for an investment asset producing an income, is given by Hull (2000:56):

\[ F_0 = (S_0 - I) e^{rT} \]

where:

- \( F_0 \) = current forward price long forward contract,
- \( r \) = interest rate,
- \( T \) = time to maturity, and
- \( I \) = present value of income.

The value of the future relative to the spot price at the time the transaction is entered into is zero, as the futures price is simply a reflection of the spot price compounded at a rate equal to the risk free rate less the dividend yield. The future’s valuation will change as time progresses, as the spot and dividend rates change and as the interest rate changes.

2.4.6 **STOCK INDICES**

Natenberg (1994:301) defines an index as “a number, which represents the composite value of items. In the case of stock indices, the value of the index is determined by the value of a group of specified shares, with the value of the shares
usually being determined by their prices in the market place. … the value of an index always reflects the total value of the shares which make up the index. Common methods of weighting an index are price weighting where the share’s value is directly proportional to its value in the index and capitalization weighted indices where the weighting is determined by the total market capitalization of the share in the index.”

In the case of the South African Indices, http://ftse.jse.co.za [2000?] shows that the FTSE/JSE Africa Index Series of the All Share Index (ALSI Top 40) is calculated by means of the following formula:

\[ \text{Index} = \frac{\text{Sum of Free Float Market Capitalisation of All Constituent Companies}}{\text{Latest Index Divisor}}. \]

In the case of the free float market capitalisation index, the floating market capitalisation of the constituents is calculated by multiplying the most recent share price by the number of shares outstanding in the firm and using these as the inputs to the Free Float capitalisation Index according to www.jse.co.za [1999?]. The divisor of the index is an arbitrary number chosen at the starting point of the index, which is adjusted when capitalisation amendments are made to the constituents of the index, allowing the index value to remain comparable over time.

\subsection*{2.4.7 Futures Prices of Stock Indices}

Index futures are based on the price of the underlying shares and they can therefore not be physically delivered. Table 2.4 below describes the general characteristics that relate to Index futures and shows that the standard delivery process is usually in the form of cash.

The parity of the futures price to the share index will be given by the equation:

\[ \text{Fo} = \text{Soe}^{(r-q)T} \]

where the index is an asset that pays a dividend (dividend yield = q).
Table 2-4 The characteristics of index futures on SAFEX

<table>
<thead>
<tr>
<th>Underlying instrument</th>
<th>An equity index (ALSI, INI RESI or FINI).</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contract Size</td>
<td>10 times the index level.</td>
</tr>
<tr>
<td>Expiry date</td>
<td>Third Tuesday of March, June, September and December or the previous business day if it is a public holiday.</td>
</tr>
<tr>
<td>Settlement Method</td>
<td>Cash</td>
</tr>
<tr>
<td>Tick Value</td>
<td>One Index point (R10).</td>
</tr>
<tr>
<td>Expiry valuation</td>
<td>Based on the average index as calculated by the JSE between the hours of 14H00 and 16H00 on the expiry date.</td>
</tr>
</tbody>
</table>

Source: Prebon Training Services (2001:40)

2.4.8 INDEX ARBITRAGE

Hull (2000:64) illustrates futures arbitrage on an index by way of the following situation where the futures price is higher than the theoretically calculated fair price of a future:

\[ F_o > S_0 e^{(r-q)T} \]

In the above situation the trader should buy the shares underlying the index, and sell the futures contract, in order to realise the arbitrage profit. Corporations holding short-term money market investments often follow this approach.

In cases where the futures fair price is less than the actual futures price, Hull (2000:64) describes the situation through the equation:

\[ F_o < S_0 e^{(r-q)T} \]

In the above case the trader would buy the index future, and sell the shares involved. These index arbitrages are often done by pension funds, as they will already own the underlying shares.

Due to the transaction costs involved in trading all the shares in a large index, index arbitrage can be accomplished through trading a relatively small representative
sample of the shares whose movements are closely correlated to the index price movement.

As discussed in section 2.2.2.1, Chung (1991:1792) shows that Index Arbitrage follows the conventional identification process of:

\[ F(t,T) = S(t)e^{r(T-t)} - D(t,T) \]

where
\( F(t,T) \) = futures price for maturity at time \( T \),
\( S(t)e^{r(T-t)} \) = Spot price of the index at time \( t \) adjusted for time value, and
\( D(t,T) \) = the dividends that are paid on the individual share adjusted for the time value.

Chung’s research follows the approaches adopted by MacKinlay & Ramaswamy (1988:137-158) and Stoll & Whaley (1990:391-412) who used intraday prices in an effort to resolve the problem of non simultaneous data by using the intraday returns of shares and their indices. In their research it is shown that the quoted index value is not a perfect measure of the true value of the index, due to the fact that the index and its constituents do not trade continuously. Therefore all combinations of prices are not always current in the index prices.

Chung (1991:1793) also shows that most studies do not include the up tick rule for short sales of the constituent shares of the index in their findings and therefore these findings are not totally correct. This rule specifies that a short sale may only occur after the share price has ticked up or has had two successive trades at the same price.

The efficiency tests that are used by Chung (1991:1795) are ex post and ex ante. In the case of ex-post tests the hypothesis is:

\[ \varepsilon_{xp} = |F(t,T) - S(t)e^{r(T-t)} + D(t,T)| - b(t) \leq 0 \]

where:
\( \varepsilon_{xp} \) is the Ex Post profit,
\( F(t,T) \) is the futures price without taking into account an execution lag,
\[ S(t) = \sum_{i=1}^{\text{number of shares}} P_i(t^*) / d(t), \]

\( t^* \) is the actual time \( t \) if the share is traded at time \( t \), otherwise \( t^* \) equals the closest time prior to the trade, 
\( P_i(t^*) \) equals the price at time \( t^* \) of the \( i^{th} \) share, and 
\( d(t) \) equals the adjusted divisor used at \( t \).

In cases where \( \nu \) is negative, where assuming \( F(t, T) - S(t)e^{r(T-t)} + D(t, T) = \nu \), but the absolute value of \( \nu \) minus any transaction costs \( |\nu| - b(t) \) is positive, the trader should sell the underlying index and buy the futures contract. If \( \nu \) is positive, and \( \nu - b(t) \) is also positive, the trader should buy the underlying index and sell the futures contract. In both these cases the profit \( \epsilon_{xp} \) which is calculated using the above formula will be realised over the time to convergence.

As traders are not guaranteed execution at the observed prices, an ex post price violation \( \epsilon_{xp} \) is considered to be nothing more than a mispricing signal to traders. The quantifiable effect of the mispricing should be calculated using:

\[ \epsilon_{xa} = F(t^*, T) - S(t^*)e^{r(T-t)} + D(t, T) - b(t^*) \leq 0 \text{ when } \nu \text{ is positive} \]

\[ \epsilon_{xa} = -[F(t^*, T) - S(t^*)e^{r(T-t)} + D(t, T)] - b(t^*) \leq 0 \text{ when } \nu \text{ is negative} \]

where:
\( \epsilon_{xa} \) is the Ex Ante profit,
\( F(t^*, T) \) is the first futures price following an execution lag after \( t \),
\( S(t^*) = \sum_{i=1}^{\text{number of shares}} P_i(t^*) / d(t^*) \),
\( P_i(t^*) \) is the first price of the \( i^{th} \) share following an execution lag after \( t \),
\( d(t^*) \) is the adjusted divisor used at \( t^* \), and
\( b(t^*) \) is the time \( t^* \) present value of the sum of the transaction costs incurred during the arbitrage.

The study therefore shows that \( \epsilon_{xa} \) is the ex ante arbitrage profit at \( t^* \) triggered by a mispricing signal being a positive \( \epsilon_{xp} \) at time \( t \).

Chung (1991:1800) then goes on to show that over the period 1984 to 1986 arbitrage opportunities and profits have become smaller after taking into account trading costs. Despite the decline in profitability his study also showed that programme trading is
still a profitable trading strategy despite the fact that profitable opportunities when using a transaction cost of 0.75% and 1% had declined to less than 50% of the opportunities originally identified.

Section 2.2.4.1 referred to Meissner et al. (2002?: 1-11), who did research into the behaviour of the correlation of the global financial markets in an effort to determine whether the correlation between markets is high enough to trade on a statistical basis given these relationships. The trading strategy used was a simple unidirectional trade based on the probability that the index which was being traded would tend in the direction that the leading exchange closed at. These findings correspond to those published by Joen & Von Furstenburg (1990:15-30) and the Economist (2001:90).

Meissner et al (2002). analysed the price directional relationships between the US Dow Jones Industrial Average, the English FTSE 100, the French CAC 40, German DAX, the Japanese Nikkie 225, the Hong Kong Hang Seng Index, and the Singapore Straits Times Index by means of simple linear regression analysis. As an explanatory example the CAC, as a function of the Dow Jones Industrial Index, can be expressed as:

\[ \text{CAC}_t = \alpha + \beta \text{Dow}_{t-1} + e_t \]

where
\( \alpha \) is the y intercept in the linear interpretation of the population of data,
\( \beta \) is the coefficient of determination for the Dow, and
\( e_t \) is the noise that relates to the expression.

This equation can be extended to show the relationship of any one particular indices’ behaviour to that of indices in other geographic areas. For example, in the case of US indices dependencies on the indices in Europe and Asia, the expression will be given by the multiple regression function:

\[ \text{US}_t = a + \sum_{i=0}^{n} \beta_i \text{Europe}_{t-i} + \sum \beta_j \text{Asia}_{t-j} + e_{t,i,j}. \]

Lo & MacKinlay’s (1995:1-60) work on maximising the predictability of share and bond markets provides an example of a linear factor model which, considers the case of two assets being asset A and asset B. Both these assets satisfy a linear two factor model, so that the return of the two assets is shown by \( R_t \), which is denoted by the
2x1 vector of the demeaned asset returns at time \( t \) \([R_{at}, R_{bt}]\), where \( R_{at} \) and \( R_{bt} \) are the returns on asset A and asset B and the return is such that:

\[
R_t = \delta_1 F_{1t} + \delta_2 F_{2t} + \epsilon_t
\]

where \( \delta_1 \) \([\delta_{a1}, \delta_{b1}]\)' \( \delta_2 \) \([\delta_{a2}, \delta_{b2}]\)' \( \epsilon_t \) \([\epsilon_{at}, \epsilon_{bt}]\)' is white noise with covariance matrix \( \sigma^2 \) and \( F_{1t} \) and \( F_{2t} \) are two factors that drive the expected return of A and B, this can be further explained by the following equalities.

\[
E[F_{1t}] = E[F_{2t}] = 0, \quad \text{Var} \ [F_{1t}] = \text{Var} \ [F_{2t}] = 1
\]

\[
\text{Cov} [F_{1s}, F_{2t}] = 0 \quad \forall \ s,t
\]

Where \( F_{1t} \) is unpredictable through time, and is considered to be white noise, while \( F_{2t} \) is predictable and is considered to be a first order auto regression AR(1), then;

\[
F_{1t} \sim \text{White Noise}, \quad F_{2t} = \beta F_{2t-1} + \eta_t, \quad |\beta| \in (0,1)
\]

Where \( \eta_t \) is a white noise process with a variance of \( 1 - \beta^2 \) and independent variable of \( \{\epsilon_t\} \) then the return should be explained by the two contemporaneous factors, being white noise and a predictable factor. Lo and Mackinley (1995:5) then show that under this linear two factor model, the contemporaneous covariance matrix and the first-order auto covariance matrix of the two assets’ returns \( R_t \) are given by:

\[
\Gamma_0 = \text{Var} [R_t] = \delta_1 \delta_1' + \delta_2 \delta_2' + \sigma^2
\]

\[
\Gamma_1 = \text{Cov} [R_t, R_{t-1}] = \delta_2 \delta_1' \beta
\]

Lo & Mackinlay (1995:6) assume that the true data generating process is unknown to investors and that these values need to be estimated by investors. This implies that factor analysis or principle component decomposition is required. In a simple two-asset process the first principle component is a portfolio \( \omega_{PC} \) that corresponds to the normalised eigenvector of the largest eigenvalue of the contemporaneous covariance matrix \( \Gamma_0 \), with a portfolio return:

\[
R_{PC1,t} = \omega_{PC} R_t
\]
In the above equation, $R_{PC1,t}$ could be considered the most important factor from a cross sectional perspective. The above therefore gives the sources of predictability of returns. The relative importance of each of the factors is given by:

$$R^2[R_{PC1,t}] = \frac{(\omega_{PC1,2}\beta)^2}{\omega_{PC1,1} \Gamma_0 \omega_{PC1,1}}$$

A second measure of predictability is the squared first order autocorrelation coefficient of $R_{PC1,t}$ given by:

$$\hat{\tau}_1^2[R_{PC1,t}] = \frac{[(\omega_{PC1,2}\beta)^2]^2}{(\omega_{PC1,1} \Gamma_0 \omega_{PC1,1})^2}$$

where $\hat{\tau}_1^2[R_{PC1,t}]$ is the measure of predictability and the other inputs used follow the conventions described above. The conditional factors that are used in the forecasting models are reliant on literature documenting the time variation in expected share returns. Sources such as Keim & Stambaugh (1986:357-390), Fearson & Harvey (1993:289-317) are relied upon to show that variables such as dividend yield and term spreads have forecast power. In Lo & Mackinlay’s (1995:16) study the following variables are used as determinants:

- $Dy_t$ is the dividend yield, which is the average dividend yield for the value weighted index for the 12-month period ending at the end of month $t$, divided by the index value at the end of month $t$.
- $DEF_t$ is the default spread of the average weekly yield for low grade bonds in month $t$ minus the average weekly yield for the long-term government bond in month $t$, where low grade bonds are rated Baa.
- $MAT_t$ The maturity spread is the average weekly yields on the long-term government bond in month $t$ minus the average weekly yield from the auctions of 3 month Treasury bills in month $t$.
- $SPR_t$ Is the S&P 500 Index’s return defined as the monthly return on a value weighted portfolio of 500 shares.
- $IRT_t$ Is the interest rate trend, defined as the monthly change of the average weekly yield on the long-term bond.
Lo & Mackinlay (1995:17) point out that a frequent complexity in reliable forecasting in financial markets due to covariance’s, cross-autocorrelations and betas. They propose the following formula to overcome some of these complexities using the independent variables described above:

\[ Z_t = \alpha + \beta_1.DY_{t-1} + \beta_2.DEF_{t-1} + \beta_3.MAT_{t-1} + \beta_4.IRT_{t-1} + \beta_5t-1 \times SPR_{t-1} + \epsilon_t \]

Where \( \beta_{5t-1} = \delta_0 + \delta_1 \times DY_{t-1} \).

As the inclusion of \( SPR_{t-1} \) allows the asymmetric lead/lag relation of Lo & Mackinlay (1990:41-66), whereby the returns of large institutions can forecast those of small institutions, but not the other way round. \( \beta_{5t-1} \) acts as a deterministic linear function of the dividend yield \( DY_t \). \( \beta_{5t-1} \) may vary through time and has the potential to capture instabilities in a systematic way. Given this fact the equation can now be restated as:

\[ Z_t = \alpha + \beta_1.DY_{t-1} + \beta_2.DEF_{t-1} + \beta_3.MAT_{t-1} + \beta_4.IRT_{t-1} + (\delta_0 + \delta_1.DY_{t-1}).SPR_{t-1} + \epsilon_t \]

And further reduced to:

\[ Z_t = \alpha + \beta_1.DY_{t-1} + \beta_2.DEF_{t-1} + \beta_3.MAT_{t-1} + \beta_4.IRT_{t-1} + \delta_0.SPR_{t-1} + \delta_1.DY_{t-1}.SPR_{t-1} + \epsilon_t \]

If \( SPDY = DY_{t-1}.SPR_{t-1} \), then this factor can be added to the list of regressors in the model described.

The least squares estimate for the conditional factor model is used to estimate the asset group’s 5x1 vector of indices, as well as 10x1 vector of size deciles and 11x1 vector for the sector portfolios. The multi-horizon return calculations with non-overlapping returns are used to avoid bias from the results.

Their model clearly reflects the basis upon which a multi-factor regression process can be used in order to infer significance of the principle components to the dependent variable being the return of the portfolio.

2.4.8.1 **Delivery of Futures**

In Hull’s (2000:74) view, the delivery of futures should be viewed from the perspective where the futures price is an increasing function of the time to maturity,
i.e. upward sloping. The trader with a short position should deliver as early as possible, as the holder of a short position can choose the settlement date. This is view due to the fact that the interest earned on the cash received will outweigh the benefit of holding the asset for the full term. Where the futures prices are decreasing, i.e. downward sloping, it is usually optimal for the short position to deliver as late as possible and one should therefore assume that the later date is more applicable.

Futures prices should generally be less than the actual expected future spot price in order to compensate speculators for the risk incurred through the passage of time. This is known as *normal backwardation*. The opposite is known as *contango*. Contango is defined by [www.investopedia.com](http://www.investopedia.com) [2000?] as “when the futures price is above the expected future spot price. Consequently, the price will decline to the spot price before the delivery date.” Backwardation is defined by [www.investopedia.com](http://www.investopedia.com) [2000?] as “the theory that futures prices will tend to rise over the life of a contract. Therefore the near term contracts trade at a higher price than the longer term contracts.” Hull (2000:74), states that the causes of contango and backwardation are a result of the market’s view relating, to the amount of systematic risk of the instrument at a point in time and the markets changing perceptions about the future spot price of the underlying instrument. The systematic risk is a function of the correlation of the returns of the instrument relative to the market's returns. Where the market views the systematic risk of an instrument to be lower than the total market’s systematic risk, a return lower than the risk free rate will be accepted, which may create the phenomenon of backwardation. Conversely, where the systematic risk is greater than the systematic risk perceived by the market, the phenomenon of contango may occur.

### 2.4.9 Options and Warrants

Options and warrants can be broadly broken down into call options which give one the right to buy an asset at a future time or within a future period at a predefined price, and put options which give the holder the right to sell the asset at a future time or within a future period at a specified price (Brigham & Gapenski, 1997:988). The call and put options can be further broken down into American, European or exotic type options. Natenberg (1994:4-7) describes an American option as an option whereby the holder can exercise the option at any time prior to expiration date and a European option as where the holder can only exercise the option on the expiration date.
The Black Scholes Option Pricing Model is based on the following equations for Calls (C) and Puts (P), (Hull, 2000:250 and Rubenstein, 1999:272-275).

\[ C = S_0 N(d_1) - X e^{-rT} N(d_2) \]
\[ P = X e^{-rT} N(-d_2) - S_0 N(-d_1) \]

where \( d_1 \) and \( d_2 \) are defined as:

\[ d_1 = \frac{(\ln(S_0/X) + (r + \sigma^2/2)T)}{\sigma \sqrt{T}} \]
\[ d_2 = d_1 - \sigma \sqrt{T} \]

Hull (2000:169) shows that the values of calls generally increase as the current share price, time to expiration, volatility, and the risk free interest rate increases. Values of calls decrease as the strike price and expected dividends increase while the value of a put option increases as the strike price, time to expiration, volatility and expected dividends increase. The theoretical value of a put option decreases as the current share price and risk free interest rate increases.

The following notation taken from Hull (200:170) will be applicable in further analysis:
- \( S_0 \) : current share price,
- \( S_T \) : Share price at time \( T \),
- \( X \) : Strike Price,
- \( T \) : Time of expiration,
- \( r \) : risk free rate of interest for maturity \( T \) (continuously compounded),
- \( C \) : value of an American Call option to buy one share,
- \( P \) : value of an American Put option to sell one share,
- \( c \) : value of an European Call option to buy one share, and
- \( p \) : value of a European Put option to sell one share.

In the event that a discreet dividend payment is anticipated for the share, the projected dividends should be discounted to the valuation date and subtracted from the spot value prior to its substitution in the formula.
While the Black Scholes formula has been widely accepted by market participants, it is not without its flaws, which relate to the fact that the model assumes a log normal distribution, constant volatility, continuity and infinite trading possibilities. Given this fact there are various other models that have been put forward to address the shortcomings in this model. Research by Britten-Jones & Neuberger (1996:347-363) and Fortune (1996:38) are some of the examples of ideas that try to address these problems in the Black Scholes model. It should be mentioned that despite these new approaches, the Black Scholes (1973:637-659) model has shown remarkable resilience and is still extremely common in the valuation of equity options. The binomial tree approach to pricing options is also very common and the Black Scholes and binomial models provide options prices that are very close to one another.

2.4.9.1 Effects of Market Changes on the Value of Options

The effect of market conditions and dividends on the value of options is shown in Table 2.5 below. The table shows that where the price of the underlying is affected, the value of the put and call options will move in opposite directions. Where the volatility is perturbed, the put and call options values will move in the same direction, if time is altered the values of the put and call options will again move in the same direction and finally when dividends are perturbed, the put and call prices will move in opposite directions.

Table 2-5 The behaviour of call and put options with changes in the market conditions when increasing one variable at a time

<table>
<thead>
<tr>
<th>Variable</th>
<th>European Call</th>
<th>European Put</th>
<th>American Call</th>
<th>American Put</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share Price</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>Strike Price</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Time to Expiration</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Volatility</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Risk Free Rate</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Dividends</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

Source: Hull (2000:157)

2.4.9.2 Bounds of Options Prices
The upper bounds of call and put option prices are explained by Hull (2000:171) in the following manner:

\[ c \leq S_0 \text{ and } C \leq S_0 \]

The value of an American or European call can never be worth more than the share. If it happens that the call is greater than \( S_0 \) then the arbitrageur can make a profit by buying the share and selling the call option.

\[ p \leq X \text{ and } P \leq X. \]

Similarly, as shown in the above equation, the value of an American or European put option at time \( T \), cannot be greater than \( X \), and it follows that the present value is:

\[ p \leq Xe^{-rT}. \]

The value of the call today can’t be worth more than the strike price discounted to today’s values. If this is the case the arbitrageur could make a riskless profit by selling the option and investing the proceeds of the sale at the risk free interest rate. The formula for the lower boundary of a European call on a non dividend paying share is provided by Hull (2000:171) as:

\[ S_0 - Xe^{-rT} \]

By way of a numerical example, the lower boundary of a call option can be calculated given \( S_0 = R20 \), \( X = R18 \), \( r = 10\% \) and \( T=1 \).

\[ S_0 - Xe^{-rT} = R20 - R18e^{-0.1} = R3.71. \]

Therefore if the European call is trading at R3.00, which is less than the actual R3.71 fair value, an Arbitrageur can buy the call and sell the shares. This gives a cash realisation of \( R20.00 - R3.00 = R17.00 \) which will be invested to time \( T=1 \) and which will grow to \( R17e^{0.1} = R18.79 \) using the risk free rate of 10\%. If the share price increases to more than R18 the arbitrageur will exercise the option and close the short position on the shares. The profit that will be realised will be \( R18.79 - R18 = R0.79 \). If the share price is less than R18, the shares should be bought in the market
and the short position closed. Presuming that the share price is at R17.00, this will result in a realised profit of R 18.79 - R17.00 = R1.79.

For European Puts not paying a dividend, Hull (2000:171) gives the lower bound of the put option price as:

\[ X e^{-rT} - S_0 \]

Using a numerical example, this boundary becomes obvious when supposing that \( S_0 \) is R37, \( X \) is R40, \( r \) is 5% and \( T \) is 0.5, then:

\[ X e^{-rT} - S_0 = 40e^{-0.05\times0.5} - 37 = R2.01. \]

If the traded European option price is R1.00, which is less than the theoretical minimum of R2.01, an arbitrageur can buy the put option and the shares for the period, which will cost \( 38e^{-0.05\times0.5} = R38.96 \). If the share price is less than R40.00, the arbitrageur exercises the option to sell the shares at R40.00 and realises a profit of R1.04. If the share price is greater than R40.00, the arbitrageur sells the shares at say R42.00, repays the loan of R38.96 and realises a profit of R3.04.

### 2.4.9.3 Effect of Dividends

The effect of dividends is core to the valuation of all underlying instruments and their derivatives. For this reason a clear understanding of the treatment of dividends in the Black Scholes model is required. With the introduction of dividends, Hull (2000:179) shows that the value of a call option can be restated as:

\[ c \geq S_0 - D - X e^{-rT} \]

The value of a put option can be restated as:

\[ p \geq D + X e^{-rT} - S_0 \]

The put-call parity relationship that will exist when dividends are introduced is given by Hull (2000:180):
The above provides a theoretical basis within which put and call option prices should trade. Any deviations from these boundaries will create pure arbitrage opportunities which can be exploited by arbitrageurs.

The boundaries of option prices can be modified to better-fit American style options, which can be exercised at any time, as there is the possibility that it is more appropriate to exercise the option depending the dividend payout dates. In these cases the most appropriate time to exercise the option would be just before the dividend pay dates. This is due to the fact that the share price will fall by an amount which is approximately equivalent to the dividend as discussed by Bhardway & Brooks (1999) and Lasfer (1995). As a practical example, presuming a share is trading at R100 and the share will go ex-dividend by 2 percent (R2) tomorrow. Then a call with a strike of R90 which expires in 2 weeks, having a theoretical value of R10 and a delta of 100, has the same characteristics as those of the share. If the trader holds the option, R2 will be lost after ex-dividend when the share trades at 98. This translates to a R2 loss from R10 to R8 in the options price.

If the trader were to exercise the option, the cost will be R90 for the share worth R100 and discard the R10 value of the option. If the trader sells the option and buys the shares, the trader will own the shares when they go ex-dividend. When the share goes ex-dividend, the price will fall to R98, but the trader would receive the dividend of R2, which leaves the trader with a profit of R10. This is a better alternative, as the trader does not lose the R2 that are associated with the dividend.

### 2.5 EQUITY ARBITRAGE TRADING PRACTICES

The derivative landscape is filled with horror stories of companies that have lost millions and in some cases billions of Dollars worth of capital due to their exposure to derivative instruments. While the majority of losses resulted from interest rate derivatives, the conceptual discussion remains the same and this discussion can therefore be applied to the equity derivative markets. The exposures which resulted in these losses were usually placed on the books with the view to reducing an existing exposure by hedging, but because of the manner in which this was done and because of poor risk management processes within the companies, these positions managed to increase the leveraged exposures to the extent that they had ability to
destroy the company. www.investorwords.com [2000?] defines risk as “the quantifiable likelihood of loss or less-than-expected returns. Examples are currency risk, inflation risk, principal risk, country risk, economic risk, mortgage risk, liquidity risk, market risk, opportunity risk, income risk, interest rate risk, prepayment risk, credit risk, unsystematic risk, call risk, business risk, counterparty risk, purchasing-power risk, event risk.”

In the sub-sections below attention will be paid to processes used to manage equities and equity derivative arbitrage, risk management process, risk limits, trading risks, dealing and delta hedging processes, and arbitrage identification and profitability measurement systems.

2.5.1 PROCESSES USED TO MANAGE EQUITY AND EQUITY DERIVATIVE ARBITRAGE

The business of equity and equity derivative arbitrage requires the appropriate structures that can be used to monitor, manage and control the business and its core components. As will be indicated in the discussion below, these components relate to the systems, management structures and the performance management of the traders. The performance of the trader is affected by the components of risk that Wander & Bein (2002:2-7) classify as systematic risk, which reflects the exposure to the broad market movements and active risk (or non-systematic risk) which results from asset allocation decisions.

2.5.2 RISK MANAGEMENT PROCESS

While all risks, including operational, legal, credit and market risk, are of consequence to the business, this section will focus only on those that rely on a system to calculate the risk measure. The above risks should all be considered in the context of the positions that the trader places on the book, but for the purposes of this research a brief overview of credit and market risk is provided, following which the focus of the research will concentrate mainly on market risk.

Market risk is defined by www.investorwords.com [2000?] as “risk which is common to an entire class of assets or liabilities. The value of investments may decline over a given time period simply because of economic changes or other events that impact large portions of the market. Asset allocation and diversification can protect against market risk because different portions of the market tend to under perform at different
times. This type of risk is also called *systematic risk.* Chorafas (1995:3) defines *market risk* as “the chance that future changes in the market prices may make financial instruments less valuable or more onerous”.

*Counterparty or credit risk* is defined by www.investorwords.com [2000?] as “the risk that the other party in an agreement will default. In an option contract, the risk lies with the option buyer as the writer may not buy or sell the underlying as agreed. In general, counterparty risk can be reduced by having an organization with a good credit rating act as an intermediary between the two parties.” It should be noted that authors such as Klien & Liederman (1996:235) refer to *counterparty risk* as *credit risk.* Chorafas (1995:3) defines *credit risk* as the “possibility that a loss may occur from the failure of the counterparty to perform according to the terms of a contract.

These risks are often hidden from the investing community and cases like Glaxo pharmaceuticals, which lost £115 million, and Orange County, which lost $2 billion according to Chew (1996:65), are classic examples of derivative losses. Part of the problem related to these losses is the manner in which companies were required to disclose the off-balance sheet exposures which were created by their derivative positions, and which only came to the fore when things had gone wrong with the position. Chew (1996:66) points out that the US accounting authorities drafted Statement 105 and 107 to account for profit and loss (P&L) transparency for off-balance sheet instruments. As these statements in themselves did not cater for all contingencies, they issued Statement 119 to address this shortcoming. In the UK the Accounting Standards Board has attempted to improve the derivative disclosure in the Operating and Financial Review section of the financial statements. In South Africa similar steps have been taken to improve disclosure through the accounting standard AC133.

Part of the solution that is embedded in these accounting statements was to adapt the accounting standards to mark to market (MTM) mechanism, as opposed to the accrual account concept that most companies used and that allowed the managers to hide losses in the accrual accounting process. The MTM approach has the benefit of quickly identifying the weakness in a particular strategy and its positions according to (Chew, 1996:83).

Klien & Liederman (1996:15) plot the reasons for Derivatives Risk Management Disasters of three well-publicised losses in Figure 2.4 below. In this figure it is shown
that the losses suffered by Barings Bank, Gibson Greeting Cards and Proctor and Gamble were the result of poor control processes within the businesses. These weaknesses in their controls are broadly broken down into “inadequate independent trade verification”, “failure to conduct independent portfolio and position valuation”, “management failure to understand derivatives and/or risk”, “faulty reporting mechanisms” and “management unaware of derivatives positions”. Each of the institutions in question failed to manage one or more of these component parts of their risks, which exposed them to losses that were incurred due to the fact that the management of the institutions did not identify the pending losses until it was too late to close out the positions.

**Figure 2.4 Reasons for derivative risk management disasters**

<table>
<thead>
<tr>
<th>Reason</th>
<th>Barings</th>
<th>Gibson Greeting</th>
<th>Proctor &amp; Gamble</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate independent trade verification</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Failure to conduct independent portfolio and position valuation</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Management failure to understand derivatives and/or risk</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Faulty reporting mechanisms; Management unaware of derivatives positions</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

**Source: Klien & Liederman (1996:15)**

Klien & Liederman (1996:73) go on to define the first steps of effective risk management as being able to clearly define the objectives of the financial risk
management that they relate to, preventing negative earnings, maximising earnings stability and minimising the cost of managing financial exposures.

Klien & Liederman (1996:245) provide a risk framework that is reflected in Figure 2.5 below. In this structure the risk management needs are detailed within the organisational structure, as well as methodologies and policies that are implemented in the organisation. The aim of this structure is the creation of a risk management system which effectively deals with the pricing risk, limits risk, risk analysis, risk education and portfolio management within the framework of the business strategy. In turn will affect the businesses risk tolerance that is decided upon by the leaders of the business and could pertain to people, data, technology, disclosure and regulations.

This type of view allows the risk team the opportunity of looking at the overall position in a holistic manner with the view to improving the overall business performance in accordance with the business strategy. As the majority of the risk factors that are measured above are not easily measured and are often subjective in nature, the measures relating to market risk are measured by systems and can be calculated in a consistent and objective manner. These measures will be discussed later in this section under the headings of limits, the Greeks, and volatility.

The risk adjusted rate of return on capital (raroc) is also considered a mechanism to measure the relative performance of the trades or portfolio. This measure of return is key to understanding the amount of capital which will be made available for the trading opportunities which present themselves.
Although many of the processes relating to derivatives are numerical procedures, risk processes require, a combination of quantitative and qualitative process, such as the ones described by Klien & Liederman (1996:10). These can be summarised as follows:

1. Do not treat the derivatives in isolation. Recognise that derivative dealing is a dynamic process that requires a dynamic approach to management, and that creates a process to understand the product lines and generally identify and review the risks on a regular basis.
2. Encourage product education at all levels of the organisation.
3. Ensure that the information is of a high quality and is timely, with standardised terminology.
4. Value the position regularly against the market and compare the hedge positions regardless of the accounting method.

5. The more complex the activity the greater the level of in house expertise that will be required. Therefore place senior and experienced managers in key positions.

6. Create a bubble up process so that people are comfortable to discuss issues.

7. Stay close to the business, and remember that you cannot prevent all losses.

In line with these requirements the board of directors needs to decide what degree of certainty they require in terms of their financial exposure as this will determine the confidence interval that they choose as the measure of their financial risk, for example the risks should not fall outside that specific level like 95, 97.5 or 99%.. The risk manager should be provided with tools to view the risks graphically and be allowed to adjust the period and view of the particular trade, for instance compared to other traders, daily or annual performance and also against a related product. (Klien & Liederman, 1996:95). Lastly, (Klien & Liederman (1996:128) point out that risk cannot be effectively managed unless the appropriate systems are in place to facilitate the timely and accurate measurement of the risks.

Chorafas (1995:310) shows the process used to quantify the potential exposures that businesses may face, in Figure 2.6 below. From the figure it is clear that the starting point in this process is the decision that relates to the confidence interval that the business would like to apply to the risk incurred in their trading practices. From that point the business will need to form an opinion about the volatility that would be used in their risk calculations. From these inputs, the business can calculate the market risk, credit risk, legal risk and other risks that the business will need to manage. These factors can then be used to calculate the worst-case scenario that the business could face, given the chosen confidence interval. Lastly, decisions will be required regarding the management of these exposures. As the research is primarily focused on the trading and positions that are entered into within the context of equity and equity arbitrage, the research will focus on the market risk element of the trading risks from this point forward as this has the greatest relevance on the research. Matters pertaining to credit risk will generally be governed by the institutions credit policy.
Chorafas (1995:365) identifies the confidence interval as being central to the management of risk, and this risk measure is a function of the board’s view on the company’s risk tolerance. If the board decides that a confidence interval of 95% is appropriate, the risk measure can be expressed as:

\[-1.96 \sigma / \sqrt{n} < \mu - x < 1.96 \sigma / \sqrt{n}\]

where:
- $x$ is the sample mean,
- $N$ is the sample size, and
- $\mu$ is the population mean.
If a confidence interval of 99% is to be used, the multiplier of 1.96 will be replaced with 2.58 and if a 90% confidence interval is used, the multiplier becomes 1.64. Companies will usually use an interval of 99%, 95% or 90%. Drawing on normal statistical inference, this analysis can then be extended to include the z and t statistics as measurements:

$$Z = \frac{x - \mu_o}{\sigma / \sqrt{n}}$$

where

* $\mu_o$ is the universe mean,
* $\sigma^2$ is the variance of the universe, and,
* $\sigma$ is the standard deviation of the universe.

If the standard deviation of the population is known, the confidence intervals will be:

$$x + \left(\frac{z\alpha/2}{\sigma} \right) \sqrt{n} \text{ and } x + \left(\frac{z_{1-\alpha/2}}{\sigma} \right) \sqrt{n}$$

where

* $x$ is the sample mean,
* $n$ is the sample size, and
* $z\alpha/2$ and $z_{1-\alpha/2}$ are the values from the z statistic tables.

Where the limit is computed from the sample, the change of the interval covering $\mu$ is $1 - \alpha$ and $\alpha$ will typically take on a value of 0.01, 0.05 or 0.1. If $\sigma$ is not known, the best estimate given by $s$ can be used such that:

$$x + \left(\frac{t\alpha/2}{s} \right) \sqrt{n} \text{ and } x + \left(\frac{t_{1-\alpha/2}s}{s} \right) \sqrt{n}$$

In a similar manner Chorafas (1995: 368) shows that using a Weiner process the risk factor can be calculated as follows:

$$RF = \beta_n \sqrt{t} z$$

where

* $Rf$ is the risk factor,
* $\beta_n$ is the historical volatility,
t is the time to maturity of the transaction, and
z is the z statistic for that confidence interval.

**Figure 2.7 Market risk factors with historical volatility at about 17 percent at three levels of confidence intervals**

![Figure 2.7 Market risk factors with historical volatility at about 17 percent at three levels of confidence intervals](image)

**Source Chorafas(1995:369)**

Figure 2.7 shows that the risk manager can measure potential future market movements at a given level of confidence that can be incorporated into a z statistic. From the figure it can be seen that the greater the level of confidence is, the greater the market risk will be. This is increased in the longer dated transactions. Chorafas (1995:370) shows that the above mathematical approach can be changed to cater for the notional principle amount (NP) for each period such that:

\[
RE = RF \times NP
\]

where
RE is the risk equivalent exposure, and
RF is the market risk factor.

As this is done on a transaction-by-transaction amount, the risk equivalent exposure of the trading positions or portfolio can be measured by:

\[
RE = \sum_{i=1}^{n} RF_i \times NP_i
\]
where
RF\textsubscript{i} is the market risk factor, and
NP\textsubscript{i} is the notional principle amount of the position on the book.

2.5.3 RISK LIMITS

One of the corner stones of risk management is the implementation of risk limits which are aimed at limiting the factors to which a trader, a trading desk, or a treasury as a whole can be exposed at any one time.

Figure 2.8 A typical system of market risk limits


In Figure 2.8 above, which reflects a typical system of market risk limits. Each limit in the figure is indicated with a cylinder, and the height of the cylinder corresponds to the size of the limit. In Figure 2.8 above the trading unit has three trading desks and each desk has its own limit. There are also limits for each of the individual traders, but only those for trading desk A are shown in the figure. The extent to which each cylinder is shaded corresponds to the utilisation of that limit.
In order to monitor market risk, many organisations segment the portfolios, and this is usually done by trader and trading desk. A hierarchy of market risk limits is typically specified to parallel such segmentation, with each segment of the portfolio having its own limits. Limits generally increase in size as one moves up the hierarchy – from traders, to desks, to the overall portfolio or from individual delivery points to geographic regions to the overall portfolio.

According to www.riskglossary.com/articles/risk_limits.htm#limits [2002?] risk limits (or simply limits) are a device for authorizing specific forms of risk taking. For example a pension fund hires an outside investment manager to invest some of its assets in intermediate corporate bonds. The fund wants the manager to take risk on its behalf, but it has a specific form of risk in mind. It doesn’t want the manager investing in equities, precious metals, or pork belly futures. It communicates its intentions with investment guidelines. These specify acceptable investments. They also specify risk limits, such as requirements that:

- the portfolio’s duration always be less than 7 years;
- all bonds have a credit rating of triple-B or better risk limits.

The first risk limit is an example of a market risk limit; the second of a credit risk limit (www.riskglossary.com/articles/risk_limits.htm#limits) [2002?].

“A stop-loss limit indicates an amount of money that a portfolio’s single-period market loss should not exceed. Various periods may be used, and sometimes multiple stop-loss limits are specified for different periods and different instruments. A trader might be given 1 day, 1 week and 1 month stop-loss limits (www.riskglossary.com/articles/risk_limits.htm#limits) [2002?]. A limit violation occurs whenever a portfolio’s single-period market loss exceeds a stop-loss limit. In such an event, a trader is usually required to unwind or otherwise hedge material exposures – hence the name stop-loss limit.

Exposure limits are limits based upon exposure risk metrics used to limit market risk, common metrics include duration, convexity, delta, gamma, and vega. Crude exposure limits may also be based upon notional amounts and are called notional limits. Many exposure metrics can take on positive or negative values, so utilisation may be defined as the absolute value of exposure. Exposure limits address many of the shortcomings of stop-loss limits. They are prospective, as the exposure limits indicate risk prior to the financial consequences being realised. Exposure metrics also provide a reasonably consistent indication of risk. In most instances traders can
be held accountable for exposure limit violations because they are accountable for their portfolio’s exposures.

Exposure limits have been found to be ineffective when spread trading, cross-hedging, or similar strategies are applied to minimise risk by taking offsetting positions in correlated assets.

The following aspects of risk limits will be discussed below: liquidity, sensitivity, and value at risk.

2.5.3.1 LIQUIDITY

The concept of liquidity risk is defined by www.investorwords.com [2000?] as “the risk that arises from the difficulty of selling an asset. An investment may sometimes need to be sold quickly. Unfortunately, an insufficient secondary market may prevent the liquidation or limit the funds that can be generated from the asset. Some assets are highly liquid and have low liquidity risk (such as stock of a publicly traded company), while other assets are highly illiquid and have high liquidity risk (such as a house).” Ackert & Tian (1999:1-19) argue that “liquidity risk arises from the possibility of an adverse price movement before a desirable trade can be executed”.

The management of trading positions will always be a function of the liquidity of the underlying positions and the relative ease with which a position can be closed out. In terms of the overall management of the liquidity risks the process should consider the size of the position in the instrument or share in relation to the overall market liquidity on that instrument or share. The overall market liquidity can then be used as the proxy against, which the percentage of the position held can be closed out without causing a severe market movement.

The bid ask spread is often used as a proxy for liquidity due to the fact that, as the traders become less sure of the true price of the instrument, they are more inclined to widen the bid ask spread in an effort to protect themselves. Therefore a higher bid ask spread indicates that the share is illiquid according to Roll (1984:1127-1139). In an effort to increase the liquidity of a security companies may be inclined to list their shares on multiple exchanges or through American Depository Receipts (ADR’s), and Global Depository Receipts (GDR’s) that allow the shares to be traded in other markets but registered locally. Where dual listed securities are concerned, Domowitz
et al. (1998:2001-2027) found that in cases where the companies list on more than one exchange and the market information linkages are poor, then the liquidity may in fact be reduced by the fact that the shares have multiple listings. Their research therefore shows that transparency in the multi-market trading environment is a key success factor for improvement in liquidity in each of the component markets.

The issues surrounding liquidity are core to the size and type of positions that the trader should place on the book. Within the South African Market research has shown that the bulk of trading is related to a range of blue chip shares (South African Journal of Business Management, 2000:31).

2.5.3.2 Sensitivity

The concept of sensitivity can be applied to arbitrage in the same way that the sensitivity concept is applied to the normal trading processes. Sensitivity risk is defined as “the degree of exposure to some source of risk”, sensitivity risk [2000?] available www.investorwords.com [2000?], or “a technique for determining what might happen in a decision analysis if a key prediction turns out to be wrong” (www.investopedia.com/terms/s/sensitivityanalysis.asp) [2002?] (accessed on 1 Jun 03). From a risk measurement perspective this measure is useful in terms of providing sensitivity scenarios, which are calculated by perturbing the underlying variables that determine the price of the instruments.

2.5.3.3 Value At Risk (VaR)

The concept of VaR is an attempt to make the risk management function less complex when being dealt with at a high level. To this end the VaR is designed to generate a single number, which aims to provide a probabilistic view of what the company’s exposures to derivative instruments are over a particular period. Chew (1996: 202) defines VaR as the amount of money an institution could lose or make due to prices that change in the underlying markets. Cuoco et al. (2001:2-3) note that VaR “… has emerged in recent years as a standard tool to measure and control the risk of trading portfolios”. This resulted in investment institutions limiting the discretion of their traders by imposing VaR limits on their portfolios.

Figure 2.9 Historical VAR formulation process
Figure 2.9 above shows that practical VaR measures can use portfolio data and historical market data as inputs. Output from the above VaR formulation is in the form of a value which is the VaR metric, and which acts as a VaR measurement. The VaR measurement then forms the basis of the view which the company has on its compliance to the VaR limits.

Value-at-risk (VaR) limits combine many of the advantages of exposure limits and stop-loss limits. According to VaR Metrics, [2002?], “VaR metrics indicate risk before its economic consequences are realized. Also like exposure metrics, VaR metrics provide a reasonably consistent indication of risk. Finally, as long as utilization is calculated for traders in a timely and ongoing manner, it is reasonable to hold them accountable for limit violations. As with exposure limits, there are rare exceptions. Consider a trader with a negative gamma position. While the trader is responsible for hedging the position on an ongoing basis, it is possible that a sudden move in the underling share price will cause an unanticipated spike in VaR.”
VaR aggregates across assets and depending upon the sophistication of a VaR measure, it can reflect even the most complex hedging or diversification effects. Accordingly, VaR limits are appropriate for limiting risk with spread trading, cross-hedging, or similar trading strategies.

VaR limits have one significant drawback, as its utilisation may be computationally expensive to calculate. For many portfolios, VaR is easy to calculate as it can often be done in real time on a single processor. For more complex portfolios, it may take minutes or hours to calculate the VaR, even with parallel processors.

The Basle Committee’s proposals of 1995 prescribed VaR computations for the purpose of assessing bank capital requirements, which should be on a uniform horizon of 10 trading days and a 99% confidence level, is supported by the International Swap and Derivatives Association (ISDA). The Basle Committee on Banking Supervision added impetus for the VaR concept as a risk measure. Despite the widespread acceptance of the VaR concept, it is not a coherent risk measure, as it does not satisfy the sub-additive property (Cuoco et al., 2001:3). This implies that the combination of the VaR’s of two portfolios can be greater than the sum of two individual VaR’s. This weakness in the VaR concept has led to additional research into alternatives such as those proposed by Basak & Shapiro (2001:318), which attempt to deal with VaR from the perspective of dynamic trading.

Basak & Shapiro (2001:378) conclude that “VaR risk management is viewed by many as a tool to shield economic agents from large losses, which when they occur, could cause credit and solvency problems. But our solution reveals that when a large loss occurs, it is a yet larger loss under the VaR risk management and hence more likely to create problems, defeating the very purpose of using the VaR risk management.” The research goes on to point out that with lognormally-distributed returns, the constraint causes traders to invest significantly more in risky assets and that a risk limit specified in terms of tail-expectation-based measures would result in neither an increased probability of extreme losses or an increased allocation to risky assets. On this basis they prefer the tail-expectation-based measure for use in risk control.

2.5.4 TRADING RISKS

The use of formal trading systems to capture the trades and manage the risks that are inherent in the positions is crucial to all parties to derivative contracts. While there
are a multitude of systems available to the investment institutions, banks, asset managers brokers etc, the choice of system will usually be determined by the instrument types and the business strategy that is followed. When trading equities, systems such as Murex, Front Arena, and Reuters are often used as the trading platforms to trade and manage the risks inherent in trading.

While these trading systems generally meet the general trading requirements in terms of recording positions that have been placed on the book, their function is not generally considered to be the identification of the trades that should be placed on the books. To this end the institutions usually develop secondary applications, which are usually Visual Basic and spreadsheet based. These applications are linked to live data sources and their function is to highlight potential opportunities that may present themselves in the marketplace.

Off-the-shelf products like Horizon have been developed to assist with the creation of basic descriptive statistical information, which may assist in the identification of statistical arbitrage opportunities. Java and Matlab have also become popular in terms of developing applications that relate to the identification of statistical arbitrage opportunities.

Embedded in the trading systems are usually measures that allow the traders and risk managers to measure the risks associated with the positions that are on their books. These measures will be discussed in the ensuing sections.

2.5.4.1 Volatility (σ)

When dealing with any share or instrument, the amount by which the value of the instrument tends to change over time is known as its volatility. This measure is therefore not only key to pricing options, it is also significant in ascertaining the amount of risk that is associated with an option position. Section 2.4.9 showed that the volatility of a share is an input to the Black Scholes option pricing formula, and a clear understanding of the application of this measure to option pricing is therefore imperative.

The term volatility has many variants in terms of its usage within a trading environment, as will be discussed below, but as a general definition the one offered by volatility available on www.investorwords.com [2000?] (accessed on 30 June
2003) is: “The relative rate at which the price of a security moves up and down. Volatility is found by calculating the annualized standard deviation of daily change in price. If the price of a stock moves up and down rapidly over short time periods, it has high volatility. If the price almost never changes, it has low volatility.”

Volatility is the standard deviation of the return provided by the shares in one year when the return is expressed using continuous compounding. According to Hull (2000:241), it is also the standard deviation of the natural logarithm of the share’s price at the end of one year. This can be expressed as the standard deviation times the square root of the change in time or \( \sigma \sqrt{\Delta t} \). As an example, when \( \Delta t \) is small, the \( \sigma \sqrt{\Delta t} \) is approximately equal to the proportional change in the shares price in \( \Delta t \).

If \( \sigma = 0.3 \) or 30% and the current share price is R50, the standard deviation of the proportional change in one week is approximately \( 0.3 \sqrt{1/52} = 0.0416 \). One standard deviation move in the shares price in one week is therefore \( 50 \times 0.0416 = R2.08 \).

### 2.5.4.2 Historical Volatility

To calculate the historical volatility, the changes in the historical prices are measured at set time intervals, for example daily, weekly etc. These measurement cycles will be repeated over a set parameter or period of time with measurement of the prices following a settlement-to-settlement structure.

Hull (2000:242) provides the following formula to estimate volatility from historical data:

\[
\mu_i = \frac{1}{n} \left( \frac{S_i}{S_i-1} \right)
\]
The usual estimation of the standard error of the standard deviation of the \( \mu_i \) is given by:

\[
s = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (u_i - \hat{u})^2}
\]

\[
s = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} \mu_i^2} \left( \frac{1}{n-1} \sum_{i=1}^{n} u_i \right)^2
\]

where

- \( n + 1 \) = number of observations,
- \( S_i \) = shares price at the end of the \( i^{th} \) interval \( (i=0,1,\ldots n) \),
- \( \mu_i \) and \( u_i \) = the drift rate of a shares price or the \( \mu \) shows the shares price grows at a continuously compounded rate per unit of time,
- \( \hat{u} \) = the mean of the \( u_i \)'s, and
- the standard deviation can be estimated as:

\[
\sigma^* = \frac{s}{\sqrt{\hat{o}}}
\]

where

- \( T \) = the length of time interval in years.

From this equation the standard error of the estimate can be calculated using the following formula:

\[
\sigma^* = \frac{\sigma}{\sqrt{2n}}
\]

Hull (2000:242-243) points out that when doing volatility calculations one should consider that it is proportional to the square root of time. Of the 365 days in a year there are about 252 trading days and when calculating volatility, the calculation should only use the days that the exchange trades i.e. don’t use weekends and public holidays.

Natenburg (1994:65) assumes that there are 256 trading days annually and explains that to approximate an annual volatility of a share the \( \sqrt{256} \) would be used to get a value of 16. The trader can approximate the daily volatility by dividing the implied or historical volatility by 16. As an example, if the trader has a futures contract at R100 and a volatility of 20%, a one standard deviation price change over a day is 20%/16=1.25%. We therefore expect to see a price change of R1.25 or less two days
out of every three or 66% of the time, or a change of R2.50 or less approximately 19
days out of every 20 or about 95% of the time.

To calculate weekly volatility one will use 52 weeks and therefore $\sqrt{52}$ will provide a
volatility equal to 7.2. The average weekly volatility is $20\% / 7.2 = 2.75\%$, which
means that the trader would expect to see a price change of R2.75 or less two weeks
out of every three, and a price change of R5.50 or less 19 weeks out of every 20. In
only one week in twenty would we expect to see a change greater than R5.50, which
can be viewed as those cases which deviated by more than two standard deviations
from the norm.

2.5.4.3 IMPLIED VOLATILITY

The implied volatility is the market's consensus of what the volatility should be as a
result of the price at which the option is trading. *Implied volatility available on
www.investorwords.com* [2000?] defines implied volatility as: “A theoretical value
designed to represent the volatility of the security underlying an option as determined
by the price of the option. The factors that affect implied volatility are the exercise
price, the riskless rate of return, maturity date and the price of the option. Implied
volatility appears in several option pricing models, including the Black Scholes Option
Pricing Model.”

Many option traders use strategies that focus exclusively on the implied volatility of
an option. Opportunities for profit may occur whenever the implied volatilities differ for
options with the same underlying security and similar maturities. However, if a futures
contract is trading at R98.50 and the interest rate is at 8%, when looking at a R105
call with three months to expiration, the volatility appears to be 16% when working
out the forecasted volatility. Using this data the theoretical value of the R105 call is
calculated in the Black Scholes Model at R0.96. The theoretical value is then
compared to the price in the market place, which is R1.34. Presuming all inputs are
loaded correctly, the market is therefore using a different volatility to the theoretical or
forecast volatility rate that was calculated. To determine the volatility rate that is
being applied by the market, one can then substitute the markets price into the Black
Scholes model to determine the implied volatility used in the market place. In this
case the volatility used by the market is 18.5%.
Using this logic we are assuming that the theoretical price of the option is known and the volatility is unknown. The implied volatility that is used in the market is constantly changing due to the fact that the underlying price, the option price and the market conditions are constantly changing. If the traders had an accurate measure of volatility then they could look at the difference between the option’s theoretical value and its price in the market and then sell options, which are overpriced relative to the theoretical value and buy options that are underpriced to the theoretical value.

2.5.4.4 Execution Risk

Central to all arbitrage operations is the ability of the trader to execute the trades at the prices identified and required in the arbitrage process. The issues relating to execution risk are in principle an extension of the discussion on liquidity in section 2.5.3.1, due to the fact that where liquidity levels are low the trader will in most cases not be in a position to execute the trades in the desired manner due to inadequate demand or supply of the security, or due to the fact that the price at which the trade will be dealt will be at levels where the bid offer spread is wider than in normal circumstances and therefore the arbitrage profitability is affected.

2.5.4.5 Greeks

The Greeks are risk measures applied in measuring and managing the risks associated with derivatives. Each of the components of these measures aims to reflect on the risk inherent in an option or portfolio of options such that the trader and the risk manager can use these measures to manage the portfolio and effect hedges which are aimed at reducing the risk that is associated with the portfolio’s position. Each of the measures which are discussed below forms a critical measure that is used by trader’s in their efforts to understand and reduce the risks and exposures that may be associated with a position at a specified time.

More formally, **Greeks**, [www.riskglossary.com](http://www.riskglossary.com) [2002?], defines these measures as follows: “The Greeks are a set of factor sensitivities used extensively by traders to quantify the exposures of portfolios that contain options. Each measures how the portfolio’s market value should respond to a change in some variable – an underling, implied volatility, interest rate or time. There are five Greeks:

- delta measures first order (linear) sensitivity to an underling;
- gamma measures second order (quadratic) sensitivity to an underling;
• vega measures first order (linear) sensitivity to the implied volatility of the underlying instrument.
• theta measures first order (linear) sensitivity to the passage of time;
• rho measures first order (linear) sensitivity to an applicable interest rate.

They are called the Greeks because four out of the five are named after letters of the Greek alphabet. Vega is the exception. For reasons unknown, it is named after the brightest star in the constellation Lyra. At times, vega has been called kappa, but the name vega is now well established.”

2.5.4.6 DELTA (Δ)

Delta [2002?], describes the delta as “... the slope of the tangent line fit to the portfolio's value function at the current underlying value.” The same web page offers the example in Figure 2.10 below, where the current underlying value is USD 101, and the slope of the tangent line 0.8 million (MM). Therefore for each unit increase in the underlying instrument, the portfolio’s price will appreciate by 0.8MM.

Figure 2.10 Delta is the slope of the tangent line

Source: Available [2002?].

Another web page, Delta, [2000?], defines delta as “the change in price of a call option for every one-point move in the price of the underlying security”, and points out that it is also called the hedge ratio.
Hull (2000:312) provides the following formula with which the delta for a call option paying a dividend can be calculated:

\[ \Delta = e^{-qT}N(d_1) \]

For a put option paying a dividend the formula will be modified to:

\[ \Delta = e^{-qT}N(d_1) - 1 \]

where

\[ d_1 = \frac{\ln(S_0/X) + (r-q+\sigma^2/2)T}{\sigma \sqrt{T}}. \]

The delta's behaviour of an option is reviewed by Natenberg (1994:99-100) who indicates that when the option is deep in the money, it will have a high delta because almost all of the gain/loss in the security will be reflected in the option price. Conversely, a deep out-of-the-money option will have a low delta, because very little of the gain/loss in the security is reflected in the option price. As an in-the-money option nears expiration, the delta will approach 100% because the amount of time remaining for the option to move out-of-the-money is small. Puts always have negative deltas; because when the value of the underlying increases, the value of the put therefore falls, and when the value of the underlying falls, the put gains value.

The delta may also be used to determine the correct number of shares to buy or sell in order to form a “riskless hedge.” Forming a riskless hedge gives one the potential of earning arbitrage profits, by profiting from the mispriced option's return to its fair market value (i.e. the price at which the option is neither overpriced nor under priced). Theoretically, the market will eventually value under priced options at their fair market value. However, it should be noted that high transaction costs may undermine this theory to the extent of the magnitude of the transaction costs.

Chew (1996:98) points out that delta hedging presumes that the delta hedge ratio is correct, as the delta is calculated using an equation that relies on the volatility (which is derived). Given the fact that the volatility is uncertain, the delta hedge recommendation may not always be correctly reflected.
The trader should view the theoretical aspect of the delta from three perspectives. The delta could be viewed from the equivalent underlying position perspective, or the hedge ratio perspective or the rate of change interpretation. Natenberg (1994:101) provides an example of the application of the delta concept through the hedge ratio. A call with a delta of 40 requires the sale of two underlying contracts for every five options purchased as 100/40 equals 5/2, while a put with a delta of -75 has 100/75=4/3 and requires the purchase of three underlying contracts for every four puts purchased.

The usefulness of this measure lies in the fact that despite the fact that complex structures with different exercise prices, expiration dates and deltas may be traded, as long as the net delta position is approximately zero, the position is delta neutral. Five call options each with deltas of 80 and ten put options each with deltas of 40, for example, would result in an overall exposure of:

\[(5 \times 80) + (10 \times -40) = 0.\]

This position would result in the book being delta neutral at that point in time. Natenberg (1994:101) confirms this in that an underlying futures contract has a delta of 100, and each 100 deltas in option positions represents a theoretical position equivalent to one underlying futures contract, therefore the options deltas can be offset against those of the futures and underlying shares. Section 2.5.5 “Dealing and Delta Hedging Processes” elaborates on the use of delta hedging in the trading environment as the delta hedging concept is central to the management of all derivative positions and arbitrage positions are no exception to this statement.

2.5.4.7 **Gamma (Γ)**

One of the primary risk measures that relates to the risks associated with an option is a measure called *gamma*. The gamma of an option shows the anticipated change in the delta for a change in the price of the underlying security (Natenburg, 1994:103). As the gamma will change for each price level, this measure should not be considered to be static. A high gamma figure would indicate a large change in the delta of the option as a result of relatively small change in the price of the underlying security.
In the event that a call and put option have the same strike price and maturity date, the gamma values of the call and the put will be the same in cases where the interest rates are zero. If interest rates are not zero, the gamma values may differ slightly due to the fact that the early exercise optionality may affect the gamma value. The Gamma for any long position in either a call or a put will be positive, and for any short position in options the gamma will be negative according (Natenberg, 1994:103-105).

Hull (2000:324) provides the following formula to calculate an index option’s gamma value where no dividend is paid:

$$\Gamma = \frac{N'(d_1)}{S_0 \sigma \sqrt{T}}$$

where

$$d_1 = \frac{\ln(S_0/X) + (r + \sigma^2/2)T}{\sigma \sqrt{T}}$$

on an index paying a dividend

$$\Gamma = \frac{N'(d_1) e^{-qt}}{S_0 \sigma \sqrt{T}}$$

where

$$d_1 = \frac{\ln(S_0/X) + (r-q + \sigma^2/2)T}{\sigma \sqrt{T}}.$$  

Gamma indicates the amount of risk involved with an option position, as a large gamma indicates higher risk, because the value of that option will change more quickly than the value of an option with a low gamma. This measure therefore reflects the rate at which the option behaves more or less like the underlying and is therefore an important measure of the directional risks that the trader has on the book.

If an option has a gamma of 5, for each point rise (fall) in the price of the underlying, the option’s delta will gain (lose) 5 delta points. Therefore if the option has a delta of 25 and the underlying moves up (down) one point the new delta will be 30 (20). The larger the gamma position, the larger the degree of risk currently on the trader’s book. Natenberg (1994:105-107) shows that the behaviour of the gamma can be summarised by way of the following general statements:
• Gamma is larger for calls or puts that are at the money and this measure becomes progressively smaller as the option moves further into or out of the money.
• The gamma increases the closer the time to expiration and should be monitored to ensure it stays within acceptable risk limits.

The delta-neutral positions can become unbalanced simply through the progression of time, changes in price of the underlying, and/or changes in volatility (Natenberg, 1994:105-108).

The general view of this research is that the gamma is mainly managed through limits, as there is no real way to hedge out the gamma exposure directly. This view is taken, as the only way that would allow the trader to directly affect the gamma would be to buy or sell an option that offsets the direction of the existing positions. There are also strategies that may look at correlations to allow the trader to reduce the gamma exposure on a particular structure by buying or selling an option in a highly correlated instrument.

2.5.4.8 THETA (Θ)

The theta or “time decay” shows the change in the option's price (in points) due to the effect of time alone. Theta is defined by *Theta, www.investorwords.com* [2000?], as: “the ratio of the change in an option’s price due to the decrease in its time to expiration also called time decay”. The longer the time until expiration, the lower the effect that time has on the price of the option. As an option nears expiration, the effect of time will be greater, particularly on out-of-the-money options. Conversely, the more time until expiration, the better chance the option has of being in the money at expiration and the lower the theta. The only exception to this positive relationship is deep in the money put options with an expiration date far into the future. In summary, options with low thetas are preferable (for purchase) to those with high thetas. Any long option position has a negative theta and will lose money more rapidly as time progresses (Natenberg, 1994:111). He also points out that the theta is therefore opposite to the gamma, where the long option has a positive gamma and the short option has a negative gamma.
This time decay factor is the rate at which an option loses value as time progresses and is best explained by way of an example. If the option’s theta is 0.05, the option will lose 0.05 in value each day that passes with no change in the market conditions. Therefore if the option is worth R2.75 today, tomorrow it will be worth R2.70.

Hull (2000:320) provides the following calculation for the theta of an equity option:

$$\Theta = \left( -\frac{S_0 N'(d_1) \sigma}{(2\sqrt{T})} - (rXe^{-rT}N(d_2)) \right) \frac{1}{2\sqrt{T}}$$

where

$$d_1 = \frac{\ln(S_0/X) + (r+\sigma^2/2)T}{\sigma \sqrt{T}}.$$  
$$d_2 = d_1 - \sigma \sqrt{T}.$$  

The calculation for the theta on a European Index option paying a dividend is:

$$\Theta = \left( -\frac{S_0 N'(d_1) \sigma e^{-qT}}{(2\sqrt{T})} + (qS_0 N(-d_1)e^{-qT}) - (rXe^{-rT}N(d_2)) \right) \frac{1}{2\sqrt{T}}$$

where

$$d_1 = \frac{\ln(S_0/X) + (r-q+\sigma^2/2)T}{\sigma \sqrt{T}}.$$  
$$d_2 = d_1 - \sigma \sqrt{T}.$$  

2.5.4.9 Vega or Kappa ($\kappa$)

Vega shows the change in the option price due to an assumed 1% change in the volatility of the underlying security. Vega shows the dollar amount of gain that should be expected if the volatility changes by one percent (all else being equal). If the option has a vega of 0.15 for each percentage change in volatility, the option will gain or lose 0.15 in theoretical value. If an option has a vega of 0.15 a volatility of 21% and a price of R3.40, then a reduction in the volatility to 19% will decrease the price of the option to R3.10 [R3.40 - (0.15 x 2%)], according to Natenberg (1994:114). Another definition of vega which may be considered here is that of www.investorwords.com [2000?], which defines vega as “the change in the price of an option that results from a 1% change in volatility”.

Volatility and the option price is always positively correlated as the greater the volatility of the underlying security, the better chance the option has of being in the
money at expiration. Therefore, options with higher volatilities will cost more than those with lower volatilities. Since vega measures the sensitivity of an option to a change in volatility, options with higher vegas are preferable (for purchase) to those with low vegas. In terms of the quantitative approach that should be followed in the calculation of the vega, Hull (2000:327) shows the formula to be:

\[ \kappa = S_0 \sqrt{T} N'(d_1) e^{-qT} \]

where:

\[ d_1 = \frac{\ln(S_0/X) + (r-q+\sigma^2/2)T}{\sigma \sqrt{T}}, \]

and

\[ q = \text{dividend yield}. \]

Hull (2000:328) points out that although the Black Scholes Model presumes that volatility is static over the life of the option, the results that are calculated are very similar to models where the volatility is presumed to be stochastic.

2.5.4.10 RHO

Rho is defined by www.investorwords.com [2000?] as: “the dollar change in a given option’s price that results from a 1% change in interest rates”. Natenberg (1194:116-118) points out that options with the highest rho’s are those that are deep in the money, as they require the highest cash outlay. The greater the time till expiration, the greater the rho. Furthermore, the means of settlement also has an impact, as cash type settlement requires an outlay, while futures type settlement results in zero rho, as there is no cash outlay. The calculation of rho for an European call is provided by Hull (2000:329) as:

\[ \text{rho} = XTe^{-rT}N(d_2). \]

For a European put:

\[ \text{rho} = -XTe^{-rT}N(-d_2) \]

where:

\[ d_1 = \frac{\ln(S_0/X) + (r+\sigma^2/2)T}{\sigma \sqrt{T}}, \]

and
\[ d_2 = d_1 - \sigma \sqrt{T}. \]

2.5.4.11 **PARTIAL DIFFERENTIAL HEDGE**

The measure of a Partial Differential Hedge (PDH) is in essence an extension of the sensitivity of the instrument to changes in the price and yield curves, that are used to price the derivative instrument. While this particular measure is not widely published, it is a useful addition to the risk management process. The PDH differs from the sensitivity report in that the sensitivity report will shift the entire curve in a parallel manner by an absolute or relative amount that is specified by the risk manager. The PDH on the other hand, will calculate the effect of an absolute or relative move of a particular point on the curve, and will therefore return the sensitivity of that point to the elected change. This measure can also be considered the delta of each of the individual instruments that are reflected on the input curve.

As this method of risk management is simply an extension of the existing sensitivity of delta and vega measures, the usual sightings of this measure in practice would be within the systems used by the institutions to trade their derivative instruments.

This research views the PDH as one approach to mathematically determine the number of options and futures that a trader should trade to neutralise the vega and delta levels. This is achieved by bucketing the risks in a portfolio into the instruments that constitute the pricing curve. The recommendation that the PDH provides is therefore a means to determine the exposure to a certain point in the pricing curve and also the number of positions that need to be traded in order to reduce the exposure to that point.

2.5.5 **DEALING AND DELTA HEDGING PROCESSES**

The traders are responsible for managing the trades that are associated with their positions and as such they need to maintain their positions within the limits, which are prescribed by the risk team. As was discussed under the risk management processes in section 2.5.2 of this chapter, a standardised set of risk measures should be run by risk monitors on a daily basis to ensure that limits and stress levels are adhered to. The overall position should be viewed in context of all the risks (Natenberg, 1994:81-82).
To reduce the risks that are inherent in the portfolio, the trader should hedge the overall position of the portfolio as this will reduce the risk. When done correctly the change in price of the underlying will be matched by the increase (decrease) in the value of the opposing position.

The hedge ratio or delta is the number of positions that will be required to establish a delta neutral position. The delta of a portfolio is expressed as a figure between 0 and 1 and changes as the market conditions change. If the delta is for example 0.57, this means that for each option the trader must sell 57% of an underlying contract to create a neutral hedge. The delta hedging process that is adopted by traders to become and remain delta neutral is discussed within the framework given by Natenberg (1994: 82-86), and which is discussed in the ensuing section.

The example below shows how a delta neutral position can be achieved:

<table>
<thead>
<tr>
<th>Contract</th>
<th>Contract Delta</th>
<th>Delta position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long 100 June 100 calls</td>
<td>57</td>
<td>5700</td>
</tr>
<tr>
<td>Short 57 June Futures</td>
<td>100</td>
<td>-5700</td>
</tr>
</tbody>
</table>

Having established a delta-neutral hedge, the position should be reviewed at regular intervals and the appropriate changes in the holdings of the futures and the June 100 calls should be made, so that each new interval represents a new-hedged position. To show the effect of this adjustment we can assume that after one week the June futures price has moved up to 102.26, the risk free interest rate is at 8%, the time to expiration is nine weeks, and the volatility is 18.3%.

The Black Scholes Model assumes that interest and volatility are constant for the life of the option. The fact that the volatility does not change in the Model will generate a new delta that will reflect the reduction in time to expiration and the change in the underlying security’s price. The new position that will summarise the current risks is outlined in the position summary below (Natenberg, 1994:83).

<table>
<thead>
<tr>
<th>Contract</th>
<th>Contract Delta</th>
<th>Delta Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long 100 June 100 calls</td>
<td>62</td>
<td>6200</td>
</tr>
<tr>
<td>Short 57 June Futures</td>
<td>100</td>
<td>-5700</td>
</tr>
<tr>
<td></td>
<td></td>
<td>500</td>
</tr>
</tbody>
</table>
Clearly, the position is currently long 500 deltas and the trader would need to transact to return to a delta neutral position, as is outlined below (Natenberg, 1994:84):

<table>
<thead>
<tr>
<th>Contract</th>
<th>Contract Delta</th>
<th>Delta Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long 100 June 100 Calls</td>
<td>62</td>
<td>6200</td>
</tr>
<tr>
<td>Short 62 June Futures</td>
<td>100</td>
<td>-6200</td>
</tr>
</tbody>
</table>

The trader therefore needs to short 5 June futures as adjustments to the original position. The adjustment is made primarily to ensure that the original position remains delta neutral, as at the end of ten weeks the trader will act in the following manner (Natenberg, 1994:85):

1. Out of the money options will expire.
2. The trader will sell any in the money options at parity or the equivalent, exercising them and offsetting them against the underlying futures contract.
3. Following from the above actions the trader will need to liquidate any outstanding futures contracts at the market price.

When considering the original hedge at the June expiration and presuming that the future is trading at R102.54, one can liquidate the June 100 calls by selling them at R2.54 or by selling futures at R102.54 and exercising the calls. Both will result in a R2.54 credit to the traders account. As the calls cost R3.25, there is a loss of R3.25 – R2.54 = R0.71 per option and the total loss is R100 x R0.71 = R71.00.

The original position also resulted in a sale of 57 June futures at R101.35. At expiration these futures must be bought back at R102.54, which translates into a loss of R102.54 – R101.35 = R1.19 per contract or 57 x R1.19 = R67.83 on the total delta hedge. The total loss on the original hedge position is therefore R71 + R67.83 = R138.83.

In the above example the trader would have made weekly adjustments to the original position throughout the life of the June future. In their endeavours to remain delta neutral, the trader was forced to buy and sell futures contracts. For example:

At week 1 the transaction was 500 deltas long, so 5 futures were sold at R102.26.
At week 2 the transaction was 1600 futures short, so 16 futures were bought at R99.07. All the adjustments that were made throughout the life of the June future resulted in a profit of R205.27.

2.5.5.1 THE CARRYING COSTS

Natenberg (1994:86) shows that to calculate the true profit that was derived from the previous example, one should look at the cash flows from each of the transactions as well as the adjustments that were made on a weekly basis. These cash flows should be discounted at the interest rate, which is 8% in the above example. This interest factor will then form part of the profit calculation. In the original position the trader bought calls and sold futures. The options required a cash outlay equal to:

= R100 x R3.25, and
= R325 for 10 weeks at 8% (interest) x 70/365 x R325 = R4.99.

This cost should be included in the calculations.

2.5.5.2 VARIATION COSTS

As the futures move up or down in price, cash will be either credited to or debited from the trader’s account. The trader’s account must earn interest on cash credits, and should also pay interest on cash debits. For example, 57 futures contracts may initially be sold at R101.35. If the futures prices rose to R102.26 one week later, our account was debited with 57 x (R101.35 – R102.26) =R51.87. Financing the debit was R51.87 x 8% x 63/365 = R0.72. To remain delta neutral, five additional futures contracts were sold. At week 2, the futures price fell to R99.07, and the account was subsequently credited 62 x (R102.26 – R99.07) =R197.78. Interest earned was R197.78 x 8% x 56/365 = R2.43. The total position can be tabulated as reflected in Table 2.6 below:

Table 2-6 Summary of the delta hedging process over time

<table>
<thead>
<tr>
<th>Week</th>
<th>Futures Price</th>
<th>Delta of 100 call</th>
<th>Total Delta Position</th>
<th>Adjustment in Futures</th>
<th>Total Futures Adjustment</th>
<th>Variation</th>
<th>Interest on Variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>101.35</td>
<td>57</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>102.26</td>
<td>62</td>
<td>500</td>
<td>sell 5</td>
<td>-5</td>
<td>-51.87</td>
<td>-0.72</td>
</tr>
<tr>
<td>2</td>
<td>99.07</td>
<td>46</td>
<td>-1600</td>
<td>buy 16</td>
<td>11</td>
<td>197.78</td>
<td>2.43</td>
</tr>
</tbody>
</table>
A total profit of R62.80 was realised in the example and this is close to the expected profit of R63.00 \((R3.88 - R3.25) = R0.63 \times 100 = R63.00\), which was projected at the deal’s inception.

This example relies on a frictionless market, which implies the following (Natenberg, 1994:87):

1. Traders can freely buy or sell the underlying contract without restriction.
2. All traders can borrow and lend at the same rate.
3. Transaction costs are zero.
4. There are no tax considerations.

The market is, however, not frictionless and all the assumptions are incorrect to a greater or lesser degree. Price movements in the futures market are for example locked once a specified price movement on the market is breached for any trading day. Also, traders cannot all borrow or lend money at the same rate as the large financial institutions – fortunately the interest rate component is the smallest factor in the options pricing. Transaction costs can, however, be very high and brokerage fees could absorb all profits. Therefore the original trading transaction costs plus the adjustment costs that are required to remain delta neutral should be closely monitored. The more adjustments that are made through the life of the strategy, the greater the transaction costs that will be incurred and the less profitable the strategy will be.

Professional traders who are exchange members will have lower transaction costs and subsequently lower adjustment costs. This situation translates to greater profitability and therefore a competitive advantage in this type of trading.
Retail clients will need to adjust less frequently as the adjustments will reduce their profit by a greater margin than that of the institutional traders. The retail trader may therefore experience larger losses and profits than the professional trader due to the fact that less frequent delta hedges are affected. The effect of taxes should also be included in calculating the option strategies profitability. For basic calculation purposes one could exclude this factor from the process described above.

2.5.6 **ARBITRAGE IDENTIFICATION AND PROFITABILITY MEASUREMENT SYSTEMS**

Internal rate of return (IRR) and capital allocation, will be discussed in more detail below:

2.5.6.1 **INTERNAL RATE OF RETURN (IRR)**

The Internal Rate of Return is defined by Brigham & Gapenski (1997:401) as “that discount rate which equates the present value of a project’s expected cash inflows to the expected value of the project’s expected costs or, equivalently, forces the NPV to equal zero”; whereas www.investorwords.com [2000?] defines the IRR as “the rate of return that would make the present value of future cash flows plus the final market value of an investment or business opportunity equal to the current market price of the investment or opportunity”.

The function of the IRR within the equity treasury-trading environment is that it is used as a profitability benchmark, which each of the trading desks need to achieve. This is due to the fact that managers and directors of the institutions and companies need to apply the capital of the firm or institution in a manner, which is aimed at delivering a return that will meet the desired IRR.

Each product will require a different amount of capital. The profitability that can be attained is often enhanced by the institution’s ability to offset the arbitrage positions with one another and therefore they have the ability to reduce the actual capital that is used in their arbitrage operations. The fact that the arbitrage operation’s capital requirements are reduced by this offsetting option assists in the trading strategies’ ability to be profitable despite the fact that they often require large notional amounts to be invested in the trading operations.
2.5.6.2 CAPITAL ALLOCATION

The capital allocation decisions of the firm are the drivers that determine whether a particular venture will receive the required funding from the business. In the same manner the arbitrage trading processes will need to compete for the resources and will be required to provide a return on capital which exceeds or at least equals the institutions required return on capital, while complying with the required risk limits in order to qualify for a capital allocation. Capital allocation is described by www.riskglossary.com [2002?] as “the process whereby business managers decide in what ventures to invest limited resources. Desirable ventures might offer high returns on invested resources or minimal risk to those resources. Since the goals of maximizing returns and minimizing risk are often incompatible, capital allocation is largely a process of balancing risk against reward. It is a process that has been pursued – at least informally – since the beginning of capitalism.

It is also pointed out by www.riskglossary.com [2002?] that “capital allocation is widely employed by trading and lending organizations. It can be used for strategically deciding which businesses to pursue, but it is also widely employed for assessing possible trades or deals with counterparties. Individual transactions are assigned capital based upon the risk they entail, and specific transactions are accepted or rejected based upon the capital they use and the profit they are expected to generate. This form of standardised capital allocation largely originated with banks. In a banking context, capital allocation can be performed in one of two ways:

- regulatory capital allocation, or
- internal capital allocation.

The first approach is a response to capital requirements imposed by statute. The most recent of such requirements is the 1988 Basle Accord and its amendments, which include the Basle II guidelines. Today, these requirements apply, in some form, to banks in most industrialised countries.

The capital that the regulator (South African Reserve Bank) requires the banks to hold has a cost and it makes sense for banks to minimise – or, rather, optimise – their use of such capital. For example, the original Basle Accord required banks to hold capital equal to:
- 0% of holdings in G-10 government debt,
- 1.6% of holdings in G-10 bank debt, and
- 8% of holdings in other debt.

Obviously, such requirements promote the holding of G-10 government and bank debt over other debt. In this way, regulatory capital requirements – and resulting regulatory capital allocation by banks – can lead to distortions in the availability of loans to certain borrowers. Such distortions should force legislators and regulators to improve or fine-tune capital requirements over time as is evident with Basle II, which improves on the original Basle Accord.

Internal capital allocation is usually performed with sophisticated models for risk and expected return. These models that have been implemented rank transactions according to their expected return adjusted in some manner for their risk. Transactions that offer a risk-adjusted return on capital above some threshold are accepted, while those that do not are rejected.

A natural question is whether regulatory or internal capital allocation is better. The answer is that this is the wrong question. For non-banks that do not have regulatory capital requirements, obviously, internal capital allocation is what they will be using. For banks, internal and regulatory capital allocation serves distinct purposes. Regulatory capital allocation serves the purpose of minimising – or optimising the use of expensive regulatory capital. Internal capital allocation has more of a risk management purpose ensuring that trades or deals are entered into based upon an analysis of both their expected return and contribution to risk as an organisation has a limited ability to take on risk.

2.6 SUMMARY

The review of the available literature, which pertains to the management of equity derivative arbitrage, its component parts, and its pricing, provides the insight that is required during the later chapters of the research.

This chapter focused on the broad concept of arbitrage and provided definitions of pure and statistical arbitrage. The sub-components of pure arbitrage, namely index, single stock futures and dual listed arbitrage were discussed, and then the review turned to the mathematical methods that have been applied to the identification of
statistical arbitrage opportunities which may present themselves. These were discussed under the headings of statistical arbitrage, option arbitrage and risk arbitrage.

The definitions and means of identification are the starting point of the literature review. With the basic concepts defined and the ability to identify the arbitrage opportunities that are present in the market, comes the need to manage the risks that are inherent to the positions taken and which will affect the profitability of the arbitrage positions. To this end the chapter turned to the management of risk, which is mainly embedded in the market risk function. The methods of measuring risk and the means to curtail excessive risk are then discussed in addition to the concepts of risk limits, the Greeks, liquidity, sensitivity, VaR and volatility. Finally, the methods used to measure profitability are considered, with a view to providing a structured method of measuring the traders' performance relative to one another and relative to the IRR of the institution.
CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

The first part of this study dealt with the literature research and provided definitions, methods, models and business practices that pertain to the equity and equity derivative environment. This chapter details the methodology applied in gathering and analysing the empirical and time series information pertaining to equity and equity derivative arbitrage in South Africa.

All the empirical research and time series methodologies which are undertaken by this research are discussed, described and considered in this chapter, such that the findings described in later chapters can be reported in a scientific manner.

3.2 DEFINITION OF THE RESEARCH AREAS

The research areas that will receive focus in this study are split into two components. The first reports on an empirical questionnaire that was distributed to institutions which deal in equities and equity derivatives. The purpose of the questionnaire was to establish the most current practice and infrastructure that is applied to the management of equity and equity derivative arbitrage. The questions explored the following facets of the respondents’ arbitrage trading activities:

- how long the respective arbitrage types have been traded,
- the volumes of arbitrage types that are traded over the specified periods,
- the methods used to identify the opportunities,
- the methods used to execute the trades,
- the methods used to manage traded positions,
- the methods used to hedge traded positions, and
- the methods used to risk manage the positions.

The first part of the questionnaire is focused on the identification, risk, cost and trading issues that pertain to trading specific arbitrage types. The latter section of the questionnaire is more generic in nature and aims to establish the structure of the
business environment, with the view to determine how these structures are managed from a systems, pricing, human resource, profitability and risk perspective.

The second component of the research analyses market data through a time series analysis. The methods applied in this section are based on the models identified in Chapter 2 and seek to determine the extent to which these models are successful in generating profits within the South African market environment. The time series information is then also applied in the development of a statistical arbitrage model, which will incorporate certain market specific data to provide a multiple regression model used to identify trading opportunities. The consolidated view of both the empirical and time series analysis are then used to create a method which provides the most effective manner in which to manage these businesses.

3.3 **Arbitrage Management Processes and Systems**

In the following sections the research methodology pertaining to arbitrage management processes and systems will be discussed with reference to the sample and target population, the research design and data collection methodology, pre-testing the questionnaire and the validity of the questionnaire, results of the content validity testing, and the analysis of the findings.

3.3.1 **Sample and Target Population**

Zikmund (1997:417) describes a target population as the complete group of specific population elements relevant to the research project. The target population for this research consists of all asset managers, stockbrokers, banks, and insurance companies (both long and short term) as these companies are the primary volume drivers of trades executed on the JSE and SAFEX. At the time the research was conducted there were 19 member banks of the Banking Council of South Africa ([www.banking.org.za](http://www.banking.org.za) [1999?]), 68 Investment managers registered under section 13B of the FSB regulations, 64 stock broking institutions and 172 short- and long-term insurance companies. It can be noted that there is a large overlap of the short and long term insurance companies in that many of the long-term life companies have separate short term insurance companies which operate under the same brand name but which are registered separately to cater for the Financial Services Board regulations which govern the industry.
Similarly, the investment managers were found to have multiple companies focusing on different aspects of the investment spectrum. Investment managers are considered to be the primary participants in the equity markets and therefore have the greatest interest in the development of models, which may be used to exploit price mismatches within the equity and derivative markets. Furthermore, these are also the companies which have the resources to build applications that can be used to monitor market movements and identify trading opportunities.

The sampling method that has been applied to create the population sample in this study can be considered to be a hybrid structure, which consists of strata of sub populations which reflect the representation of the banks, stock brokers, asset managers, and insurance companies.

As with all stratified sampling it has the limitation that generalisations across strata may not always be possible due to the fact that the findings in one strata cannot be applied directly to another with any degree of certainty. This research assumes that the four strata all play an equally significant role in the equity business and hence they are included in random proportional or quota-driven samples; subsequently there are 20 representative institutions from each strata.

The research excludes the treasuries of large retail institutions, as they generally focus more on the management of the company’s cash and interest rate exposure, and are therefore not in the business of trading for profits in the equities and equities derivative markets. Table 3.1 below depicts the sample for this research questionnaire.
The sample covers 11 of the 19 Registered local banks, or about 58% of the registered banking sector. Although 3 of these 19 banks have been taken over or have been liquidated, the site still reflects these banks. Nine international investment banks operating in South Africa are included in the study and take the bank sample to the required 20 participants. About 29%, or 20 of the 68 investment management companies listed on the FSB’s website (www.fsb.co.za [1998?]), were included in the sample – these investment managers are registered under section 13B. At the time of this research there were 64 stockbrokers listed on the JSE website and of these, nine were terminating their membership and two were restricted in a manner that did not allow them to trade equities and warrants. Twenty of the possible 53 remaining stockbrokers were randomly selected and included in the sample. This translates to about 38% of the total population of stockbrokers, according to www.jse.co.za [1999?]. Within the insurance sector, 20 companies were included in the survey. The exact percentage of the total population is deceptive as many of the companies are registered for both short- and long-term purposes, while some also have multiple

<table>
<thead>
<tr>
<th>Banks</th>
<th>Stock Brokers</th>
<th>Investment Managers</th>
<th>Short and Long Term Insurance Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSA Bank Ltd</td>
<td>Barnard Jacobs Mholi</td>
<td>STANLIB ASSET MANAGEMENT LIMITED</td>
<td>METROPOLITAN LIFE LIMITED</td>
</tr>
<tr>
<td>Barclays</td>
<td>Andisa Securities</td>
<td>INVESTEC ASSET MANAGEMENT (PTY) LTD</td>
<td>MEDSCHEME LIFE ASSURANCE COMPANY LIMITED</td>
</tr>
<tr>
<td>Citibank N.A.</td>
<td>EDB Stockbrokers</td>
<td>MMTR CREDIT EQUITY MANAGEMENT (PTY) LTD</td>
<td>LIBERTY GROUP LIMITED</td>
</tr>
<tr>
<td>Deutsche Bank AG</td>
<td>ABSA Securities</td>
<td>MOMENTUM ADVISORY SERVICE (PTY) LTD</td>
<td>OLD MUTUAL LIFE ASSURANCE COMPANY SOUTH AFRICA LIMITED</td>
</tr>
<tr>
<td>Investec Bank Ltd</td>
<td>Investec</td>
<td>DBB ASSET MANAGEMENT (PTY) LTD</td>
<td>MUNICH REINSURANCE COMPANY OF AFRICA LIMITED</td>
</tr>
<tr>
<td>Nedcor Ltd</td>
<td>Merrill Lynch South Africa (Pty) Ltd</td>
<td>PRESIENT INVESTMENT MANAGEMENT (PTY) LTD</td>
<td>MOMENTUM GROUP LIMITED</td>
</tr>
<tr>
<td>Rand Merchant Bank Ltd</td>
<td>Kagiso Securities</td>
<td>Gryphon Asset Management (PTY) Ltd</td>
<td>HOLLARD INSURANCE COMPANY LIMITED THE</td>
</tr>
<tr>
<td>The Standard Bank of S A Ltd</td>
<td>Deneck Trading (Pty) Ltd</td>
<td>Davenport Fund Management</td>
<td>ALEXANDER FORBES INSURANCE COMPANY LIMITED</td>
</tr>
<tr>
<td>HSBC</td>
<td>Deutsche Securities</td>
<td>Metropolitan Asset Managers</td>
<td>ALLIANZ INSURANCE LIMITED</td>
</tr>
<tr>
<td>ABN Amro</td>
<td>FSA Online Securities Limited</td>
<td>PRUDENTIAL PORTFOLIO MANAGERS (SA) (PTY) LTD</td>
<td>PROSPERITY INSURANCE COMPANY LIMITED</td>
</tr>
<tr>
<td>JP Morgan</td>
<td>JP Morgan Equities</td>
<td>DBB ASSET MANAGEMENT (PTY) LTD</td>
<td>UNIVERSAL ASSURANCE COMPANY LIMITED</td>
</tr>
<tr>
<td>Morgan Stanley</td>
<td>Thebe Securities</td>
<td>ROBERT COWEN INVESTMENTS (PTY) LTD</td>
<td>SANTAM BEPERK</td>
</tr>
<tr>
<td>Merrill Lynch South Africa</td>
<td>Vector Equities</td>
<td>NCD MUTUAL ASSET MANAGERS (SOUTH AFRICA) (PTY) LTD</td>
<td>SANTAM LIFE INSURANCE COMPANY LIMITED</td>
</tr>
<tr>
<td>Commerzbank AG</td>
<td>Cadiz Stock Broking</td>
<td>Capital Alliance Securities (PTY) LTD</td>
<td>CAPITAL ALLIANCE LIFE LIMITED</td>
</tr>
<tr>
<td>ING Barings</td>
<td>BP Beaufort</td>
<td>ALLAN GRAY LTD</td>
<td>CHARTER LIFE INSURANCE COMPANY LIMITED</td>
</tr>
<tr>
<td>Crédit Agricole Indosuez</td>
<td>Citigroup Global Capital Markets</td>
<td>ALLIANCE CAPITAL MANAGEMENT (PTY) LTD</td>
<td>DISCOVERY LIFE LIMITED</td>
</tr>
<tr>
<td>Credit Suisse First Boston</td>
<td>DWM Securities</td>
<td>FRANCE FUTURES &amp; OPTIONS NOMINEES (PTY) LTD</td>
<td>INVESTMENT SOLUTIONS LIMITED</td>
</tr>
<tr>
<td>Mettle Treasury</td>
<td>Cazenove SA (Pty) Ltd</td>
<td>CORONATION ASSET MANAGEMENT (PTY) LTD</td>
<td>REGENT LIFE ASSURANCE COMPANY LIMITED</td>
</tr>
<tr>
<td>KBS</td>
<td>Capital Securities (Pty) Ltd</td>
<td>CONSILIAM CAPITAL SA (PROPRIETARY) LIMITED</td>
<td>SA EAGLE LIFE LIMITED</td>
</tr>
<tr>
<td>First National Bank of SA Ltd</td>
<td>Parexime Equities (Pty) Ltd</td>
<td>MBB Financial Services (PTY) LTD</td>
<td>SAGE LIFE LIMITED</td>
</tr>
</tbody>
</table>
companies within the short- and long-term structures. Given the above information, about 12% of the total insurance sector is included in the sample.

This selection provides a cross section of the industry participants who deal with shares and derivates on a large scale and therefore the research results should provide a clear idea of the current thinking within the equity trading and equity derivative trading industry. Within this sample group of 80 institutions the equity derivative traders and their directors were requested to complete the questionnaire (Appendix 2) that was distributed to all institutions in the sample via e-mail.

3.3.2 RESEARCH DESIGN AND DATA COLLECTION METHODOLOGY

Figure 3.1 below provides a process flow of the methodology that has been applied in gathering and analysing the empirical research of this study.

Figure 3.1 The research methodology adopted in gathering equity arbitrage information from the South African market environment

The methodology that has been adopted by this research has been aligned to the current literature describing research methodologies. The idea behind a research design, according to Zikmund (1997:48), is to create a master plan which identifies methods and procedures for the collection and analysis of the information forming part of the study.
According to Leedy (1993:122) there are four discreet research methodologies which are dictated by the type of data required, namely:

- The descriptive survey method. This method is appropriate for data derived from simple observational situations, such as physical observations or observations between means of questionnaires or poll techniques.
- The historical method. This method is appropriate for the primary data that is primarily documentary or literature in form.
- The analytical survey method. This method is appropriate for data that is quantitative in nature and that require statistical techniques to extract its meaning.
- The experimental method. This method is appropriate for data derived from an experimental control situation or a pre-test / post-test design.

Given the methodologies described above, this research uses the descriptive survey method due to the fact that arbitrage information is gathered from a large number of institutions that share their observations and experience in this research. It was decided that the most effective and appropriate manner in which to gather this information would be to use a research questionnaire, as it would be impractical to perform structured interviews with over eighty individuals at different companies across the country.

Because of the large size of the sample the questionnaire was distributed through e-mail and the respondents were then contacted telephonically to confirm that they have received the questionnaire, to discuss the process required to complete the questionnaire and the time frames which are applicable for the completion of the questionnaire. Where respondents did not complete the questionnaire within the time period provided and where the matter could not be resolved telephonically, the respondents were visited in order to get them to complete the required form and ensure that the institution’s input was obtained.

The following aspects raised by Zikmund (1997:385) were considered in designing the questionnaire:

- complexity should be avoided,
- questions should not be leading or loaded,
- questions should not be ambiguous,
- assumptions should not be made,
- questions should not be double barrelled, and
- the questions should be designed in a manner which allows the respondent to complete the questionnaire in a short period of time.

Most of the questions were close-ended, but in some instances the respondents were required to express an opinion or provide alternatives, which were not provided in the questionnaire. Close-ended questions are preferred and were used in the questionnaire to allow for:

- the rapid answering of questions,
- keeping questions simple enough to allow the respondents to answer them without the presence of an interviewer, and
- focusing the respondent’s attention to specific issues that need to be addressed, by means of structured questions.

The open-ended questions were only used in instances where standard alternatives were not available and respondents were expected to provide diverse responses.

The questionnaire was split into two areas, the first being questions relating to the different arbitrage types, and the second being questions relating to the strategic, business and operational processes that the organisation has adopted. In the first section the questions were standardised as much as possible between the arbitrage categories, with the focus being mainly on frequency, identification, profitability and risk management. Such standardisation was aimed at providing the respondents with a situation whereby they would only need to think through the meaning of the question once and would thereafter be in a position to apply that meaning to all types of arbitrage.

### 3.3.3 **Pre-testing the Questionnaire and the Validity of the Questionnaire**

Zikmund (1997:402-404) states that the pre-test process should be applied to a selected group who has a similar makeup to that of the respondents who will finally complete the questionnaire. The purpose of the pre-testing was to ensure that the respondents could follow the questionnaire format, that the questionnaire flows naturally, that the respondents could answer the questions easily, that questions
were not ambiguous, that questions were relevant and that they covered all aspects included by the research.

The pre-testing was completed by a sub-sample constituting 10 (12.5%) respondents in the total sample. The makeup of this group can be broken down into different institutions, namely banks, asset managers, stockbrokers, insurance companies.

The respondents involved in the pre-testing were required to complete the questionnaire (see Appendix 2). In addition to the actual questionnaire, a diagnostic questionnaire was completed (see Appendix 3) by each of the respondents involved in the pre-testing, such that the content validity could be measured. The findings of the diagnostic questionnaire are presented by way of frequency distributions for each of the questions posed, such that a clear picture of the respondent’s views could be determined.

3.3.4 Results of the Content Validity Testing

There were 10 companies that were asked to complete the section pertaining to content validity prior to the general distribution to the remaining respondents. The results can be summarised as follows:

1. All the respondents felt that the questionnaire flowed in a natural and appropriate manner.
2. All the respondents felt that the purpose of the questionnaire was clearly understood, and that they understood what the questionnaire hoped to determine.
3. Nine of the respondents were of the opinion that all the questions were clear. The view of the one respondent was that less focus should be given to volatility arbitrage. However, besides this comment the respondent was comfortable that the questions were clear. The questions were therefore not altered as a result of this comment as the information was considered useful in determining whether the companies had the ability to cater for options in their arbitrage trading strategy.
4. Eight of the respondents were of the opinion that there were no ambiguous questions in the questionnaire. Two were, however, not comfortable and as a result of this, two questions were rephrased in a more concise manner.
5. All of the respondents felt that the questions were relevant with further commentary being that while they may be relevant, they may not be relevant to all parties given the fact that not all parties trade all arbitrage types.

6. Six of the respondents felt that the questions were not too sensitive, but four of the respondents were of the view that some of the information requested was sensitive and they could therefore not answer all questions. On further analysis it was determined that the concerns related mainly to salaries paid by the institutions and the market risk and stop loss levels that are applied by the organisations. The questions were left unaltered for those companies who were prepared to share the information.

7. The average time taken to complete the questionnaire was about 31 minutes.

3.3.5 Analysis of the Findings

The approach that is followed in this section of the research is focused on determining the general practices applied in equity derivative arbitrage. For this reason the majority of the statistical information gathered in this section of the research is reflected through frequency distributions of the responses received.

These distributions allow for the correlation of responses across questions which in turn allows second order conclusions to be generated from the responses received.

3.4 Questionnaire Content

3.4.1 Equity Derivative and Arbitrage Processes

3.4.1.1 Trading Processes

The research firstly establishes whether the respondents trade a specific arbitrage type and this information is consolidated across the sample to determine the sample mean of respondents who trade the specific arbitrage type. Where the respondents do not trade an arbitrage type, a series of options is provided which are used to determine why this is the case.
Where the respondents indicated that the business which they represent trades one or more of the arbitrage types under review, the questionnaire aims to determine whether their view was that the process could be improved, and if so how this would be achieved. These results are presented through frequency distributions and tables reflecting the cumulative results.

3.4.1.2 IDENTIFICATION PROCESSES

The trade identification process adopted by the market is critical to the success of any arbitrage trading that takes place. In this section the focus areas are the manner in which the market participants identify the trading opportunities and the duration of the opportunities, i.e. the duration of the visibility in the market. The results are presented as the number of the sample, applying different methods of identifying trading opportunities. A frequency distribution of the market’s view of the duration of arbitrage opportunities is also provided.

3.4.1.3 PROFITABILITY SIMULATIONS

This area of the study analyses the current level to which the industry has developed systems aimed at maximising the performance of the returns of arbitrage opportunities through the use of simulations. These simulations can be viewed as being both backward and forward looking. The backward-looking simulations entail that the historic profitability can be calculated and can be used as a benchmark for the future trades. The forward-looking simulations rely on the profit maximisation results of the backward looking simulations to create the most likely situation which can then be used to generate the trade combinations which will generate the greatest future profitability.

The focus of the research in this area is primarily to establish whether the industry has adopted either of these simulation approaches in their attempts to increase profitability. The questions posed to the respondents do not delve into the very workings of the models used to analyse the historical and projected profitability of the trades as this information is considered to be proprietary and will either be partially disclosed or will not be disclosed at all. The results of these questions are presented in simple statistical format showing the number of respondents in the sample who use these simulation methods.
3.4.1.4 TRADER'S DISCRETION

With the exception of programme trading the final decision about whether an arbitrage trade should be entered into is at the discretion of the trader. For this reason the research attempts to determine whether the managers of the arbitrage traders feel that all opportunities that present themselves in the market are capitalised upon by traders, hence how effective the traders really are.

The findings of the research questionnaire are presented as the number of businesses within the sample, that feel that their trader's are effectively controlled and whether they may miss trades on occasions. These findings are reflected as the number of institutions who rely on the trader to determine all trade opportunities.

3.4.1.5 EXECUTING TRADES TO ENSURE ARBITRAGE

In this section of the research, the instruments used to execute the arbitrage types are analysed. The research focuses on the fact that for the pure arbitrage to be successful the price differential must be locked in and this is done through the purchase or sale of either the underlying or one of the associated derivative instruments. In the case of statistical arbitrage, the research also determines which instruments are used to effect the arbitrage trades.

The types of arbitrage trading and the implied frequency of the trades is analysed per arbitrage type and presented in terms of the number of institutions that trade the respective arbitrage types and what instruments they use to execute the arbitrage. Further information in terms of the instruments used to cover the exposures is also presented, per arbitrage type.

The respondents were requested to give an indication of whether they use a Partial Differential Hedge (PDH) to manage their risk and where they do not use this measure the questionnaire aims to establish the reasons for not using this risk measure. The view taken by the research is also that where pure arbitrage is being traded the execution of the arbitrage in itself leaves the investor in a position that is delta neutral and does not require elaborate mechanisms to lock in the arbitrage profits.
3.4.1.6 STOP LOSSES

The application of stop losses to trades that have been entered into is common to most trading strategies and also applies to all statistical arbitrage types. For this reason the research aims to reflect the general market approaches that are adopted for stop losses. The areas analysed are firstly whether a stop loss is indeed applied and adhered to. Secondly, the aim is to determine at what level the respondents implement their stop loss levels and lastly to determine whether the stop losses are applied in a rigid manner to all statistical arbitrage types. In other words, whether the same stop loss level applies to every statistical arbitrage type or whether some statistical arbitrage types are considered more risky and that a more stringent stop loss is therefore applied.

In order to establish the risk appetite for the individual arbitrage opportunities, the respondents are requested to provide a stop loss level for each statistical arbitrage type. This information can then be analysed across the sample to establish the extent to which stop losses differ and the average levels at which each of the stop losses are applied to the statistical arbitrage types. This allows for inferences regarding the arbitrage types that respondents consider to carry the greatest level of risk.

This information is presented as the number of institutions that apply a stop loss to each of the statistical arbitrage types. The average stop loss levels that are applied by the industry to each of the arbitrage type is also reflected. This information is presented in the form of frequency distributions reflecting the findings relating to the respondents responses.

3.4.1.7 DURATION OF TRADES

The research aims to establish the average duration of the visibility of each of the arbitrage types. The options provided to the respondents range from one day to three months. The view of the research is that the longer the duration of the opportunity, the less obvious it is to the market and the less effective the market is in removing these opportunities. The findings are reflected through a frequency distribution showing the average time the respondents consider the opportunities to be visible in the market.
3.4.2 GENERAL RISK MANAGEMENT PROCESSES

The general risk management processes which are discussed here involve processes adopted in measuring risk, limits, delta, gamma, volatility, vega and rho.

3.4.2.1 PROCESSES ADOPTED IN MEASURING RISK

It was pointed out in Chapter 2 that there are two types of arbitrage that are analysed in this research. The first is pure arbitrage, which in theory results in a virtually risk free profit situation, while the second is statistical arbitrage, which has a high mathematical probability of making money, but the profit is not risk free.

For pure arbitrage the view is held that there should be no risk inherent in the positions that form part of the equity arbitrage book. If all risk cannot be removed through the transactions that establish the arbitrage, it is implied that there is a deviation from the concept of a risk free return on arbitrage and hence the arbitrage is not considered to be a pure arbitrage.

The arbitrage process flows from the fact that an identified price discrepancy requires the trader to take certain steps to lock in the profit on the price discrepancy. This entails buying one instrument, which is considered to be inexpensive, while selling a related instrument, which is overpriced relative to the instrument being bought. This situation will cover simple static situations used for pure arbitrage strategies. However, when volatility and statistical arbitrage trades are placed on the book, a dynamic hedging process must be adopted as the quality of the hedges may decay over time and these hedges must therefore be adjusted.

This implies that the risk management function needs to have a thorough understanding of the positions that the book or portfolio is running and how each of these positions translate into the risks reflected through the risk measures. This information is gathered through the summation of the risks associated with the deals that form part of the trading portfolio. These deals contribute to the limit and risk utilisation as calculated by the market risk managers.
3.4.2.2 LIMITS

The market’s view relating to the risk limits is determined by establishing what sorts of limits the respondent’s of the questionnaire use. The questionnaire provides the respondents with a range of options relating to the limits that are commonly used by the risk functions, such as currency limits, exposure limits, VaR limits, limits on the Greeks etc. The respondents are also provided with the opportunity to provide information on other limits that are applied within their business environment. The findings relating to the applied limit types are presented as frequency distributions.

In addition to the trading limits described above the research also aims to determine at what levels the sensitivity limits have been set for each of the underlying limits. This is primarily a market risk function, but the interest in this measure from a research perspective relates to the fact that the lower the limits that are applied, the less trading that is allowed for each arbitrage type. This question is posed in an open-ended manner, and the findings are presented as a frequency distribution.

3.4.2.3 DELTA

The delta concept was discussed in Chapter 2, section 2.5.4.6 and basically measures the sensitivity of the derivative instrument to changes in the price of the underlying instrument. In the case of futures, the future is deemed to have a delta of 100 to the underlying instrument. The analysis is therefore considered mainly for options positions traded in the arbitrage process.

The questionnaire aims to establish whether the institution has the ability to readily measure the delta positions that are embedded in their trades and the results are presented as the percentage of the sample, that have the ability to measure their delta positions.

Where the respondents do measure the delta, an open-ended question is posed which aims to determine how the delta risk is managed in the institution. The results gathered in this manner are then presented through a frequency distribution.
3.4.2.4 Gamma

The concept of the gamma that a position may have created was discussed in Chapter 2, section 2.5.4.7, and was described as the extent to which the delta will change as a result of a change in the price of the underlying share. Here again this relates to option trading and therefore a large segment of the sample may not use or require this measure.

The questionnaire aims to determine whether the respondents measure the gamma positions that are on the book as a result of the positions that have been traded. Whether they do have the ability to readily calculate the gamma positions and, how they hedge the gamma exposure without closing out the positions that have been traded is also determined.

The results are presented firstly as the percentage of the sample that measure the gamma associated with their positions and secondly how the market participants manage the gamma risk that they may have accumulated is shown through a frequency distribution.

3.4.2.5 Volatility

The questionnaire sets forth a series of questions, which aim to determine the market’s perception towards the use of historical and implied volatility in pricing options.

The primary area that is considered is at what point the market prefers to trade using the theoretical price, which then drives the market price back towards the theoretical price and therefore results in the price convergence which is of interest from an arbitrage perspective. The results are presented as a frequency distribution reflecting the sample’s view on when the market should trade the theoretical or market prices.

3.4.2.6 Vega

The vega was defined in Chapter 2, section 2.5.4.9, as the measure that is used to determine the effect on the price of an option which results from a change in the volatility of the instrument. The areas considered meaningful with regard to the vega
are whether the respondents measure the vega exposures that are inherent in the positions that they may be holding as a result of their arbitrage trades. The results are shown as the percentage of respondents who can measure their vega exposure.

Where respondents trade options and they actively measure the vega associated with their positions, the questionnaire then aims to determine whether the respondents use the vega recommendation to manage exposures that the option positions may have created. The findings are presented as the number of institutions that use the vega to measure and reduce exposure that results from option positions.

3.4.2.7 Rho

The respondents are required to answer certain questions that relate to the arbitrage position’s sensitivities to changes in the interest rate. This measure was discussed in Chapter 2, section 2.5.4.10, and relates primarily to options and futures through their reliance on the projected and realised interest rate in their pricing.

The respondents were asked whether the rho is a risk measure that is actively monitored from a trading and risk management perspective within the equity derivative arbitrage environment. Where the respondents answer in the affirmative, this fact is noted and added to the total number of respondents who actively utilise this measure. Where the respondents answer in the negative, the questionnaire aims to determine the underlying reason why the measure is not employed within the environment. The results of the research are presented as the number of institutions in the sample using the rho as a risk measure and where the respondents do not use this measure a frequency distribution, is used to show the reasons why they do not use this measure.

3.4.3 Cost Profit Measurement Processes

The relevant aspects in the cost profit measurement process are the measuring of equity trading costs and the measuring of profitability. These aspects will be discussed in the sub-sections below.
3.4.3.1 **Measuring Equity Trading Costs**

The major cost drivers in equity and equity derivative trading relate to the transaction costs and securities lending costs. The respondents are required to rate which expenses contribute most to their overhead costs for each of the respective arbitrage types. All responses are then consolidated and presented in a frequency distribution for each arbitrage type.

Further costing details are gathered by establishing what the average human resource cost component of the arbitrage operations are. This is determined by questions about the number of arbitrage traders employed, the average cost of each trader and whether the cost allocation per trader is split into various business units. In other words, whether all arbitrage traders are centralised in one area or dispersed into various sections of the business. This information is again presented through a frequency distribution.

Further information that is pertinent to the costing is whether the traders only trade arbitrage positions or whether they also trade other equity related positions. If they trade a range of equity related positions, a portion of their cost should be allocated to that trading strategy. This information is presented as the number of respondents trading arbitrage positions that do not only focus on arbitrage trading.

The questions also focus on determining the cost per trade on each of the relevant exchanges, the cost of securities lending, and the average cost per trader. These findings are represented through frequency distributions per cost type.

3.4.3.2 **Measuring Profitability**

The respondents’ ability to measure the profitability of each arbitrage type is presented per arbitrage type. This profitability is a function of the gross return that the arbitrage positions provide, less all the associated costs that are incurred in the trading processes. The details of these costs were discussed in section 3.4.3.1 above.

For the purposes of the research, costs will be split into direct cost, which are the visible costs of trading and indirect cost, which are allocated to the business unit, but
which cannot be controlled directly by the traders. The allocated indirect costs will not form a part of the analysis, simply because these costs will vary between institutions and because the trading desks cannot control these in their day-to-day business. At best the trading desks can aim to achieve the highest return possible prior to taking into account the allocated costs.

Questions relating to whether the arbitrage operation should be expanded provides insight into whether arbitrage trading is profitable or not, as where the respondents feel that they need to expand the business, this also implies that the strategy is profitable and adding to their capacity will allow greater profitability. The result is reflected as the number of the respondents wanting to expand this area of their business.

The respondents were asked whether they would discontinue their arbitrage operations in the event that the operations do not meet the profitability requirements of the institution for certain set periods of time. These responses are measured in terms of how many years it would take before the arbitrage operation is closed down, where it does not meet the profitability requirements. These findings are presented as a frequency distribution of the average time it would take the institutions to decide to close down the arbitrage business where the business type is not deemed to be profitable.

Another measure in the questionnaire is whether the respondents consider the arbitrage operations to provide any strategic advantage. This could be the case as the operations may assist in the neutralisation of positions that the equity derivative operation have on the books at certain periods in time. Where this is the case, this fact may influence their decision to keep the arbitrage desk running despite the fact the business does not directly meet the profitability requirements. This result is reflected as the number of respondents in the sample who do consider their arbitrage operations to provide a strategic advantage.

3.5 Identification of Arbitrage Opportunities

The research design and data collection methodology is of particular importance for the identification of arbitrage opportunities.
3.5.1 RESEARCH DESIGN AND DATA COLLECTION METHODOLOGY

This section of the study relies on the use of market trade data received from the Johannesburg Stock Exchange (JSE) and the South African Futures Exchange (SAFEX). The closing prices, rates, and dividend yields, which are used in future and option calculations, are taken from Bloomberg and Reuters. The closing prices are also used to calculate the historical volatility and are the primary inputs to the statistical trading.

The valuation models that are applied in this research analysis are drawn from Chapter 2, and are applied in the manner prescribed in the relevant source documentation. While there is not always one correct mathematical technique to derive a particular answer, this research follows those practices prescribed by the authors referenced in the literary review. Figure 3.2 below reflects the methodology employed in the time series analysis undertaken by this research.

**Figure 3.2** Representation Of The Research Methodology Adopted In Analysing Equity Arbitrage Opportunities Using A Time Series Approach
For the purpose of this research, arbitrage opportunities were investigated with reference to the Johannesburg Stock Exchange (JSE), the South African Futures Exchange (SAFEX), dividend yields and dividends, risk free rates, stop loss strategy, the number of trades and volumes traded, transaction costs, profitability, index and single stock futures, risk or merger arbitrage, dual listed arbitrage, statistical arbitrage, and volatility arbitrage.

3.5.1.1 JSE SECURITIES EXCHANGE (SA)

The starting point of derivative valuation is the underlying instrument and therefore emphasis was placed on receiving the correct trade price and trade data pertaining to the trades on the ALSI Top 40 shares. To facilitate this requirement the JSE Securities Exchange (JSE) was approached to provide all the trade data that relates to the ALSI Top 40 constituents for the specified period being researched.

The share price and other trade data were used in conjunction with the futures trade data that was provided by SAFEX and was applied to SSF trade calculations. The period over which the analysis using this trade by trade data took place is 02 January 2001 to the 30 December 2002 and this involved about two million trades on the ALSI Top 40 shares. The purpose of including all trades that took place on the exchange was to avoid situations where the prices in question were non simultaneous in nature.

The data was requested and provided in the following format:

- Trade date
- Trade time
- Share or warrant name
- Number of shares/warrants traded
- Price at which the trades occurred.

This information serves as the basis for the conversion into the theoretical price of the related derivative instruments given the dividend and risk free rates that are required to calculate the theoretical price. These calculated theoretical prices become the basis of comparison to the actual price of the traded derivative instrument.
3.5.1.2 South African Futures Exchange (SAFEX)

In order to establish the extent of the price discrepancies within the futures market, all contracts traded on SAFEX which relate to the SSF contracts on the ALSI Top 40 index constituents for the period 03 January 2001 up until 30 December 2002, are included in this research. Similarly, all the contracts that relate to the ALSI Top 40 index for the period 3 January 01 to 31 December 03 were included in the futures trade data. SAFEX provided all the trade information on all the Single Stock Futures and index futures that form part of the ALSI Top 40 index. This translates into more than one million future trades, which are included in the study.

The trade data was requested and provided by SAFEX in the following format:

- Trade date
- Trade time
- Contract name
- Number of contracts traded
- Price at which the trades occurred.

The SAFEX futures prices therefore act as the actual traded prices against which the theoretical prices of the contracts as calculated from the underlying share prices is compared. The valuation models discussed in Section 2.4.7 and 2.4.8 are employed to determine these theoretical futures prices. In instances where there are price differentials, which are of such a magnitude that they justify the initiation of arbitrage trades, these trades were used to quantify the number of available arbitrage opportunities that were present, given the assumptions of the research.

3.5.1.3 Dividend Yields and Dividends

The dividend yields that are used in this research are taken from Bloomberg and are expressed as annualised yields. The Bloomberg forecast of dividends is a respected source; therefore the research assumes that this data source will provide dividend yields that reflect the market's expectation with a relatively high degree of accuracy.

The dividend yields that were extracted from Bloomberg matched the periods of data received from the JSE and SAFEX. The data fields required for the research information included dividend yield information for each trade date, the share’s name
and alpha code (short code) and the annualised dividend yield (in a continuously compounded format). Where the actual dividends were used these were taken from the Bloomberg screen.

3.5.1.4 Risk Free Rates

The risk free rates that are used in the analysis were taken from the daily closes of the Standard Bank page on Reuters. These rates are used to discount future values back to the valuation date, which will be the trade date on which the arbitrage trades occur. The rates used as basis for calculations are the one month Jibar rate, the three month Jibar rate, Forward Rate Agreement (FRA) rates out to two years and Swap rates out to 20 years, which are bootstrapped to provide the zero rates. These zero rates are then adapted to reflect the relevant compounding frequency that is applied in the relevant formula.

Once the yield curve has been stripped (bootstrapped) it is a simple case of determining the actual number of days that the instrument has to maturity and then through linear interpolation, a zero value for that term structure can be determined from the zero curve. This interpolated value can then be applied to the formula for the relevant instrument after taking into account the relevant compounding frequency as discussed above, or the value can be converted into a discount factor for present value purposes.

3.5.1.5 Stop Loss Strategy

When the profitability of each of the statistical trading types is analysed, the core reason that would result in the trader closing out each of the arbitrage opportunities is either due to the convergence of the trades in accordance with the arbitrage intention, or as a result of a stop loss being triggered and thereby forcing the trader to close out a position which is losing money.

The stop loss level that is applied in this model is determined through the empirical research findings, which requested the respondents to provide the stop loss levels which, are applied to each arbitrage type. The average stop loss is calculated from these responses and is applied to the time series analysis. Within the time series testing the average stop loss is applied to any trade which breaches that stop loss level. These trades are then closed out.
3.5.1.6 **NUMBER OF TRADES AND VOLUME TRADED**

The number of arbitrage trades that are traded by the market is a reflection of the degree to which mispricing of instruments is present within the market. This particular measure of opportunities is also a function of the duration of the opportunities within the market, as the longer the mispricing remains, the greater the opportunity for the traders to exploit the mispricing before the price differential between the theoretical price and the observed price in the market narrows. This price convergence would result from demand and supply factors which will drive the prices to the point where profitable arbitrage will no longer be possible.

This information is compared to the responses received from the respondents, as described in section 3.4.1.7, whereby they were requested to indicate how long their arbitrage opportunities are visible in the market per arbitrage type. This measure was performed to establish whether the market is effectively utilising the opportunities that are presented.

While the above factors all affect the actual number of trades and volumes which may be profitably transacted, the research makes certain assumptions and applies certain constraints in terms of the number or shares or contracts that may be traded for each arbitrage opportunity. These constraints and assumptions are applied to provide consistency to the testing process and are implemented by allowing a set number of shares to be traded per arbitrage opportunity. This volume is set at a low level such that the effects of the trades should not move the market prices dramatically.

The approach adopted to SSF was to take the minimum trading volume on the JSE and SAFEX and apply the pricing to this volume of shares. Where the ALSI index is traded either for index arbitrage or statistical arbitrage, the research assumed that only 10 contracts would be traded for each opportunity that presents itself.
3.5.1.7 Transaction Costs

The transaction costs that are incurred are applied to the time series testing are based on the feedback of respondents from the empirical research. The average cost as reflected by the feedback for each of the following cost drivers is applied to the relevant equations: SAFEX costs, Uncertificated Securities Tax (UST) rate, JSE trading costs, margining costs and lending costs. All these components are then added to the cost of the arbitrage such that a realistic idea of the profit or loss that is attributable to the arbitrage trades is calculated from the point of entering the trade until the trade is closed out on the exchanges.

When trading on the JSE a number of direct costs are incurred which can be decomposed into STRATE costs, Central Securities Depository Participant (CSDP) costs and Uncertificated Securities Tax (UST). Where multiple purchases or sales are concluded to fill one order, there will be a charge for each transaction entered into in the effort to fill the order i.e. if three trades are concluded to fill an order of 100 shares then the trader will incur brokerage once but will incur the STRATE costs three times. This cost of purchasing shares on the JSE excludes the UST, which is applied as a fixed percentage of 25 basis points of the consideration traded. Therefore, in each case the profit calculation should take into account the additional effects of UST on profitability. While this cost was applied across all groups in the sample, it should be noted that stock brokers acting as agents are exempt from UST tax.

The cost of trading on SAFEX is relatively low compared to trading on the JSE and where member institutions trade on SAFEX, they will generally be charged a different rate per instrument type i.e. future vs option, and also a different rate for different underlying instruments i.e. equity vs index. This research will use the average costs as reflected by the respondents in the empirical research portion of this study.

In all cases where the underlying shares are sold short, the trader who sells the shares short will need to deliver the shares that were sold to the market by the settlement day in accordance with the JSE regulations. These shares must be available in the sellers account by the second day after the short sale was concluded. In the event that the shares are not available for delivery then the short sale will fail and the JSE will fine the trader who entered into the short sale. The securities
lending costs that are applied are the average lending costs as reflected in the empirical research.

### 3.5.1.8 Profitability

The research calculates the theoretical profitability of the various arbitrage types after taking into account the transaction costs and a low level of available liquidity. The details of these two methods were discussed above in sections 3.5.1.6 and 3.5.1.7. The research applied these methods for testing purposes and to show that the strategies are indeed profitable. These assumptions may be lifted in practice and the participants may be able to trade in larger volumes and more frequently than that which was allowed in the research. As the volumes of transactions increase the profitability of the various strategies will increase in Rand terms, as fixed cost drivers like staff costs and systems costs will be reduced per unit trade as a result of the increase in volume. The transaction costs will also reduce on a per share level as greater volumes are traded per order placed.

The transaction, securities lending, staff and capital costs that are used in this research are determined through the questionnaire discussed earlier. These costs are directly observable as a result of the trading activities, but it should be highlighted that the research is not taking into account the capital effects that pertain to reserving and capital requirements that flow from regulations, which govern the accounting treatment of these instruments.

### 3.5.1.9 Index and Single Stock Futures

The method that is applied to the identification of index and SSF arbitrage situations, given the time series data sets described previously, is to run a trade identification programme which matches and extracts all trades that occur on the JSE and SAFEX within a certain time period of one another. The time elapsed between trades causes the data to be non-simultaneous, and for this reason the smaller the time differences between trades that occur on the JSE and SAFEX the less likely it will be that this type of error distorts the findings of this research and the associated number of trades and the profits of these trades.

The application developed registers each SAFEX trade for SSFs as per the data provided by SAFEX and returns all JSE trades that relate to that futures instrument.
within the time range of 30 minutes. The application also returns the actual number of
days that the contract has until maturity, which is determined by establishing the
maturity day, month and year from a contract maturity table. The current date is then
subtracted from the maturity date to provide the number of days to maturity.

The appropriate annual dividend yield that applies to the particular share or index is
taken from a dividend table, for the ALSI Top 40 shares. This data is sourced from
Bloomberg data services and is provided in a continuously compounded yield format.
It should be noted that the continuously compounded rate does provide a close
approximation of the value of the SSF, but that the results would be improved by
using the discreet dividend method for SSF, whereby the next dividend is projected
and applied to the formula in a discounted dividend manner which discounts the
dividend by the discount factor which can be calculated using the bootstrapped zero
rate, compounding frequency, and the number of days to the pay date.

The discreet method provides more accurate results when the shares go ex-dividend,
due to the ex-dividend effect, which reduces the share price right after the dividend is
paid to the shareholders by about the amount of the dividend declared. The effect of
continuous compounding of dividends is less obvious in the case of indexes due to
the fact that the dividends are not all paid at the same point in time and hence the
smoothing has a less significant effect on the pricing as this approach looks at
 dividends on an annualised basis such that the total dividend yield is smoothed out
over the year.

The final component required to calculate the theoretical price of a future, given the
price of the underlying share is the relevant risk free rate (RFR) that should be
applied to the formula. The method of determining the correct RFR is to interpolate
for the RFR from the bootstrapped Jibar, FRA and Swap curves given the number of
days to the contract’s maturity date. This implies using the number of days from the
trade date to the maturity date to interpolate the risk free rate from the zero curve.
The details describing the method used to create the zero curve is discussed in
section 3.5.1.4.

The above components are then applied to the formula defined in Chapter 2 section
2.4.2 to 2.4.5 and all these factors then provide the theoretical price of the futures
contract. This theoretical price is then subtracted from the traded futures price to
establish whether there is a mispricing of the future in the market at that point in time.
If the future price is too high relative to the theoretical price then the model will sell the traded number of futures and buy the underlying shares in the market at the traded prices reflected by actual JSE trades and vice versa.

Where an Index future or SSF arbitrage opportunity has presented itself in the market the trader will execute the arbitrage by buying or selling the future and selling or buying the underlying. The long futures position and the short underlying positions will be maintained until the prices converge through the normal market movements over time. The trade size that the model will apply is a function of the smaller of the JSE volume or the SAFEX volume for the SSF i.e. the system will assume that the trader only entered trades in sizes that could be executed on both exchanges in a manner that creates the pure arbitrage position.

The findings are presented in two ways, the first will present the opportunities which are present without taking into account transaction costs, and the second will take into account transaction costs, which will include JSE trading costs, SAFEX trading costs, brokerage, STRATE, UST, and securities lending costs. Where profitability of the trade prior to transaction costs is less than the transaction costs which will be incurred, the trade will be excluded from the analysis, as these trades will never realise a return greater than the costs that will be incurred in transacting the positions required for the arbitrage. These costs and the expected profit from the prices converging will be known at the deal inception and the profitability can therefore be catered for in an absolute manner.

3.5.1.10 Risk or Merger Arbitrage

The analysis of risk arbitrage using time series data is based on all corporate events, i.e. all SENS data which refers to mergers, acquisitions, cash and share offers and also the historical trade information pertaining to the price of the share under review, for the period May 2001 to February 2004. The trade data that was relied upon was provided by the JSE and reflects every trade effected in the securities during the time of the corporate action.

The assumption applied in this research is that all corporate action information, which involves mergers, acquisitions, and cash offers is available to the investment community at large at the time that the Stock Exchange News (SENS) notification is sent from the JSE to the investment community. This assumption is aligned to the
market’s methodology of ensuring that information is distributed to all market participants simultaneously, and the assumption therefore does not rely on any information that is not factual or that is based on rumour or insider trading.

The details of the corporate events are provided through Stock Exchange News (SENS) and the offer price that is provided in the SENS announcement is the price which is applied in the calculation of the arbitrage opportunities that present themselves. These offer prices are updated at each instance that a new offer is communicated via SENS.

The methodology that is applied, is to buy or sell ten thousand shares of the company being acquired on the day that the SENS announcement is made. Where the offer is at a discount the shares of the company being acquired should be sold and where the offer is at a premium, the shares should be purchased. This holding will then be held until the corporate action date at which time the profit or loss on the trading strategy will be realised. The research does not assume that huge volumes of shares are purchased in one trade as this increase in demand may move the market to unprofitable levels. For this reason, the assumption is made that at least ten thousand shares will be purchased on the day of the announcement at the closing price published on Bloomberg. The assumption is also made that the transactions can only occur on the announcement date, which implies that no position in the time series testing will exceed ten thousand shares. The positions will only be closed out on the pay date or takeover date or termination date as specified in the SENS announcement.

Where capitalisation shares are being offered the methodology is to purchase the share at the SENS announcement date and the position will be maintained until the ex-dividend date at which time the benefits of the capitalisation award will be materialised through the close out of the risk arbitrage position that was entered into at deal inception.

The scope of the analysis will be to look at instances where South African companies which form part of the ALSI Top 40 have been acquired or have acquired/divested from a holding in other listed companies. The research will specifically exclude instances where foreign companies are purchased/sold as this will assume that all companies in the South African environment are able to trade the offshore arbitrage. Institutions which have the ability to trade dual listed arbitrage may well be in a
position to trade these opportunities, but this research will not analyse these findings as the analysis of risk arbitrage in the European markets has been well documented in other research which is available.

All private companies which are bought or sold will be excluded from the research as there is no price data available for the private companies. This implies that it is not obvious as to the extent of the share price moves following the offer which is made for the company.

The results of the profitability analysis of risk arbitrage is presented through frequency distributions of the profitability of the trading strategy, in addition to a distribution of the duration of the risk arbitrage trades. The transaction costs that will be incurred in the trading process are factored into the calculations.

3.5.1.11 DUAL LISTED ARBITRAGE

In measuring the dual listed arbitrage opportunities, all ALSI Top 40 underlying instruments that have a primary listing in London and a secondary listing in Johannesburg or vice versa were identified for the period January 2000 up to and including 31 December 2003. All last trade prices that occurred on the London Stock Exchange (LSE) were compared to the last trades on the JSE for the same period. The currency rate that is used in the analysis is the daily closing price of the South African Rand (ZAR) to the British Pound (GBP). Shortcomings of this method relate to non-simultaneous data being used as exchange rate volatility combined with the effect of moves on the exchanges may affect the valuations.

Appendix 1 taken from www.jse.co.za [1999?] lists the dual listed shares that are listed on the JSE and other exchanges. This list forms the basis from which the dual listed securities were identified. For the purposes of this research the focus will be on the shares that form part of the ALSI Top 40 and that are listed on the London Stock Exchange. Table 3.2 below reflects those shares that are included in the test sample due to their inclusion in the ALSI Top 40 and also the listing on the LSE.
Table 3-2 Dual listed shares codes of the shares included in the time series testing

<table>
<thead>
<tr>
<th>Bloomberg Code</th>
<th>Share name</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAL LN Equity</td>
<td>Anglo Gold</td>
</tr>
<tr>
<td>AGL SJ Equity</td>
<td></td>
</tr>
<tr>
<td>BIL SJ Equity</td>
<td>Biliton Plc</td>
</tr>
<tr>
<td>BLT LN Equity</td>
<td></td>
</tr>
<tr>
<td>DDT LN Equity</td>
<td>Dimension Data</td>
</tr>
<tr>
<td>DDT SJ Equity</td>
<td></td>
</tr>
<tr>
<td>INP SJ Equity</td>
<td>Investec Plc</td>
</tr>
<tr>
<td>INVP LN Equity</td>
<td></td>
</tr>
<tr>
<td>LAF LN Equity</td>
<td>Lafarge Plc</td>
</tr>
<tr>
<td>LAF SJ Equity</td>
<td></td>
</tr>
<tr>
<td>LBT SJ Equity</td>
<td>Liberty International Plc</td>
</tr>
<tr>
<td>LII LN Equity</td>
<td>Lonmin plc</td>
</tr>
<tr>
<td>LMI LN Equity</td>
<td></td>
</tr>
<tr>
<td>LON SJ Equity</td>
<td></td>
</tr>
<tr>
<td>OML LN Equity</td>
<td>Old Mutual Plc</td>
</tr>
<tr>
<td>OML SJ Equity</td>
<td></td>
</tr>
<tr>
<td>SAB LN Equity</td>
<td>South African Breweries Plc</td>
</tr>
<tr>
<td>SAB SJ Equity</td>
<td></td>
</tr>
</tbody>
</table>

Source: Bloomberg December 2003

The first three characters in the Bloomberg code describes the share code and the two characters after the space and before the word equity highlight which exchange the code relates to. The word equity simply indicates that the general Bloomberg identification shows this to be an equity product.

The research views the arbitrage opportunities at day end only and takes into account the fact that the bid ask spreads must be crossed in both the purchase and sale of the shares and currency that is required to effect the transactions. To provide a monetary equivalent of the effects of the mispricing, the research assumes that only ten thousand shares can be traded for each opportunity that is presented without affecting demand and supply and therefore price.

The analysis measures the profitability of the arbitrage types before and after the relevant transaction costs have been applied, such that the research can identify perceived opportunities versus those that are real opportunities. Once the profitability prior to transaction costs is determined, the appropriate trading costs are subtracted from the results, to provide the profitability of the strategy after transaction costs.
The results of the dual listed securities arbitrage opportunities are shown as the number of possible transactions that presented themselves on an annual basis for each of the dual listed shares for the period under review in addition to an indicative level of how profitable the trading strategy is over the period under review.

3.5.1.12 Statistical Arbitrage

Reverre (2001:474-477) defines a methodology to identify and exploit statistical arbitrage opportunities. This approach is applied to the ALSI Top 40 shares, to determine which shares are highly correlated over time. The correlation level that is set as the threshold for inclusion in this research is 60% or greater for the 4 year period and the relationships are calculated using the last traded prices of shares as reflected by Bloomberg for each day in the sample period from January 2000 to December 2003.

While Reverre (2001) used share combinations that had correlations greater than 80%, it is not specified how the correlations are calculated. The method used in this study is to take the natural logarithm (ln) of the closing price of the share at a specified date (d) divided by the closing price of the share from the previous day (d-1), or when expressed in notation ln (d/d-1). These correlations would be higher if the correlations were calculated using the lognormal of the two share prices on the same day or if the lognormal of the change in the individual share prices was used to establish the correlation.

A further consideration which Reverre (2001) specifies, is that the three-month correlation should be used to establish the relationships. This study relies on the average of the three-month correlation over a four-year period, which also explains the lower overall correlation used.

Following the identification of the shares, which exhibit these relationships, the share pairs are matched and compared to one another in the manner described in Chapter 2, section 2.4.1. Using the methodology described in section 2.4.1 to identify shares that are over or underpriced relative to their correlated shares, the following approach is applied: If the normalised change is greater than 1.5 then the shares forming the denominator in the price ratio calculation is purchased while a number equal to the ratio of the shares of the share forming the numerator in the price ratio is sold.
Similarly, if the normalised change is less than –1.5, the shares acting as the denominator in the ratio calculation is sold while purchasing one times the ratio of the shares that act as the numerator at that time.

The findings will be presented in tabulated form reflecting the number of trades entered into, the average profitability of the trades, the average duration of the trades and the number of trades that were closed out as a result of the stop loss being triggered. The effects of trading costs will be applied to the calculation such that the results before and after transaction costs are visible. The costs that will be applied depend on the nature of the arbitrage opportunity and will depend on the instruments that are traded, for instance shares, options or futures.

Analysis into the predictability of global indexes, with the view to generating global index arbitrage opportunities was undertaken by Meissner *et al.* (2002:1-11), as discussed in Chapter 2, section 2.2.4.1. In the application of this method to the South African environment, the following indexes are used in the manner described in the research: Dow Jones Industrial Average represented the American stock exchanges. The FTSE 100, the DAX and the CAX indexes were averaged to provide an average for European stock exchanges and the Hang Seng, Nikkei, and the AS51 indexes were averaged to provide the average for the Eastern and Australian exchanges. From a South African perspective the Top 40 index was used as the representative index for the purpose of this research.

The research using this method spanned the period June 2000 up to June 2004 and weekends or holidays were excluded from the sample data. The process followed is to perform a regression analysis on the data to establish statistical relationships by applying multiple regression. The regression analysis results are presented in the findings with the view to proving the statistical inference that will be drawn upon for the remainder of the analysis.

As described by Meissner *et al.* (2002:1-11) the ability of the leading index to predict the lagging indexes is considered in this method. The method adopted is to identify cases where moves fall in the bands of 0.5% to 1%, 1% to 1.5%, 1.5% to 2%, 2% to 2.5%, 2.5% to 3% and greater than 3% or –0.5% to -1%, -1% to -1.5%, -1.5% to -2%, -2% to -2.5%, -2.5% to -3% and where moves smaller than -3% occurred in the leading index relative to the lagging index.
Where these events occurred, the duration and the magnitude of the move in the lagging index is observed such that the statistics of the number of moves in the same direction and the average move for each of the respective bands can be determined.

The data is presented in a matrix format which shows the percentage of times when the lagging indexes move in the same direction as the leading index for each of the thresholds described above. The matrix also shows the extent of the move in the lagging index expressed as a percentage return.

3.6 SUMMARY OF RESEARCH METHODOLOGY

This chapter describes the methods applied in gathering the information required for this research. Because the research requires input from nationally dispersed institutions dealing in equity derivatives, it was decided that a self administered research questionnaire would be the mechanism that would best meet the requirements of the research pertaining to arbitrage trading processes.

The questions posed relate to the methods, processes and actions that are taken by the respondents in running their equity arbitrage operations. The questionnaire also deals with the risk management practices and structuring of the institutions arbitrage business.

The research pertaining to the identification of arbitrage opportunities focuses on testing index futures arbitrage, single stock futures arbitrage, dual listed arbitrage, risk arbitrage and statistical opportunities in time series testing methodology.

The inputs that are required for the identification of arbitrage opportunities are sourced from the JSE, SAFEX, Bloomberg and Reuters. As all information was not available for all periods, the research focuses on different time periods for different arbitrage types. The research generally covers four years of historical data, but it should be noted that the SSF analysis was only done for a two year period The SENS data required for the Risk Arbitrage data is only available from May 2001 and therefore the research was extended up to and including February 2004.

The performance of each of the arbitrage types is measured once the required inputs have been added to the relevant formula. These findings are presented in a manner, which reflects the average profitability, the number of trades that are entered into
relative to the number of trades that are profitable, the effects of transaction costs on
the overall profitability of the trading strategy, and the average volume traded per
arbitrage type.
CHAPTER 4

RESEARCH FINDINGS

4.1 INTRODUCTION

Chapter 3 of the research outlines the manner in which the empirical and time series analysis are executed, analysed and reported in Chapter 4. Therefore the focus of the first section of Chapter 4 is to provide the details of the results that were gathered through the completed empirical questionnaires, received from the respondents in the sample. These results start with a review of the statistics pertaining to the number of respondents who returned the questionnaire.

The chapter then reflects each of the research elements that were considered in Chapter 3, and presents these in terms of the questions that were posed to the 80 institutions that were included in the sample. The second section of this research details the results obtained from the time series analysis into the various arbitrage types.

4.2 RESPONSES BY THE SAMPLE

As indicated in Chapter 3, a stratified quota sampling method was used. Feedback was provided by 76 (95%) of the respondents, while the remaining 4 (5%) refused to answer the questionnaire. Of these 76, six institutions (7.8%) noted that they participated in equity arbitrage but that the information was considered to be proprietary and that company policy was not to disclose any operational information and they therefore did not complete the questionnaire. Those institutions that felt this information was of a proprietary nature are three foreign investment banks and three foreign stock broking institutions.

The responses received from the banks included in the sample showed that eleven of the respondents did trade equity derivative arbitrage. However given their internal policies, three of the international banks would not provide details of their operations. Three of the international banks did provide meaningful input about their arbitrage trading, as did five of the South African banks.
All insurance companies and stock broking institutions that were included in the sample responded to the questionnaire. Where the institutions did not trade any equities or equity derivatives directly as they outsourced the function, the responses were marked as not part of the core business. This response was confirmed verbally with the relevant person responsible for the investments of the company, be it the financial director or the investment manager of the company in question.

The responses received from the stockbrokers showed that eleven (55%) of the institutions in the sample did not trade equity arbitrage; of these, a further two were in the process of creating desks to perform this function. The primary reasons for not trading arbitrage is that their business models are focused on facilitating client-driven transactions. There are nine stock broking institutions which trade equity and equity derivative arbitrage; of these nine, three were international stock broking institutions that felt the information was of a proprietary nature and they were therefore not prepared to complete the questionnaire.

Feedback from the asset managers showed that five of the respondents traded some equity derivative arbitrage strategies. In the sample two of the asset managers were multi-managers and therefore allocated their funds into other funds and therefore they did not directly partake in equity investments. One company no longer exists and therefore no information could be gathered on its processes. Where the asset managers participated in equity arbitrage the main thrust of these trading activities was housed in the hedge funds that these asset managers had set up to cater for arbitrage trading.

Given the feedback, there were 27 companies in the sample that traded arbitrage strategies; two of these would not complete the questionnaire, despite numerous requests to do so and after declining meetings that were set up to get the questionnaire completed. Six of these respondents felt that the information was too sensitive to share, while 19 completed the questionnaire. It should also be noted that not all companies trade all arbitrage types and that the figures discussed thus far are viewed at a consolidated level for all arbitrage types.

### 4.3 Arbitrage Business Structures

In an effort to ensure meaningful interpretation of the results of the empirical findings, only the institutions that do trade equity arbitrage and which did provide feedback on
the questionnaire were analysed from this point forward. Therefore the analysis will focus on the 19 companies that do trade equity arbitrage.

4.3.1 BUSINESS STRUCTURES AND STRATEGIES

The responses show that some institutions are not geared towards the arbitrage market in any way, while others have progressed to more advanced stages in terms of the business structures that they have put in place to deal with the arbitrage types that they are trading. It could also be added that the business type played an important part in determining whether the institution was involved in arbitrage trading. Banks (55%) are for instance most likely to conduct arbitrage trading, while insurance companies (0%) are least likely to have arbitrage trading structures in place.

The consolidated findings of the sample shows that insurance companies in the sample do not partake in any form in equity trading or arbitrage trading directly, due to the fact that they outsource the investment function to asset managers who perform the investment function on their behalf. The investment process followed by the insurance companies would as a general rule reflect the investment parameters prescribed by the Financial Services Board which governs the Insurance industry and the investment management industry.

Of the banks, only two indicated that they outsourced the equity investment function and hence the equity arbitrage function to their sister companies such that the sister companies performed a centralised investment and treasury role. All other banks who indicated that they traded arbitrage housed the equity derivative and arbitrage trading within their treasuries and followed a centralised structure, in that the arbitrage trading was consolidated in one area, which fell under equity derivatives.

Of the institutions that traded arbitrage, 17 (89%) adopted a centralised business structure, while the remaining two used decentralised structures. The reason for the centralised choice was mainly due to the fact that the institutions also used these traders to trade other types of equity trading.

Twelve (63%) of the respondents who trade equity arbitrage were of the opinion that the trading provided the institution with a strategic advantage. This statistic helps in explaining why the institution felt that they would keep the arbitrage books active for years after they were no longer profitable. Six (35%) institution would keep the book
even if it did not make money for a period longer than two years. Four (23%) responded that they would only shut the book, if it did not make money for a period of three years or longer, while four (23%) said they would keep the book even if it did not make money for a period of four years or longer.

4.3.2 **Equity Arbitrage Structures and Trading**

The research showed that 13 of the institutions that participate in equity arbitrage trading, positioned the trading within the equity derivative structure within the business. The remaining six either positioned the desk in an area focused on arbitrage, or positioned the arbitrage trading in a hedge fund structure.

4.4 **Trading Processes**

Below, trading processes are discussed with reference to index and SSF arbitrage, risk and merger arbitrage, dual listed arbitrage, statistical arbitrage, volatility arbitrage and arbitrage risk processes.

4.4.1 **Index and SSF Arbitrage**

Of the institutions that do partake in equity derivative arbitrage, 14 (74%) trade index and SSF arbitrage. The five institutions that do not trade index or SSF’s felt that this was not part of their core business and have no interest in this type of trading.

**Figure 4.1 Views on improving futures arbitrage trading**

![Figure 4.1 Views on improving futures arbitrage trading](image)
From Figure 4.1 above it can be seen that six of the respondents felt that their processes can not be improved in any way, five of the respondents felt that the identification of these opportunities can be improved, nine of the respondents felt that they would like an improved execution process, three felt that the market risk process around these trades could be improved, and lastly one of the respondents felt that the deal by deal profitability process could be improved. It should be noted that the respondents could choose more than one area of improvement in the selection provided.

4.4.1.1 IDENTIFICATION PROCESSES

The study shows that institutions that do trade equity arbitrage are in favour of improved identification processes. All respondents indicated that their identification processes relied on spreadsheets, which were linked to live data sources, and these then calculated the fair value of the future given the spot prices, the risk free rate and the dividends. Of the respondents eleven institutions had done some development around their identification processes and this development went further than the basic spreadsheet application.

The respondents all use a discreet dividend process in the calculation of the value of the index, with only one institution indicating that it also looks at the continuous dividend yield. The general sources of dividend information were shown to be Bloombergs (37%), Inet (27%), Reuters (18%), and analyst forecasts were applied in about 55% of all cases. The dividends were split according to analysts forecasts in ten (71%) cases, in four cases they were split on a historical basis. In five of the cases the respondents also used proprietary methods to assist in splitting the dividends for both index and SSF.

4.4.1.2 TRADER’S DISCRETION

As mentioned above, none of the respondents have developed automated trading processes to effect the transactions on their behalf. Traders are needed to physically place the order with the exchange. Therefore, the view held by this research is that institutions may miss trading opportunities as a result of the trader being away from the desk for one reason or another. No clear indication of the magnitude of these missed opportunities is obtainable and there are no existing measures applied by the respondents to manage this area of the business.
As the empirical findings also reflect that the price discrepancies are visible for periods of at least a day, it could be argued that a mitigating factor is the fact that the opportunities are visible for long periods of time, as discussed under section 4.4.14.

4.4.1.3 Hedging and Stop Losses

In its true form the index and single stock futures arbitrage would never require the trades to be hedged. Of the institutions in the sample which traded SSF and index arbitrage, only two did not trade this arbitrage in its pure form, and they used a representative basket of the index or traded the arbitrage using other derivative instruments, such as options and futures. The fact that they did not trade the arbitrage in its pure form implies that they need to adopt a stop loss strategy, as the convergence may not occur as expected. The respondents set these stop loss levels at 5% in one case and a level between 5% and 10% in the other case. Where the impure form of index and SSF arbitrage was applied, the respondents who applied this methodology used the delta to calculate the hedge requirements.

The remaining twelve respondents all applied futures arbitrage trading in the conventional form whereby they traded the future and the underlying shares. As a result, none of these institutions felt the need to hedge or place any stop loss on the futures arbitrage trades.

The reasons cited by the companies for not trading a representative hedge of the index was due to the fact that eight were of the opinion that the representative basket introduced additional risk into the trade, and four were of the opinion that this mechanism was an ineffective mechanism for effecting this trading strategy.

Of the institutions that trade this strategy eleven (78.5%) were of the opinion that the securities lending pool was adequate and did not adversely affect their trading as they could source the shares required to settle the short sale transactions.

4.4.1.4 Number of Trades and their Duration

The 14 institutions that confirmed that they traded futures arbitrage had in general been trading the strategy for a number of years, with only one institution having traded for less than a year, three institutions had traded SSF and Index arbitrage for
between one and three years, six institutions had traded this strategy for between three and five years, and four had traded the strategy for a period greater than five years. This data is presented graphically in figure 4.2 below.

**Figure 4.2 Futures arbitrage trading duration**

![Figure 4.2 Futures arbitrage trading duration](image)

Figure 4.3 below shows that four (36%) of the respondents entered into less than five trades per week, five (45%) entered into between five and ten trades a week, two of the respondents traded between 20 and 50 such transactions while three indicated that they traded more than 50 such transactions every week.

**Figure 4.3 Number of trades entered into on a weekly basis**

![Figure 4.3 Number of trades entered into on a weekly basis](image)

Figure 4.4 below shows that the respondents viewed the general duration of these opportunities in the market to last up to a month. Three felt that the opportunities
were visible for only one day, while seven of the respondents felt that the mismatches were visible between one day and a week; two felt that the mispricing is generally visible between one and two weeks; one felt that the mispricing was visible in the market for a period of two weeks to a month; and one was of the opinion that the mispricing was visible for a period of a month.

**Figure 4.4 Futures arbitrage duration**

![Figure 4.4 Futures arbitrage duration](image)

The general consensus was also that the trades tend to converge prior to the actual maturity date of the futures contracts and therefore the trades were closed out before the contract maturity date. Figure 4.5 below shows that four respondents indicated that they closed out their positions early in less than 10% of all arbitrage trades and one indicated that between 10% to 30% of the futures arbitrage trades were closed out prior to the maturity date. One respondent indicated that about 30% to 50% of their futures arbitrage trades were closed out prior to the futures maturity, and eight of the respondents indicated that the prices converged before maturity and they therefore closed the trades before maturity in more than 50% of the arbitrage trades they entered into.

The research also assumed that where index or SSF arbitrage trades converged, the trades would be terminated. This implies that the research does not assume that trades will be held to maturity and the view of this research is that there is no point in holding on to the trades until the futures expiry if the arbitrage converges prior to the futures close-out date. It may be argued, however, that in some instances the position suites the book and therefore the traders would prefer to maintain the
position until the expiry date. While this may be true, this discussion does not form part of the research and should be considered at the relevant book level.

**Figure 4.5 Percentage of trades closed out early**

![Bar chart showing the percentage of trades closed out early](image)

<table>
<thead>
<tr>
<th>% of trades closed out before maturity date</th>
<th>Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 10%</td>
<td>1</td>
</tr>
<tr>
<td>&gt; 10% but &lt; 30%</td>
<td>2</td>
</tr>
<tr>
<td>&gt; 30% but &lt; 50%</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 50%</td>
<td>5</td>
</tr>
</tbody>
</table>

### 4.4.1.5 Profitability and Risks

Only one of the respondents was of the opinion that the trading strategy was not meeting the profitability requirements. The rest of the respondents felt that these trades met their profitability requirements and hence they would continue trading these arbitrage strategies.

Table 4.1 below reflects a matrix of responses that the respondents consider to be the primary cost drivers and which affect their business directly in futures arbitrage trading. The rating scale that was used, set four as the most significant cost and one as the least significant cost. It is apparent that transaction-hedging costs are considered the most significant costs, while securities lending costs rate a close second. Staff and systems costs were generally rated as secondary costs in terms of this type of strategy.
Table 4-1 Cost drivers in futures arbitrage

<table>
<thead>
<tr>
<th>Cost Driver</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction / Hedging costs.</td>
<td>5</td>
<td>5</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Securities lending cost.</td>
<td>4</td>
<td>7</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Staff</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>Systems</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

The risks that are considered the most significant in this type of trading are execution risk and all the respondents indicated that this risk had a negative impact on their business. Dividend risk was rated second highest with twelve of the respondents rating this as a concern. Nine were concerned with market risk components of the trading; six were concerned with the scrip lending availability; and three rated the interest rate risk as a concern. Figure 4.6 below shows the above information in the form of a frequency distribution.

**Figure 4.6 Rating of significant risk types**

![Risk types distribution chart]

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### 4.4.2 Risk and Merger Arbitrage
Of the 19 companies who trade equity arbitrage, eight (42%) did not participate in risk arbitrage as they felt that this type of trading was not part of their core business. Eleven companies in the total sample actively trade risk arbitrage.

4.4.2.1 Identification Processes

The study shows that respondents who trade risk arbitrage are in favour of improved identification processes. Only one respondent was of the opinion that the process could not be improved in any manner. Eight of the respondents were of the opinion that the identification could be improved; six would like to see the execution of the trades improved, while three were of the opinion that the market risk process around these trades could be improved. Not one of the respondents felt that they were lacking in any way in terms of the ability to measure the mark to market (MTM) performance of the risk arbitrage trades. This information is summarised in the frequency distribution in Figure 4.7.

Figure 4.7 Views on improving risk arbitrage processes

Only three of the respondents had done some development in terms of systems capabilities to identify and manage these trades. The systems of all the respondents are linked to live data feeds. All the respondents also used spreadsheets in their management and identification of the risk arbitrage trades.

4.4.2.2 Trader’s Discretion
There is no automated trading process to identify and effect the transactions on behalf of the traders, therefore the trade opportunities may be missed as a result. No clear indication of the magnitude of these missed opportunities was obtainable as the respondents do not have a mechanism to monitor and track these missed trade opportunities.

A common comment from the respondents was that this type of trading cannot be easily automated due to the fact that the deals differ in each case and the manner in which the data is transmitted through SENS does not lend itself to a high degree of automation due to a lack of consistence in the message format.

4.4.2.3 Hedging and Stop Losses

Of the respondents that traded risk arbitrage, one respondent from an investment institution did not apply a stop loss level. Three of the respondents set the stop loss levels at 5% or below. Six respondents set the stop levels between the range of >5% and <10%. One respondent indicated that their stop loss was set at between 10% and 15%. This information is presented in Figure 4.8 below.

Figure 4.8 Stop loss levels applied in risk arbitrage

All the respondents who trade risk arbitrage used the underlying instruments to hedge exposures, while one respondent also used futures and one used options in addition to the underlying instruments. Nine of the respondents used the delta to determine the hedge ratio’s while one used a PDH on the delta. Another one also
used the PDH on the vega, and another used a stock split process to determine the hedge requirements.

4.4.2.4 NUMBER OF TRADES AND THEIR DURATION

The institutions that provided feedback on this type of arbitrage had been trading these strategies for varying time periods and the results are shown in Figure 4.9 below. One institution has been trading risk arbitrage for less than a year, seven institutions have been trading risk arbitrage for a period of three to five years and three institutions have been trading for a period between five and ten years.

Figure 4.9 Time the respondents have traded risk arbitrage

The number of risk arbitrage trades that were entered into by the market could not be set at a monthly average as the trading opportunities are driven by the corporate activity in the market – this comment ties back to the findings of the literature covered in the literature review section on risk arbitrage as discussed in Chapter 2. Therefore the results of trading activities will be centred on the corporate activity calendar, and no trading will occur where there is no corporate activity.

Figure 4.10 below shows that the general duration of these opportunities in the market may last for more than a month in the opinion of three of the respondents. One respondent feels that the mispricing is generally visible for about one week to two weeks, five feel that the mispricing is visible for one day to one week and two of the respondents were of the opinion that the mispricing was visible for only one day.
4.4.2.5 PROFITABILITY AND RISKS

All of the respondents were of the opinion that these trades met their profitability requirements and hence they would continue trading these types of arbitrage. Four of the respondents were of the opinion that the execution of the risk arbitrage trades was a process that added to the risks in the risk arbitrage process. Two of the respondents felt that credit risk was a factor which should be considered in this type of arbitrage. Ten of the respondents felt that the market risk component was the largest contributor to the risks associated with risk arbitrage, six were concerned about the legal risk associated with the trades mainly due to competition commission approvals, and six were concerned with deal failure for reasons other than legal reasons. Figure 4.11 below reflects the responses in the form of a frequency distribution.

Figure 4.11 Risks that are considered meaningful in risk arbitrage
The general consensus amongst the respondents is also that the trades tend to converge as per the traders expectations. Almost all of the respondents (90%) were of the opinion that the trades converge in the manner that they expected. Where the trades did not converge in the expected manner, the respondents ascribe the cause of the non-convergence to regulatory reasons e.g. competition commission stopped the deal from proceeding; deals being revised in a manner that inhibits the prices from moving to the levels that were expected from a profitability perspective; fact that the time it takes to conclude the deal is so long that it reduces the profitability from a return on capital perspective to levels which do not meet the profitability requirements.

The respondents’ views on deals being concluded successfully is clear from the frequency distribution shown in Figure 4.12 below. The respondents are all of the opinion that the deals do, as a general rule, result in the prices converging as expected. However, where this is not the case, either the time it takes to conclude the deal, deal failure or deal revision are the reasons cited for the deals not being profitable.

**Figure 4.12 Deal success, failure and profitability in risk arbitrage**

The consolidated view of the respondents who traded risk arbitrage was that six considered transaction cost to be the primary cost drivers in the risk arbitrage trading process, six felt that securities lending costs were the next largest contributor to costs in this strategy. Five felt that staff were the third largest contributor to costs, while six felt that systems used for risk arbitrage were the least significant of the costs
incurred. Table 4.2 below reflects the respondents’ ratings per cost driver, with 1 being the highest and 4 being the lowest.

Table 4-2 Cost drivers in risk arbitrage

<table>
<thead>
<tr>
<th>Cost driver</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 3 2 1</td>
</tr>
<tr>
<td><strong>Transaction / Hedging costs.</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 2 1 2</td>
</tr>
<tr>
<td><strong>Securities lending cost.</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 6 3 1</td>
</tr>
<tr>
<td><strong>Staff</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 1 5 3</td>
</tr>
<tr>
<td><strong>Systems</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 2 1 6</td>
</tr>
</tbody>
</table>

4.4.3 DUAL LISTED ARBITRAGE

Only two respondents indicated that they traded the dual listed strategy. The rest of the respondents indicated that they did not trade dual listed arbitrage for the following reasons. One of the respondents said they had no system, which could be used to house these trades, four said they had no interest in trading this arbitrage type, eight said this business strategy was not part of their core business, seven indicated that they do not have the legal/entity ability to trade dual listed securities on the international exchange and one respondent was of the opinion that this type of arbitrage does not exist. The details of the responses received are reflected in Figure 4.13 and it should be noted that the companies could have provided more than one reason why they do not trade dual listed arbitrage.

Figure 4.13 Respondents’ reasons why dual listed arbitrage is not traded
4.4.3.1 **Identification Processes**

The study shows that the two respondents who do trade dual listed arbitrage both feel that their processes can be enhanced through improved identification processes. Both respondents indicated that their identification process relied on spreadsheets that are linked to live data sources, and these then determine whether there is any mismatch in price given the exchange rates fed from the data vendor.

Both respondents indicated that they trade positions, that relate to the currency mismatches between the same shares on different exchanges, and one respondent indicated that that institution traded the dividend effects as, and when they presented themselves. The research did not delve into the regulatory arbitrage processes that could be employed to generate profits as a result of differences between SA, UK and EU taxation legislation.

4.4.3.2 **Trader’s Discretion**

As none of the respondents have developed an automated trading process to effect the transactions on their behalf, this implies that the traders must manually act upon all trade opportunities. Therefore the companies may miss trading opportunities as a result of this operational constraint that they face at this time.

In the dual listed arbitrage trading environment where many of the trading gaps appear as a result of volatile currencies, it is crucially important to have prompt system-based trading that monitors the price disparity continuously and that effects the trades on the shares and the currencies in an efficient manner, in order to maximise profitability.

4.4.3.3 **Hedging and Stop Losses**

The two respondents who participated in this type of arbitrage trading indicated that they adopted stop losses when participating in this trading strategy and this stop loss was set at a level of 5% or below. The hedges that are used include the sale or purchase of the underlying instrument on the London Stock Exchange, while the currency exposure was also hedged out as part of the hedging process. None of the respondents used derivative instruments to hedge out their exposure.
The hedges that are put in place to reduce the risks faced on the shares are always done in the underlying shares and this is always considered to be a delta hedge. Liquidity is said to be a constraint in this type of trading, primarily due to the fact that very large positions may be needed to generate the profits required in this trading. Further feedback showed that the liquidity was greater on the London Stock Exchange. Finally the respondents rated execution risk and market risk as their biggest risks in this trading strategy.

4.4.3.4 NUMBER OF TRADES AND THE TRADING PERIOD

Of the two institutions that indicated that they were trading dual listed arbitrage one had been trading this arbitrage for between one and three years while the other had been trading for between three and five years.

The number of transactions entered into on a monthly basis ranged between 20 and 50 transactions per month for both respondents.

4.4.3.5 PROFITABILITY AND RISKS

Both respondents felt that these trades met their profitability requirements and hence they would continue trading these arbitrage strategies. Furthermore, both respondents felt that the execution and market risks involved with these trades are significant, as the execution process involved the purchase or sale of forward currency components which is not present in most other forms of arbitrage trading.

The respondents indicated that transaction costs are the primary drivers in these trades with securities lending cost being rated as the second largest cost contributor, followed by systems costs and then staff costs.

4.4.4 STATISTICAL ARBITRAGE

Of the total sample of 80 institutions there were eight respondents who are involved in statistical arbitrage in some form. The details of the trading types were indicated to be rather elementary, as described below in section 4.4.4.1, with the majority of the respondents being involved in pairs type trading.
Figure 4.14 below indicates that all the respondents who trade statistical arbitrage were of the opinion that the process could be improved. All eight of the respondents felt that the trading process could be improved through enhanced identification processes, while five were of the opinion that the execution process could be improved. Three were of the opinion that the market risk around these trades needed some work, and only one was of the opinion that the performance management of the statistical arbitrage trades should be improved.

Figure 4.14 Respondents views on improving the statistical arbitrage process

4.4.4.1 IDENTIFICATION PROCESSES

All respondents indicated that their identification processes rely on spreadsheets that are linked to live data sources, and this data is then applied to mathematical and statistical formulae to calculate the statistical arbitrage trades. Six of the respondents that trade statistical arbitrage had done some development to assist in the statistical arbitrage identification process. The remaining institutions rely entirely on the data from spreadsheets that are then analysed by the traders in the hope of identifying the statistical arbitrage trades.

All of the institutions that trade statistical arbitrage, are involved in pairs trading between related shares or highly correlated shares. Only two of the respondents used other statistical techniques like linear algebra techniques on the underlying shares. An investigation of the use of derivatives in statistical arbitrage reveals that only four respondents used statistical arbitrage processes in the derivative context.
Only one respondent uses the statistical information for the purposes of volatility arbitrage.

4.4.4.2 TRADER’S DISCRETION

As none of the respondents have developed automated trading process to effect the statistical arbitrage transactions on their behalf, the opinion of this research is that there must be statistical trade opportunities that are not traded due to the human component involved in trading this strategy. The fact that the analysis is left to the traders implies that the results are dependent on the traders’ mathematical and statistical ability for the identification of the trade opportunities. Given this information, the institutions may miss trading opportunities as a result of the process. No clear indication of the magnitude of these missed opportunities was obtainable.

4.4.4.3 HEDGING AND STOP LOSSES

As the statistical arbitrage process has by its very nature a large degree of risk, all the institutions involved in this type of trading use a stop loss process to reduce the downside where the trades do not converge in the manner that they had expected. Three of the institutions apply a stop loss level of 5% or below, four institutions apply a stop loss level between five and ten percent and one institutions applied a stop loss of between 15% and 20%. These findings are reflected in Figure 4.15 below.

Figure 4.15 Stop loss levels applied in statistical arbitrage

All the respondents are of the opinion that the securities lending pool is adequate to cater for the lending requirements that were incurred in statistical arbitrage trading.
All of the respondents said they hedge using the underlying instruments, while four use options, four also use futures and one use forwards to hedge out the exposure created by the statistical arbitrage trades. This is reflected in figure 4.16 below.

**Figure 4.16 Hedge instruments used in statistical arbitrage**

![Hedge Instruments Used in Statistical Arbitrage](image)

All the respondents in the sample who trade statistical arbitrage use the delta in one way or another to determine their hedge requirements, three of the companies use the PDH on the underlying contracts to determine the hedge requirements, and six of the respondents perform a similar process using the actual delta to determine the hedge requirements. One company uses a PDH on the underlying volatility curve to establish the hedge requirements for the options that are on the book.

It should also be noted that this is one area of the research where all respondents felt that the actual sensitivity and loss limits could not be shared as this would compromise their trading strategy.

**4.4.4.4 Number of Trades and their Duration**

The respondents that provided feedback on this type of arbitrage type indicated that two of them had been trading statistical arbitrage for a period of one to three years. Another three had been trading statistical arbitrage for about three to five years and a further three indicated that they had been trading this strategy for a period between five and ten years. This information is reflected in Figure 4.17 below.
Figure 4.17 Period that the respondents have traded statistical arbitrage

The average number of statistical arbitrage trades that the respondents entered into on a monthly basis varied and the results are shown in Figure 4.18 below, with four respondents entering into less than five trades in a month, two companies indicated that they traded between five and ten trades a month, one respondent said they traded between ten and twenty trades a month, while one respondent said they traded between twenty and fifty statistical arbitrage trades in a month.

Figure 4.18 Number of statistical trades entered into on a monthly basis
All the companies that trade this arbitrage strategy focus only on the liquid shares and indicated that they avoided the non-liquid shares when executing this trading strategy.

4.4.4.5 PROFITABILITY AND RISKS

All the respondents that are involved in this arbitrage strategy were of the opinion that this was a profitable trading strategy. The responses that were received in terms of the actual returns required ranged from any number greater than zero after transaction costs to 20% annually.

The respondents were of the opinion that the transaction costs were the most significant cost that they incur in their statistical arbitrage trading; this was followed by securities lending costs, then systems costs, followed by staff costs. Table 4.3 below reflects the responses received from the institutions that trade statistical arbitrage.

Table 4-3 Costs break down in statistical arbitrage trading

<table>
<thead>
<tr>
<th>Cost Driver</th>
<th>Cost Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction / Hedging costs.</td>
<td>4 3 2 1</td>
</tr>
<tr>
<td>Securities lending cost.</td>
<td>5 2 1 0</td>
</tr>
<tr>
<td>Staff</td>
<td>2 6 0 0</td>
</tr>
<tr>
<td>Systems</td>
<td>0 0 3 5</td>
</tr>
<tr>
<td></td>
<td>1 0 4 3</td>
</tr>
</tbody>
</table>

Seven of the eight respondents were most concerned with the market risk associated with the statistical arbitrage trades, and considered this to be critical in managing their risk, while four indicated that they considered the Greeks to be significant indicators of risks in this trading. Two were concerned with execution risk one with legal risk and one with credit risk. Figure 4.19 below shows the perceived risks as viewed by the respondents to the questionnaire.
What is of interest is that none of the respondents considers the currency risk to be significant in their statistical trading process, which implies that they are not doing statistical arbitrage between the local and international exchanges. This is particularly interesting when viewed in light of the volatility arbitrage strategy discussed below and the dual listed arbitrage strategy discussed above.

### 4.4.5 Volatility Arbitrage

In the entire sample only three respondents traded volatility arbitrage, which implies that this field of arbitrage does not receive a large degree of attention. The respondents that do not trade volatility arbitrage provided the following feedback, which is best described by Figure 4.20 below. One respondent indicated that they do not have a system to track or identify these trades, one indicated that they have no interest in this type of trading, eleven indicated that this type of trading was not part of their core business, and one respondent is of the opinion that this trading does not exist.

![Figure 4.19 Risks in statistical arbitrage](image-url)
4.4.5.1 IDENTIFICATION PROCESSES

Of the institutions that trade volatility arbitrage all were of the opinion that their trading process would be improved through the development of more appropriate mechanisms that could identify the volatility arbitrage opportunities that exist in the market. One of the respondents indicated that the execution process could also be improved.

Not one of the respondents have any formal system, that can be used to identify volatility arbitrage opportunities, and the mechanism used to identify arbitrage types is to analyse and identify volatility arbitrage opportunities in a spreadsheet.

All of the respondents indicated that they trade volatility arbitrage on a speculative basis, with two of the respondents trading the reversion to historical means as a strategy and one respondent trading the spread between the volatilities of different maturities. One of the respondents also takes a view on volatilities between companies that are highly correlated.

4.4.5.2 TRADER’S DISCRETION

Given the fact that all respondents involved in volatility arbitrage are using spreadsheets to determine whether or not to trade these strategies, all decisions are left to the trader in this regard. There is therefore no real benchmark that can be used
to indicate how many opportunities were missed and how effective the trader is at trading this strategy.

Obviously, the traditional mechanisms of performance against budget can be used to determine how effective the trader is over the given period, but this does not prove that the trader was effective in all trades, or that the results were not generated by only one trade which went in the favour of the trader.

Only one institutions trades volatility arbitrage that is considered to be pure arbitrage. This trading is done on the basis of taking offsetting positions at equivalent strikes in different countries where there are different volatilities applied to the same shares on different exchanges.

4.4.5.3 HEDGING AND STOP LOSSES

All three respondents that traded volatility arbitrage apply stop losses to the trades. Two of them set the level at between 5% and 10%, while one set the level at between 15% and 20%. A frequency distribution of the stop loses employed by the respondents is provided in Figure 4.21

Figure 4.21 Stop losses applied in volatility arbitrage

All the above respondents use the underlying instrument and their associated options to effect their hedging requirements. Two said they also use futures and forwards to
hedge their positions. All respondents involved in this type of trading use PDHs to determine the hedge requirements through delta and vega hedging.

**4.4.5.4 Number of Trades and their Duration**

The respondents that provided feedback on volatility arbitrage indicated that one of them had been trading between one and three years another had been trading between three and five years and another had been trading for a period of between five and ten years. This information is reflected in the Figure 4.22 below.

**Figure 4.22 Duration of the volatility arbitrage strategy**

Two of the respondents entered into between five to ten trades per month, while one of the respondents made between 20 and 50 such trades in any given month. This information is shown in figure 4.23 below.

**Figure 4.23 Number of volatility trades made every month**
4.4.5.5 Profitability and Risks

All of the respondents that are involved in volatility arbitrage felt that the trading was a profitable strategy that needs to provide returns of at least 20% annually.

The respondents felt that the transaction costs are the most significant cost that they incur in their volatility arbitrage trading; this is followed by securities lending costs, staff costs and then systems costs.

Figure 4.24 below shows that all of the respondents felt that market risk is the largest risk that was encountered, while two felt that the risks indicated by the Greeks and execution risks are also significant risks that are encountered in this type of trading. One respondent raised concerns around the risk with counterparties and legal risks that may be involved in this type of trading – these concerns must relate mainly to OTC trades as the exchange trades are generally considered to be safe from a credit perspective.

All respondents felt that the securities lending pool is adequate to cater for their volatility arbitrage trading processes, and the strategy is only applied to liquid shares, which implies that they should be in a position to trade in and out of their positions as and when they need to do so.

Figure 4.24 Risks in volatility arbitrage
What is of interest is that only one of the respondents considered the currency risk to be significant in their statistical trading process, which implies that the majority (66%) of the institutions are not trading volatility arbitrage between the local and international exchanges.

4.4.6 Arbitrage Risk Processes

All respondents indicated that the arbitrage operations risk limits roll up into the normal equity and equity derivative risk limits. This is as a result of the fact that the positions are traded onto the standard equity and equity derivative trading systems and hence the market risk process looks at the overall risk of the equity positions.

Eleven (58%) of the 19 respondents felt that the arbitrage risks should be viewed independently from the other risk limits applied to the equity desk due to the fact that the traders would often place extremely large yet riskless positions on the books which then impacts the notional limits of other trades that the desk as a whole may enter into.

4.4.6.1 Trading Costs

Eleven of the respondents indicated that each trade cost them about R60, the remaining eight respondents traded at levels below this cost with the one respondent only being charged about R15 per trade. UST is a taxation cost and therefore all respondents who are not brokers would pay a quarter of a percent of the value of the trade for each instance where they purchased shares. Where the respondent is a stockbroker, they are exempt from this cost given recent changes to the UST legislation.

The respondents all indicated that the securities lending costs were not fixed at any one level, and the lending rate was dependent on the share and its availability. Twelve of the respondents indicated that an average lending rate of about 1% per annum was appropriate for the ALSI Top 40 shares. The remaining respondents indicated that their lending costs varied between 0.6% and 1%.

The futures trading costs on SAFEX ranged between one basis point and five basis points. Three respondents indicated that the SAFEX costs were about five basis points per trade; one was of the opinion that it was about four basis points per trade;
seven indicated that they pay about two basis points; and three indicated that they pay one basis point per trade. Practically this translates to about three rand a trade on SAFEX.

The fact that the respondents have differing values for the cost drivers indicates that certain participants have a cost leadership advantage in arbitrage trading. The research therefore holds the opinion that these institutions with lower cost structures, should trade a greater number of trades and also generate greater profitability than the institutions who do not have these cost advantage.

4.4.6.2 PROCESSES ADOPTED IN MEASURING RISK

Twelve of the respondents that trade equity arbitrage and which completed the questionnaire indicated that their equity market risk limits are managed by the general market risk function in the organisation. The type of business also plays a part in this answer, as those respondents that are more involved in investment management indicated that their position risk is not picked up by the general market risk functions. This seems to be because the investment managers generally follow a buy and hold strategy.

4.4.6.3 LIMITS AND SENSITIVITY

The respondents were not forthcoming with regards to the limits and sensitivities that are implemented in their companies. This is logical as this information may be put to tactical use in terms of squeezing participants where they are known to hold a certain position.

With this in mind the research does not intend to delve into the mechanisms used to create limits for trading books as this function will be performed in different manner in different institutions given their risk appetites and capital available within the institution.

Eleven of the respondents were of the opinion that the market risk function should view the arbitrage risks separately, which would imply that they would prefer to view arbitrage trading through a separate limit process.
4.4.6.4 **PARTIAL DIFFERENTIAL HEDGE (PDH)**

The use of PDHs was limited to the banks and stockbrokers who responded to the questionnaire and which traded derivative instruments in their arbitrage strategies. These institutions used this measure to determine what the relevant risks are in each of the risk buckets that are defined by time periods. The use of the PDH measure was extended to delta and vega.

4.4.6.5 **GREEKS**

Of the sample that completed the questionnaire and which traded equity arbitrage, 16 respondents have the ability to calculate the delta of the position. 15 of these 16 indicated that they use the delta to manage their arbitrage books.

Fourteen of the respondents indicated that they have the ability to measure the vega, theta, gamma and rho associated with their positions, but only eleven said they have experienced the need to manage their books using Vega and Rho. Twelve respondents said they use gamma in managing their books. The fact that 14 respondents have the ability to calculate and use the vega measure in their business processes does imply that they can extend their hedging processes to include options on the underlying and indexes when trading arbitrage. The fact that eleven respondents are currently using this measure implies that they already have the processes working in their environment and that the extension of options to their arbitrage processes should be relatively simple and it is a business decision to enter this market.

As shown in the analysis of the various arbitrage types discussed above, the different arbitrage types, require different techniques to measure and manage the risks associated with the positions. The respondents mainly rely on the Greeks to measure the risks associated with statistical arbitrage using options and futures. However, it should be noted that there is some interest rate risk associated with the pure arbitrage positions, as if the interest rate is incorrect then the theoretical or fair value and the Rho is incorrect.
4.4.6.6 **Profit Control Processes**

From the individual analysis of the various arbitrage types described above, it is obvious that there is no clearly defined method through which the traders are measured against all trade opportunities that may have presented themselves in the market. Twelve of the respondents measured the traders’ performance against a budget which is agreed to at the start of each financial period.

Where the respondents were asset managers the method employed was to measure the performance of the trades against the benchmark that they use to measure the performance of their portfolio’s. Two companies used alternative methods, which were also the equivalent of monetary performance measures and two companies did not complete this question.

4.4.6.7 **Setting Benchmarks and Managing Traders**

The respondents employ between one and three traders to take ownership of the equity arbitrage business type, with 14 of the respondents employing two traders. Figure 4.25 below reflects the breakdown of the number of equity arbitrage traders per respondent that indicated they were trading equity arbitrage. The average trader would earn in excess of R600,000 annually, according to nine of the respondents that did not feel this information was too sensitive. Two of the respondents indicated that the traders would earn between R400,000 and R550,000 excluding bonuses.

**Figure 4.25 Number of equity arbitrage traders employed per firm**
Thirteen (68%) respondents who were of the opinion that the traders should also focus on other trading activities in addition to equity arbitrage trading. This is due to the fact that the arbitrage trades do not present themselves continually, or to phrase this in a different manner, there is not enough volume to justify only letting the traders focus on equity arbitrage trading. There is no clear sector split between the six respondents that are of the opinion that the traders should only focus on arbitrage and those that felt that the traders should focus on other related trading matters. Where respondents prefer the traders to focus only on arbitrage trades, this is due to the specialised and time consuming nature of the arbitrage operations.

In general equity arbitrage is housed in the equity derivative area in 13 of the 19 cases where the respondents trade equity and equity derivative arbitrage. In the six cases where the trading was not housed in the equity derivative area, these structures are housed in an area that focused only on arbitrage, be it a hedge fund or a separate trading desk.

### 4.4.6.8 Simulations and Monte Carlo Profit Maximising

Only twelve (63%) of the 19 respondents that trade equity arbitrage have the ability to simulate the profitability through historical scenarios and only six use Monte Carlo analysis to forecast and attempt to achieve maximum profitability of the arbitrage trading opportunities in the future.

The view held by the research is that for effective statistical arbitrage trading to take place, an approach should be available to maximise the profitability in the future. This requirement only becomes necessary where the respondents trade statistical and volatility arbitrage, as there is no need for these predictors where pure arbitrage is concerned.

### 4.4.6.9 Measuring Profitability

The feedback that was received from the respondents indicates that the measurement of profitability is performed in an appropriate manner from the perspective of the traders who completed the research questionnaire. There is only one instance where the trader was of the opinion that the index and SSF arbitrage is not performing as well as it was expected to perform.
Of further interest is that a formal approach is not used to determine the expected profitability given the historical performance of the trades prior to setting up an arbitrage trading desk.

In terms of the measurement of profitability different approaches are applied. The generalisations that can be gleamed from the responses are that where asset managers are involved the measurement techniques are based on benchmark performance, while in the treasury and stock broking environments trading performance is set against budgets for each arbitrage type.

4.5 RESULTS OF TIME SERIES ANALYSIS

This section reviews each of the arbitrage types and strategies that have been discussed throughout the previous chapters in the context of a time series analysis. The method employed is to discuss each of the arbitrage strategies individually with the emphasis being on the number of trades traded, the transaction costs incurred and the profitability of the strategy over time.

A statistical analysis and profitability of arbitrage types is presented, as well as an analysis of findings relating to index and single stock futures.

4.5.1 STATISTICAL ANALYSIS AND PROFITABILITY OF ARBITRAGE TYPES

The empirical research concluded amongst equity arbitrage trading entities was used to determine what the realistic cost drivers and stop loss levels are that should be applied in the time series analysis. Therefore the findings with regard to actual costs and stop loss levels were used as inputs to determine the profitability of the different arbitrage types in the time series analysis.

4.5.2 ANALYSIS OF FINDINGS RELATING TO INDEX AND SINGLE STOCK FUTURES

4.5.2.1 GENERAL

The analysis of the arbitrage opportunities within the time series context showed that both SSF and Index futures arbitrage opportunities were present in the market for the respective periods under review. The research was based on actual traded levels as
provided by the JSE and SAFEX. In the case of SSF, the liquidity was visible in both futures and the underlying, whereas in the case of index futures the liquidity in the future was visible while the liquidity in the underlying shares was assumed due to the varying nature of the index constituents and the large number of trades that need to be traded in each index trade that is simulated.

Where the calculated profitability of any given trade after transaction costs was calculated to be less than R100, the trade was excluded from the results as the effort and risks involved in putting these trades on the books and managing the trades until the point where the prices converge or the contracts mature, would in reality not justify the amount of effort involved in terms of the returns generated.

For index arbitrage it was assumed that only ten contracts would be purchased in any one trade on any given day where a price mismatch was identified. This fact is not considered to be a limitation as the intention is to define the process and not to scale the transaction to the extent where even the smallest differences in pricing can be traded to reflect a profit. This comment is considered to be prudent as the actual liquidity in the futures, the underlying shares and the lending pool is finite, so the scale on which the trades can be performed is constrained by these factors.

The research does not, however, suggest that it is not possible to trade more than ten contracts at a time, but in practice where liquidity permits and the future value allows for arbitrage, greater volumes are encouraged.

### 4.5.2.2 Number of Trades

There were over 49,000 SSF trades included in this research as a result of the fact that trades occurred in both the SSF on the SAFEX and the underlying shares on the JSE within half an hour of one another. Where this event occurred the number of days to maturity, the bootstrapped risk free interest rate and the dividend yield was applied to the spot price, in accordance with the futures pricing formula, to determine the implied futures price. The implied futures price was deducted from the actual futures prices to determine whether arbitrage opportunities were present.

The research indicates that during the period under review and given the assumptions and methodology applied, there were 1,155 profitable SSF trade opportunities before transaction costs factored into the calculations. After taking into
account all transaction costs but excluding securities lending costs, there were 737 profitable trades.

The total number of profitable transactions after all transaction costs, securities lending cost and cost of capital were taken into account, were 699. This implies that about 60% of all mispriced SSFs can be capitalised upon, after taking into account the transaction costs, securities lending costs and the cost of capital employed. Where the mispricing is observed the cost of completing the transaction can be calculated prior to entering into the trade and therefore if the mispricing is not large enough to be profitable, then the strategy will not be executed. Of the 699 profitable trades, 609 incurred securities lending costs, which had a negative effect on the profitability of the strategy. The findings described above are reflected in Table 4.4 and Figure 4.26 below.

Table 4-4 Number of profitable trades identified in the SSF market for the period January 2001 to December 2002

<table>
<thead>
<tr>
<th>Month and year</th>
<th>Profitable trades before costs</th>
<th>Profitable trades after costs</th>
<th>Transactions which incur securities lending costs</th>
<th>Number of profitable trades after all costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>January-01</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>February-01</td>
<td>9</td>
<td>3</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>March-01</td>
<td>18</td>
<td>12</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>April-01</td>
<td>16</td>
<td>9</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>May-01</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>June-01</td>
<td>5</td>
<td>5</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>July-01</td>
<td>14</td>
<td>13</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>August-01</td>
<td>19</td>
<td>11</td>
<td>10</td>
<td>11</td>
</tr>
<tr>
<td>September-01</td>
<td>36</td>
<td>25</td>
<td>6</td>
<td>26</td>
</tr>
<tr>
<td>October-01</td>
<td>18</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>November-01</td>
<td>24</td>
<td>14</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>December-01</td>
<td>9</td>
<td>4</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>January-02</td>
<td>36</td>
<td>21</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>February-02</td>
<td>56</td>
<td>12</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>March-02</td>
<td>95</td>
<td>35</td>
<td>26</td>
<td>31</td>
</tr>
<tr>
<td>April-02</td>
<td>112</td>
<td>98</td>
<td>93</td>
<td>96</td>
</tr>
<tr>
<td>May-02</td>
<td>82</td>
<td>69</td>
<td>61</td>
<td>66</td>
</tr>
<tr>
<td>June-02</td>
<td>93</td>
<td>19</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>July-02</td>
<td>229</td>
<td>222</td>
<td>213</td>
<td>213</td>
</tr>
<tr>
<td>August-02</td>
<td>58</td>
<td>24</td>
<td>14</td>
<td>24</td>
</tr>
<tr>
<td>September-02</td>
<td>60</td>
<td>28</td>
<td>14</td>
<td>23</td>
</tr>
<tr>
<td>October-02</td>
<td>55</td>
<td>21</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>November-02</td>
<td>33</td>
<td>33</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td>December-02</td>
<td>70</td>
<td>37</td>
<td>19</td>
<td>36</td>
</tr>
</tbody>
</table>

**Total:** 1,155 | 737 | 609 | 699
The results are portrayed on a monthly basis and as can be seen there is no clear indication that the market is getting more efficient as time progresses, and there is no definitive number of SSF arbitrage opportunities that present themselves in any period.

**Figure 4.26 Profitable trades and the effects of trading costs, capital costs and securities lending costs on the SSF trades**

The average numbers of profitable SSFs traded during the period under review are 30 profitable trades per month. When looking at the change in volume traded between 2001 and 2002 the average volumes increased but the exact magnitude differs depending on the base month that is used for the calculation. However, the results show that the there were 110 mispriced SSFs, in 2001 and there were 589 such events in 2002.

The analysis of the ALSI Top 40 index arbitrage spanned the period from 4 January 2000 up to and including 31 December 2003. These pricing details were obtained from Bloomberg’s last trade data and this data was used as the basis for determining index arbitrage opportunities. The first contract which allowed a full years worth of analysis was the March 01 contract. The results reflect only trades on the futures that are 1 year or less from maturity, due to the fact that the research wishes to avoid cases where the dividend forecasts become questionable and also because the liquidity and method used to reflect the closing price when no trades have occurred.
may result in the SAFEX pricing reflecting opportunities that do not exist. This is one of the reasons why the number of trades tapers off as the research approaches the March, June, September and December 04 contracts, as the rolling effect of the time analysis ends on the December 2004 contract.

The research shows that there were 1,737 trades, which met the profitability requirements during this time and the contracts involved in the trading included those reflected in Table 4.5 below.

**Table 4-5 ALSI Top 40 index arbitrage trades reflected at a contract level for the period under review**

<table>
<thead>
<tr>
<th>Futures Close Date</th>
<th>Future Settlement Date</th>
<th>Number of trades</th>
</tr>
</thead>
<tbody>
<tr>
<td>H1</td>
<td>15-Mar-01</td>
<td>150.00</td>
</tr>
<tr>
<td>M1</td>
<td>21-Jun-01</td>
<td>72.00</td>
</tr>
<tr>
<td>U1</td>
<td>20-Sep-01</td>
<td>96.00</td>
</tr>
<tr>
<td>Z1</td>
<td>20-Dec-01</td>
<td>98.00</td>
</tr>
<tr>
<td>H2</td>
<td>21-Mar-02</td>
<td>161.00</td>
</tr>
<tr>
<td>M2</td>
<td>20-Jun-02</td>
<td>110.00</td>
</tr>
<tr>
<td>U2</td>
<td>19-Sep-02</td>
<td>83.00</td>
</tr>
<tr>
<td>Z2</td>
<td>19-Dec-02</td>
<td>139.00</td>
</tr>
<tr>
<td>H3</td>
<td>20-Mar-03</td>
<td>163.00</td>
</tr>
<tr>
<td>M3</td>
<td>19-Jun-03</td>
<td>145.00</td>
</tr>
<tr>
<td>U3</td>
<td>18-Sep-03</td>
<td>165.00</td>
</tr>
<tr>
<td>Z3</td>
<td>18-Dec-03</td>
<td>125.00</td>
</tr>
<tr>
<td>H4</td>
<td>18-Mar-04</td>
<td>123.00</td>
</tr>
<tr>
<td>M4</td>
<td>17-Jun-04</td>
<td>73.00</td>
</tr>
<tr>
<td>U4</td>
<td>16-Sep-04</td>
<td>28.00</td>
</tr>
<tr>
<td>Z4</td>
<td>18-Dec-04</td>
<td>6.00</td>
</tr>
</tbody>
</table>

The data in Table 4.5 above shows that the number of trade opportunities is relatively consistent per future analysed with and average number of trade opportunities per future being about 126. This average was calculated after excluding the 2004 contracts due to the fact that the data was only analysed up to the end of 2003 and therefore inclusion of these contracts would create an inaccurate reflection of the average Index arbitrage opportunities which presented themselves for each contract.

The range of trade opportunities that were observed was 72 to 165 trades for the June 01 and September 03 contracts respectively. Figure 4.27 below reflects this trade information in the form of a frequency distribution.
The profitable index arbitrage trades on the 2001 contracts showed 416 profitable trading opportunities, 2002 contracts showed 493 profitable trading opportunities while the 2003 contracts showed 598 profitable trading opportunities. These increases show that there is an average increase of profitable index arbitrage of about 20% during the period under review.

**Figure 4.27 Frequency distribution of the number of trades entered into given the research assumptions**

![Bar chart showing the frequency distribution of trades.](image)

### 4.5.2.3 Volume Traded

The average volume traded using the methodology applied to SSFs whereby only traded volumes at each mismatch level could be traded, is 31 contracts per trade.

The assumptions were different for arbitrage trading on the ALSI Top 40 Index and these volumes were set to only ten contracts per futures price mismatch per day. This assumption is considered to be restrictive, as the liquidity should in actual trading circumstances allow for more contracts to be traded.

### 4.5.2.4 Transaction Costs

The transaction costs incurred in the ALSI Top 40 Index arbitrage trades over the entire period is R 15,876,124. This value includes trading costs relating to the
brokerage, JSE, STRATE, SAFEX and UST. It does not include securities lending costs.

Where index arbitrage is traded, the assumption is made that the whole order will be filled with one trade in each of the underlying shares that make up the ALSI Top 40 and also that one trade will buy the volume required in the future. There will be cases where more than one trade is concluded to fill the order, so this may not always be a realistic assumption. However, as the exact number of trades (or hits) that will be required to fill each of the required orders is not directly visible for the purposes of this analysis this assumption will need to be made.

The average cost that was applied to the calculations was taken as the average of the transaction costs from the research findings in section 4.4.6.1. and was set at R60 per trade. It should be obvious that the less the transaction costs, the more profitable the trading strategy will be and the more arbitrage trades that the company can trade.

The empirical research showed that the transaction costs incurred differed substantially between the various respondents that traded arbitrage, and where large volumes of trades are required such as in the case of index arbitrage these economies become vital in the profitability matrix, as mentioned in section 4.4.6.1.

While company structures differ, the brokers should receive a marginal benefit, which will equate to the 0.25% being the UST costs, as the legislation now allows for the brokers not to be charged this cost. This benefit will aid the brokers in being more competitive in the index arbitrage process environment.

The securities lending costs that were incurred in the index arbitrage trades identified amounted to roughly R907,000. This is another case where the costs that the institutions incur for this lending service varies between institutions, as reflected in the empirical research, and therefore a institutions ability to compete is affected by this cost driver. Section 4.4.6.1 of this chapter provided the respondents’ views that the average securities lending cost is set at about 1% per annum on the consideration being borrowed. Therefore, the time series testing uses 1% for its securities lending calculation purposes.
4.5.2.5 PROFITABILITY

SSFs showed profits of R1,833,191 before costs and after deducting the SAFEX, JSE, UST costs, the profitability is reduced by R461,923 to R1,371,510. After the cost of capital was considered, the profitability was reduced by a further R1,205. Securities lending costs reduces the profitability by yet a further R150,094. The profitability after all costs over the period was R1,220,211, or an average profitability of R1,746 per trade. The findings proved that where the prices on the instruments converge prior to the contract’s maturity it is beneficial to close out the positions as this resulted in a saving due to a reduction in the capital costs. This information is reflected in Table 4-6 below.

Table 4-6 Average and actual profitability of SSFs over the period January 2000 to December 2002

<table>
<thead>
<tr>
<th>Month and year</th>
<th>Number of profitable trade after all costs</th>
<th>Net Profit after all transaction costs and cost of capital</th>
<th>Average profitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>January-01</td>
<td>4</td>
<td>1,001.06</td>
<td>250.27</td>
</tr>
<tr>
<td>February-01</td>
<td>3</td>
<td>977.04</td>
<td>325.68</td>
</tr>
<tr>
<td>March-01</td>
<td>11</td>
<td>1,758.59</td>
<td>159.87</td>
</tr>
<tr>
<td>April-01</td>
<td>9</td>
<td>11,407.55</td>
<td>1,267.51</td>
</tr>
<tr>
<td>May-01</td>
<td>3</td>
<td>2,972.13</td>
<td>990.71</td>
</tr>
<tr>
<td>June-01</td>
<td>3</td>
<td>4,334.04</td>
<td>1,444.68</td>
</tr>
<tr>
<td>July-01</td>
<td>10</td>
<td>4,717.89</td>
<td>471.79</td>
</tr>
<tr>
<td>August-01</td>
<td>11</td>
<td>3,970.15</td>
<td>360.92</td>
</tr>
<tr>
<td>September-01</td>
<td>26</td>
<td>34,127.10</td>
<td>1,312.58</td>
</tr>
<tr>
<td>October-01</td>
<td>15</td>
<td>19,260.18</td>
<td>1,284.01</td>
</tr>
<tr>
<td>November-01</td>
<td>11</td>
<td>5,245.13</td>
<td>476.83</td>
</tr>
<tr>
<td>December-01</td>
<td>4</td>
<td>5,154.00</td>
<td>1,288.50</td>
</tr>
<tr>
<td>January-02</td>
<td>20</td>
<td>15,091.32</td>
<td>754.57</td>
</tr>
<tr>
<td>February-02</td>
<td>9</td>
<td>910.74</td>
<td>101.19</td>
</tr>
<tr>
<td>March-02</td>
<td>31</td>
<td>32,548.79</td>
<td>1,049.96</td>
</tr>
<tr>
<td>April-02</td>
<td>96</td>
<td>112,202.43</td>
<td>1,168.78</td>
</tr>
<tr>
<td>May-02</td>
<td>66</td>
<td>70,308.49</td>
<td>1,065.28</td>
</tr>
<tr>
<td>June-02</td>
<td>18</td>
<td>40,060.50</td>
<td>2,225.58</td>
</tr>
<tr>
<td>July-02</td>
<td>213</td>
<td>242,105.07</td>
<td>1,136.64</td>
</tr>
<tr>
<td>August-02</td>
<td>24</td>
<td>86,027.62</td>
<td>3,584.48</td>
</tr>
<tr>
<td>September-02</td>
<td>23</td>
<td>26,917.81</td>
<td>1,170.34</td>
</tr>
<tr>
<td>October-02</td>
<td>20</td>
<td>12,624.96</td>
<td>631.25</td>
</tr>
<tr>
<td>November-02</td>
<td>33</td>
<td>364,885.34</td>
<td>11,057.13</td>
</tr>
<tr>
<td>December-02</td>
<td>36</td>
<td>121,603.57</td>
<td>3,377.88</td>
</tr>
</tbody>
</table>

699 1,220,211.49 1,745.65
Figure 4.28 Actual profitability distribution of SSFs over the period January 2000 to December 2002

Figure 4.28 above shows the actual profitability of the single stock futures. The distribution shows that the July 02, November 02, and December 02 months were particularly profitable for this trading strategy.

Figure 4.29 Average profitability of SSFs on a monthly basis
Figure 4.29 above shows the average profitability of the SSFs during the two year period on a monthly basis. The figure indicates that the average profitability per trade has increased over time. The figure also shows that the average profitability per trade changes on a monthly basis and this average profitability ranged from about R100 per trade to R11,000 rand per trade. With the obvious exception of the November 2002 month the average profitability per trade is R1,700. This average profitability varies considerably from month to month as is evidenced by the figures above.

The Index arbitrage analysis reflects that the trading strategy is lucrative, but that the costs involved in generating these profits can be substantial. Table 4.7 and Figure 4.30 below depicts the profitability of index arbitrage trades that were generated on each of the futures contracts that were traded during the period under review. The net profitability of the strategy over the period is shown to be R 11,282 million rand, with the average profitability being about R 6,500 per trade.

Table 4-7 Profitability and average profitability of Index arbitrage for each of the futures contracts over the period January 2000 to December 2003

<table>
<thead>
<tr>
<th>Future Settlement Date</th>
<th>Profitability of trades</th>
<th>Average profitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-Mar-01</td>
<td>476,444.91</td>
<td>3,176.30</td>
</tr>
<tr>
<td>21-Jun-01</td>
<td>337,105.60</td>
<td>4,682.02</td>
</tr>
<tr>
<td>20-Sep-01</td>
<td>336,085.02</td>
<td>3,500.89</td>
</tr>
<tr>
<td>20-Dec-01</td>
<td>285,060.13</td>
<td>2,908.78</td>
</tr>
<tr>
<td>21-Mar-02</td>
<td>838,316.29</td>
<td>5,206.93</td>
</tr>
<tr>
<td>20-Jun-02</td>
<td>942,981.14</td>
<td>8,572.56</td>
</tr>
<tr>
<td>19-Sep-02</td>
<td>1,056,393.33</td>
<td>12,727.63</td>
</tr>
<tr>
<td>19-Dec-02</td>
<td>2,189,003.34</td>
<td>15,748.23</td>
</tr>
<tr>
<td>20-Mar-03</td>
<td>1,257,681.24</td>
<td>7,715.84</td>
</tr>
<tr>
<td>19-Jun-03</td>
<td>607,318.18</td>
<td>4,188.40</td>
</tr>
<tr>
<td>18-Sep-03</td>
<td>1,124,435.15</td>
<td>6,814.76</td>
</tr>
<tr>
<td>18-Dec-03</td>
<td>533,504.09</td>
<td>4,268.03</td>
</tr>
<tr>
<td>18-Mar-04</td>
<td>878,374.82</td>
<td>7,141.26</td>
</tr>
<tr>
<td>17-Jun-04</td>
<td>230,380.67</td>
<td>3,155.90</td>
</tr>
<tr>
<td>16-Sep-04</td>
<td>117,772.04</td>
<td>4,206.14</td>
</tr>
<tr>
<td>18-Dec-04</td>
<td>71,768.73</td>
<td>11,961.46</td>
</tr>
</tbody>
</table>

|                   | 11,282,624.66          | 6,495.47              |
Figure 4.30 Frequency distribution of the profitability of the index arbitrage trades for the period January 2000 to December 2003

4.5.2.6 CONCLUSIONS REGARDING SSF’S ARBITRAGE AND INDEX ARBITRAGE

The results that are depicted in this research show that Index and SSFs arbitrage are lucrative trading strategies even when considering the costs of trading these strategies. The results show that, even using the stringent assumptions applied to reduce the negative effects of non-simultaneous data whereby the trades need to be effected in the underlying and the future in a minimum period of time as discussed in section 2.2.2.1, these arbitrage strategies generate positive returns over time.

The research does not indicate that there is a reduction in profitability of the trading strategy over time, but the view held by the research is that as more participants enter the market the actual revenue generated by each participant may come under pressure due to limited liquidity and the finite nature securities lending pool.

Where Index arbitrage is analysed, the research takes measures to avoid problems around non-simultaneous data, as discussed in section 2.2.2.1, and accounts for the effects of transaction costs, securities lending costs and taxes as discussed in section 4.4.6.1.

The view held by the research is that the simple nature of these trades allows for the automation of the process such that no human intervention is required. It is the expectation that the next level of development in this field of arbitrage in the South
African environment will involve the development of more sophisticated systems which will be able to transact these trades without human intervention. As mentioned this type of pure arbitrage does not require human input and it could be argued that the human component may be a liability in this regard as the applications act in the exact manner described by their code and will not miss trade opportunities.

4.5.3 ANALYSIS OF FINDINGS RELATING TO RISK OR MERGER ARBITRAGE

4.5.3.1 GENERAL COMMENTS

The analysis into the risk arbitrage processes that was adopted in this research was covered in Chapter 2 and 3. The period under review started in May 2001 and ended in February 2004, with corporate events which relate to cash or stock offers on local companies included in the ALSI Top 40 forming part of this research.

Where odd lot offers are announced these are excluded from the research as the potential profitability to the individual investor is limited to the single odd lot which they may own. Mergers and acquisitions which occurred outside of the South African borders were excluded from the research, as most institutions do not have the ability to trade the offshore leg, as discussed under the dual listed empirical research leg.

Private companies were also excluded from the analysis as when these were the target for the acquisition the net economic effect could not be determined within the market as there was no published or traded share price against which to gauge the effects of the takeover.

4.5.3.2 NUMBER OF TRADES

The number of trades that could be included in this research was governed by the actual number of corporate events that took place over the ALSI Top 40 for the period under review. The trades, which were included in this research, were those corporate events, which resulted in the majority of shares in one company being transferred to the acquiring company. These transactions were usually performed by providing cash for the shares being acquired or through the issue of shares to the shareholders of the company being acquired.
There were 167 mergers, acquisitions and cash stock offers during the research period. Figure 4.31 below reflects the types of corporate events that formed part of the SENS announcements provided by the JSE. One was a preference share issue, while 64 were classified as private sales of companies, or open market purchases of shares by the acquiring company – these were therefore excluded. Three transactions which could have been analysed were still pending at the end of February 2004 and these results could therefore not be reported upon. There are 65 transactions done offshore and therefore these fall outside the scope of the research. There were therefore 34 mergers and acquisitions left for analysis within the sample period and ALSI Top 40 sample group. Of these 34 transactions, five transactions resulted in negative returns while 29 (85.3%) resulted in positive returns.

Figure 4.31 Corporate events in the risk arbitrage sample of the ALSI Top 40

4.5.3.3 VOLUME TRADED

In order to quantify the effects of the arbitrage strategy, this research assumed that when the takeover is announced, then 10,000 shares of the company being acquired will be purchased. It is also assumed that this volume will be purchased at a price equal to the closing price on the day that the announcement is made. This assumption is restrictive in a sense, as the prices would tend to move in the direction of the premium or discount being offered during the days trading. Therefore the closing price may not be the most optimum level at which the trades could have been concluded during the trading day. However the research does consider this to be a conservative method and this approach is therefore adopted.
While the mispricing of the shares often continued for days and sometimes weeks after the announcement was made, the research did not assume that additional positions would be taken during any period other than the day of the announcement. The research also did not allow for the positions to be closed out at any time prior to the deal closure or termination date.

The combination of the above two factors have a negative effect on the total profitability that could be generated by this trading strategy, but this process does lend itself well to the creation of a control environment where the variables and trading methodologies are kept to a minimum. In practice, a more flexible method should be applied such that profits may be enhanced further.

**4.5.3.4 TRANSACTION COSTS**

The transaction costs that are applied to the transactions entered into were discussed in section 3.5.1.7 and section 4.4.6.1 and all costs ranging from JSE trading costs to UST and lending costs were included in the study. The actual costs applied were again the averages from the empirical studies discussed in section 4.4.6.1 and amounted to R60 per trade, 0.25% for UST and 1% for securities lending.

Table 4.8. below, shows that transaction costs amounted to about R4,080, while the largest cost driver was the UST component in these trades as this amounted to about R68,785. Securities lending costs were only incurred in cases where the takeover or issue was being transacted at a discount and therefore the share would need to be sold short at the announcement date and then purchased after the last day to register. This cost amounted to R1,129. The total transaction costs that were incurred in this trading strategy amounted to R73,994.
Table 4-8 Analysis of costs incurred in risk arbitrage

<table>
<thead>
<tr>
<th>Cost Type</th>
<th>Cost incurred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction Costs</td>
<td>4,080.00</td>
</tr>
<tr>
<td>UST</td>
<td>68,785.32</td>
</tr>
<tr>
<td>Securities Lending Costs</td>
<td>1,129.32</td>
</tr>
<tr>
<td>Total Cost Incurred</td>
<td>73,994.63</td>
</tr>
</tbody>
</table>

4.5.3.5 PROFITABILITY

Given the assumptions made in terms of the volumes traded for each of the risk arbitrage trades that presented themselves, the profitable trades generated R2,951,665 over the three year period. The loss making trades were limited to five trades as mentioned and a stop loss of 6% was applied in the calculations. This translates into total losses amounting to R4,200 for the period under review.

Figure 4.32 Percentage distribution of returns generated through Risk arbitrage for the period 2001 to 2004

Figure 4.32 above reflects the risk arbitrage profitability findings expressed as percentages before and after costs. The values are also converted into annualised returns for general information, but this is not the key measurement technique applied. The general profitability of the transactions entered into showed a return of 19,735% after costs and this figure when expressed on an annualised basis translates to 72,565%. In chapter 2 it was explained that it is best not to report on these results in the annualised form as the arbitrage trades cannot be repeated once the deals have been concluded.
The research therefore indicates that the general profitability of this trading strategy is at a level which justifies trading these opportunities and that risk arbitrage in South Africa does exist and is generally as profitable as the opportunities which present themselves in the international environment where this arbitrage type is traded actively as discussed in Chapter 2.

4.5.3.6 CONCLUSION REGARDING RISK ARBITRAGE

The risk arbitrage strategy is definitely lucrative and returns are of similar magnitudes as the returns found in similar research into risk arbitrage in the international markets. The fundamental driver of the profitability of this strategy is corporate activity and given the fact that more than 50% of the corporate activity that occurs in the ALSI Top 40 shares is performed offshore, it can be implied that profit maximisation will occur where institutions have the ability to trade in the local and international markets such that they can capitalise on the greater number of mergers, acquisitions and share issues that take place in the international markets.

Given the fact that only companies in the ALSI Top 40 were included in the research, the profitability of this strategy should be increased by adding the companies which undergo corporate activity but which are not included in the ALSI Top 40 index. This is due to the fact that the volumes of corporate activities, drive the profitability of this strategy as mentioned earlier.

In summary, this is an extremely simple and lucrative arbitrage type that lends itself to arbitrage and which can be traded with limited downside given a rigid adherence to a stop loss of 6% or below. The complexity in this strategy lies in the fact that it cannot be automated in a simple manner due to the non-standardised method used in SENS messages. This again implies that opportunities may be easily missed, and may partly explain why these opportunities remain visible in the market for the lengthy periods described in the empirical research leg of this chapter.
4.5.4 ANALYSIS OF FINDINGS RELATING TO DUAL LISTED ARBITRAGE

4.5.4.1 GENERAL COMMENTS

The dual listed arbitrage analysis follows the assumption that shares in the same company on different exchanges should trade at the same or similar price given the exchange rate conversion factor and the costs associated with trading any price differences. The trade opportunities are presented in cases where the SA bid is less than the UK offer or where the UK bid is greater than the South African offer price. The process also involves crossing the currency spread as Pounds are bought to purchase the shares and sold again when the shares are sold – this additional cost can be avoided where the pounds are kept offshore and need not be converted back to Rand. This decision will be a function of the institution view on the currency and for the purposes of the research it is assumed that the currency spreads will be crossed and that the money will be converted back to its original base currency.

The findings that are generated in this research pertain to the South African and London stock exchanges, but the logic can be extended to American Depository receipts and any other exchange be it in the US, Europe or Australia where companies have multiple listings.

One of the limitations of the research is clearly that the analysis only looks at the last share price traded on the exchange and applies currency conversion at the close of business of the respective day to these share prices.

4.5.4.2 NUMBER OF TRADES

The total number of trades is clearly a function of the number of dual listed shares and if the South African shares listed in the US, Australia and European Union exchanges were included in the research there would be a greater number of trades. However, for the nine dual listed shares which were included in this study the results discussed below presented themselves.

Table 4.9 below shows that over the period from 1 January 2000 until the 31 December 2003 there were 2,396 instances where dual listed arbitrage opportunities presented themselves.
The number of trades recorded for each of the respective years shows that on average about 600 trades could be entered into annually. The range of trading opportunities remained fairly constant and the monthly variance was less than 100 trades for the period under review.

**Table 4-9 Number of dual listed arbitrage trades identified in the research**

<table>
<thead>
<tr>
<th>Share Code</th>
<th>Total number of trades in sample</th>
<th>Trades in 2000</th>
<th>Trades in 2001</th>
<th>Trades in 2002</th>
<th>Trades in 2003</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGL</td>
<td>488</td>
<td>114</td>
<td>129</td>
<td>143</td>
<td>102</td>
<td>2,398</td>
</tr>
<tr>
<td>BIL</td>
<td>222</td>
<td>64</td>
<td>65</td>
<td>54</td>
<td>39</td>
<td>563</td>
</tr>
<tr>
<td>INP</td>
<td>66</td>
<td>50</td>
<td>18</td>
<td>-</td>
<td>-</td>
<td>188</td>
</tr>
<tr>
<td>LBT</td>
<td>375</td>
<td>58</td>
<td>58</td>
<td>121</td>
<td>138</td>
<td>592</td>
</tr>
<tr>
<td>LON</td>
<td>198</td>
<td>48</td>
<td>33</td>
<td>61</td>
<td>66</td>
<td>560</td>
</tr>
<tr>
<td>LAF</td>
<td>104</td>
<td>46</td>
<td>7</td>
<td>8</td>
<td>43</td>
<td>119</td>
</tr>
<tr>
<td>OML</td>
<td>314</td>
<td>110</td>
<td>84</td>
<td>64</td>
<td>56</td>
<td>563</td>
</tr>
<tr>
<td>SAB</td>
<td>68</td>
<td>22</td>
<td>12</td>
<td>27</td>
<td>7</td>
<td>119</td>
</tr>
<tr>
<td>DDT</td>
<td>563</td>
<td>100</td>
<td>188</td>
<td>156</td>
<td>119</td>
<td>634</td>
</tr>
</tbody>
</table>

Figure 4.33 below shows the same information in the form of a frequency distribution. This figure shows that over the period under review Dimension Data, Anglo American, Liberty and Old Mutual were the shares which were most likely to generate arbitrage trades.

**Figure 4.33 Distribution of the dual listed arbitrage trades over the sample period**
4.5.4.3 VOLUME TRADED

The assumption made in this section of the research is again that only 10,000 shares will be traded where a price discrepancy is identified. This is due to the fact that the actual bid/offer volumes are not available and therefore the research sets the available level at a volume, which this research assumes can be executed with relative ease.

The results should be a lot more impressive if every opportunity, which presented itself during any trading day of the research period, was visible in the research data in addition to the actual volume available. However, despite this limitation the research does show that these opportunities exist and can be traded in a profitable manner, which correlates with the empirical research findings earlier in this chapter. These showed that where market participants have the legal ability to trade dual listed arbitrage they did find the strategy to be profitable.

4.5.4.4 TRANSACTION COSTS

All LSE and JSE transaction costs, broker fees, taxes and lending costs were included in the research, and were in line with the market norms as identified in the empirical research leg of this study discussed in Section 3.5.1.7 and Section 4.4.6.1. Securities lending cost were set at 1% per annum, while UST was set at 0.25%, and the trading costs were set to R60 per trade.

The assumption was made that the orders would be filled in one trade, which implies that the total transaction cost that is incurred by the trades in the time series data is R287,760.

4.5.4.5 PROFITABILITY

The findings of the time series analysis into dual listed arbitrage are summarised in Table 4.10 and Figure 4.34 below. Each of the shares that were included in the sample are shown to have generated profits after taking into account transaction costs, taxes and securities lending costs. The average profitability per trade is about R5,700 after taking into account the costs mentioned above. The capital costs were calculated using the overnight rate as the positions are assumed to be closed out the following day as the prices converge. This cost should disappear when South Africa
moves to a T+3 settlement, which is aligned with the London settlement timeline. Currently South Africa uses a T+5 settlement process and therefore there is a slight capital cost as a result.

The total profitability of this strategy for all shares included in the study amounted to R13,680,808. The annual returns ranged between R2,5 million and R5,1 million, with the average being R3,42 million per annum. Table 4.10 also shows the results of the individual shares performance on an annual basis and Anglogold (AGL) is shown to have performed the best in this type of arbitrage trading. This fact is more obvious when looking at Figure 4.34, which depicts the profitability by share.

**Table 4-10 Annual profitability per share and the annual cumulative profitability of the trading strategy**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AGL</td>
<td>4,492,199</td>
<td>741,749</td>
<td>1,253,897</td>
<td>798,692</td>
<td>1,000,000</td>
</tr>
<tr>
<td>BIL</td>
<td>637,694</td>
<td>206,162</td>
<td>156,553</td>
<td>104,574</td>
<td>1,000,000</td>
</tr>
<tr>
<td>INP</td>
<td>620,303</td>
<td>514,028</td>
<td>106,274</td>
<td>-</td>
<td>1,000,000</td>
</tr>
<tr>
<td>LBT</td>
<td>1,915,551</td>
<td>139,211</td>
<td>183,837</td>
<td>811,831</td>
<td>1,000,000</td>
</tr>
<tr>
<td>LON</td>
<td>3,102,851</td>
<td>343,911</td>
<td>477,953</td>
<td>542,728</td>
<td>1,000,000</td>
</tr>
<tr>
<td>LAF</td>
<td>197,740</td>
<td>40,493</td>
<td>2,973</td>
<td>113,752</td>
<td>1,000,000</td>
</tr>
<tr>
<td>OML</td>
<td>453,418</td>
<td>40,522</td>
<td>27,785</td>
<td>67,429</td>
<td>59,556</td>
</tr>
<tr>
<td>SAB</td>
<td>360,829</td>
<td>186,702</td>
<td>105,681</td>
<td>93,606</td>
<td>4,892,320</td>
</tr>
<tr>
<td>DDT</td>
<td>1,900,224</td>
<td>112,389</td>
<td>47,294</td>
<td>473,361</td>
<td>2,526,346</td>
</tr>
<tr>
<td>Total</td>
<td>13,680,808</td>
<td>3,067,668</td>
<td>3,194,474</td>
<td>4,892,320</td>
<td>2,526,346</td>
</tr>
</tbody>
</table>

**Figure 4.34 Profitability distribution of the dual listed arbitrage trades over the sample period**
4.5.4.6 CONCLUSION REGARDING DUAL LISTED ARBITRAGE

The dual listed arbitrage strategy is traded by a limited number of institutions in the South African environment as discussed in Section 4.4.3.1, mainly due to the fact that exchange control restricts the residents of South Africa from trading these strategies. However, for the institutions that do have the legal ability to trade these strategies, it is shown that this type of mispricing happens frequently enough to justify this trading strategy, and more importantly the revenues that are generated through these trades can also justify this type of trading.

In confirmation of the empirical findings the time series analysis shows these trades to be very profitable, and the strategy is simple to automate. A further consideration is that these trades have limited downside as they are basically a form of pure arbitrage and the trade prices are shown to converge the following day in all the cases identified in the research. This implies that the capital employed in this strategy may be large, but the inward flow of cash will happen within days of the initial trade. Therefore the capital costs incurred will reflect the rate differential in the overnight rates of the relevant countries.

4.5.5 ANALYSIS OF FINDINGS RELATING TO STATISTICAL ARBITRAGE

4.5.5.1 GENERAL COMMENTS

This area of the research applies two fairly simple statistical models which have been published in recent years. The first is the model proposed by Reverre (2001), which is in essence a pairs trading strategy, while the second is an index arbitrage trading strategy proposed by Meissner (2002). The details of these strategies were covered in Chapter 2, section 2.4.1 and section 2.4.6 respectively.

The Reverre (2001) Method

The findings showed that only eight cases of average correlations above 60% were encountered for the four-year period from January 2000 to December 2003 for the ALSI Top 40 shares. The research used the correlation for the full period to identify the shares that met the correlation requirements. This was done to allow the sample to remain constant over the sample period. In the event that shorter periods were
used, the pairs reflected in the sample would in some cases reflect results, which would skew the overall results due to the fact that their correlations refer to certain periods only. The shares that exhibited these correlation relationships are shown in Table 4.11 below. The research can also show that where the time period is shortened, the number of correlated shares and the degrees of correlation will increase dramatically.

Table 4-11 ALSI Top 40 shares with correlations greater that 60% for the period January 2000 to December 2003

<table>
<thead>
<tr>
<th>Share Pairs</th>
<th>Share Names</th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGL BIL</td>
<td>Anglo Gold vs Billiton</td>
<td>0.648035062</td>
</tr>
<tr>
<td>AMS IMP</td>
<td>Amplats vs Implats</td>
<td>0.629812672</td>
</tr>
<tr>
<td>CRH CRN</td>
<td>Coronation vs Coronation</td>
<td>0.763416789</td>
</tr>
<tr>
<td>DUR HAR</td>
<td>Durban Roodeport Deep vs Harmony</td>
<td>0.610932075</td>
</tr>
<tr>
<td>FSR RMH</td>
<td>First Rand Bank vs Rand Merchant Bank</td>
<td>0.754777916</td>
</tr>
<tr>
<td>GFI HAR</td>
<td>Goldfields vs Harmony</td>
<td>0.725735476</td>
</tr>
<tr>
<td>INL INP</td>
<td>Investec vs Investec</td>
<td>0.871172412</td>
</tr>
<tr>
<td>JNC MTN</td>
<td>Jonnic Holdings vs MTN</td>
<td>0.751930317</td>
</tr>
</tbody>
</table>

The interesting fact that becomes obvious from viewing these relationships is that in all cases where industrial shares are highly correlated, there is a relationship between the companies. The companies may for instance be sister companies or have substantial interests in one another, such as Coronation Capital vs Coronation Holding, First Rand Bank vs RMB, Invested Ltd vs Investec Plc, or Jonnic Holdings vs MTN. The second group that is identified are those which relate to the same industries and in this case almost all (except two) related to the mining industry and deal either in gold or platinum production, for example Anglo Gold vs Billiton, Amplats vs Implats, Durban Roodeport Deep vs Harmony and Goldfields vs Harmony.

The basis upon which the trading methodology proposed by Reverre (2001) was analysed, was to assume that 10,000 shares would be traded for each opportunity that presented itself over the period under review This number was set at this relatively low level, so that liquidity constraints would not create a problem on any of the underlying instruments being analysed. The period that this analysis covered is 1 January 2000 up to December 2003. The analysis only looked at the relationship
between the underlying shares and applied Reverre (2001) method in the manner proposed in his work.

Meissner, Shegal and Toa’s Method (2002)

This method was discussed in Chapter 2, section 2.2.4.1 of this research and aims to establish whether global index arbitrage exists by using changes in the leading index to predict changes in the value of the lagging indices.

As the research focused on the ALSI Top 40, the statistical results of a multiple regression analysis where the US, Europe and Asia are the independent variables relative to the ASLI Top 40 as the dependent variable, are reflected in Table 4.12 below.

Table 4-12 Multiple regression of global indices to predict movement in the ALSI Top 40

<table>
<thead>
<tr>
<th>Index Range</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>European Average (FTSE 100, DAX, CAC)</td>
<td>3.17E-32</td>
</tr>
<tr>
<td>US - Dow Jones</td>
<td>1.49E-06</td>
</tr>
<tr>
<td>Asia Average (Nikkie, Hang Seng, AS 51)</td>
<td>1.34E-10</td>
</tr>
</tbody>
</table>

The p values were significant at a 95% level, and are reflected in Table 4.13 below.

Table 4-13 P-values reflecting statistical significance in the analysis of the behaviour of the ALSI Top 40 relative to the independent variables (being global index ranges)

<table>
<thead>
<tr>
<th>Index Range</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>European Average (FTSE 100, DAX, CAC)</td>
<td>3.17E-32</td>
</tr>
<tr>
<td>US - Dow Jones</td>
<td>1.49E-06</td>
</tr>
<tr>
<td>Asia Average (Nikkie, Hang Seng, AS 51)</td>
<td>1.34E-10</td>
</tr>
</tbody>
</table>

4.5.5.2 Number of Trades

The trade outcomes using the method proposed by Reverre (2001) are described in Table 4.14 below for each of the correlated pairs that were identified. The summary statistics that can be provided are that there were 3,044 trades executed using this
strategy over the four-year period. Of these trades 1,339 were profitable and 1,705 were unprofitable after taking into account the costs involved in trading, which means that about 44% of the trades entered into were profitable. Analysing the overvalued positions resulted in 711 being profitable, while 829 were unprofitable giving a profitability ratio of about 46%. The undervalued positions provided the following results: 628 trades were profitable, while 876 were unprofitable, giving a profitability ratio of about 42% after transaction costs.

Table 4-14 Trade details and profits using the Reverre (2001) method

<table>
<thead>
<tr>
<th>Correlated shares</th>
<th>Long positions</th>
<th>Short positions</th>
<th>Long positions</th>
<th>Short positions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>overvalued</td>
<td>overvalued</td>
<td>undervalued</td>
<td>undervalued</td>
</tr>
<tr>
<td>AGL BIL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit making</td>
<td>50</td>
<td>47</td>
<td>52</td>
<td>51</td>
</tr>
<tr>
<td>Loss making</td>
<td>68</td>
<td>71</td>
<td>65</td>
<td>66</td>
</tr>
<tr>
<td>% profitable trades</td>
<td>42%</td>
<td>40%</td>
<td>44%</td>
<td>44%</td>
</tr>
<tr>
<td>Most profitable trade</td>
<td>92,364.29</td>
<td>11,156.49</td>
<td>87,190.00</td>
<td>7,713.82</td>
</tr>
<tr>
<td>Least profitable trade</td>
<td>-78,999.59</td>
<td>-10,908.59</td>
<td>-114,560.00</td>
<td>-8,455.49</td>
</tr>
<tr>
<td>AMS IMP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit making</td>
<td>55</td>
<td>62</td>
<td>62</td>
<td>40</td>
</tr>
<tr>
<td>Loss making</td>
<td>63</td>
<td>56</td>
<td>52</td>
<td>74</td>
</tr>
<tr>
<td>% profitable trades</td>
<td>47%</td>
<td>53%</td>
<td>54%</td>
<td>35%</td>
</tr>
<tr>
<td>Most profitable trade</td>
<td>330,257.96</td>
<td>169,358.10</td>
<td>314,805.00</td>
<td>166,001.22</td>
</tr>
<tr>
<td>Least profitable trade</td>
<td>-312,243.29</td>
<td>-180,550.20</td>
<td>-283,867.50</td>
<td>-266,829.54</td>
</tr>
<tr>
<td>CRH CRN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit making</td>
<td>33</td>
<td>28</td>
<td>13</td>
<td>40</td>
</tr>
<tr>
<td>Loss making</td>
<td>28</td>
<td>33</td>
<td>48</td>
<td>21</td>
</tr>
<tr>
<td>% profitable trades</td>
<td>54%</td>
<td>46%</td>
<td>21%</td>
<td>66%</td>
</tr>
<tr>
<td>Most profitable trade</td>
<td>4,740.86</td>
<td>12,652.68</td>
<td>8,564.50</td>
<td>7,268.21</td>
</tr>
<tr>
<td>Least profitable trade</td>
<td>-5,876.38</td>
<td>-5,821.17</td>
<td>-5,606.25</td>
<td>-8,010.57</td>
</tr>
<tr>
<td>DUR HAR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit making</td>
<td>55</td>
<td>47</td>
<td>49</td>
<td>48</td>
</tr>
<tr>
<td>Loss making</td>
<td>60</td>
<td>68</td>
<td>73</td>
<td>74</td>
</tr>
<tr>
<td>% profitable trades</td>
<td>48%</td>
<td>41%</td>
<td>40%</td>
<td>39%</td>
</tr>
<tr>
<td>Most profitable trade</td>
<td>132,765.92</td>
<td>15,724.46</td>
<td>126,655.00</td>
<td>24,288.79</td>
</tr>
<tr>
<td>Least profitable trade</td>
<td>-100,646.47</td>
<td>-8,584.77</td>
<td>-205,990.00</td>
<td>-13,961.12</td>
</tr>
<tr>
<td>FSR RMH</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit making</td>
<td>56</td>
<td>37</td>
<td>55</td>
<td>33</td>
</tr>
<tr>
<td>Loss making</td>
<td>41</td>
<td>60</td>
<td>46</td>
<td>68</td>
</tr>
<tr>
<td>% profitable trades</td>
<td>58%</td>
<td>38%</td>
<td>54%</td>
<td>33%</td>
</tr>
<tr>
<td>Most profitable trade</td>
<td>5,779.58</td>
<td>3,142.86</td>
<td>7,598.75</td>
<td>58,741.26</td>
</tr>
<tr>
<td>Least profitable trade</td>
<td>-6,074.61</td>
<td>-2,304.50</td>
<td>-126,334.75</td>
<td>-2,777.19</td>
</tr>
<tr>
<td>GFI HAR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit making</td>
<td>45</td>
<td>56</td>
<td>47</td>
<td>53</td>
</tr>
<tr>
<td>Loss making</td>
<td>67</td>
<td>56</td>
<td>77</td>
<td>71</td>
</tr>
<tr>
<td>% profitable trades</td>
<td>40%</td>
<td>50%</td>
<td>38%</td>
<td>43%</td>
</tr>
<tr>
<td>Most profitable trade</td>
<td>201,805.25</td>
<td>78,716.52</td>
<td>138,230.00</td>
<td>76,596.22</td>
</tr>
<tr>
<td>Least profitable trade</td>
<td>-153,659.30</td>
<td>-129,303.68</td>
<td>-93,320.00</td>
<td>-109,988.05</td>
</tr>
<tr>
<td>INL INP</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit making</td>
<td>10</td>
<td>15</td>
<td>12</td>
<td>5</td>
</tr>
<tr>
<td>Loss making</td>
<td>12</td>
<td>7</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td>% profitable trades</td>
<td>45%</td>
<td>68%</td>
<td>67%</td>
<td>28%</td>
</tr>
<tr>
<td>Most profitable trade</td>
<td>70,880.48</td>
<td>50,535.81</td>
<td>76,527.50</td>
<td>42,787.59</td>
</tr>
<tr>
<td>Least profitable trade</td>
<td>-43,228.45</td>
<td>-83,170.00</td>
<td>-33,272.50</td>
<td>-32,165.47</td>
</tr>
<tr>
<td>JNC MTN</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profit making</td>
<td>61</td>
<td>54</td>
<td>44</td>
<td>46</td>
</tr>
<tr>
<td>Loss making</td>
<td>66</td>
<td>73</td>
<td>51</td>
<td>49</td>
</tr>
<tr>
<td>% profitable trades</td>
<td>48%</td>
<td>43%</td>
<td>46%</td>
<td>48%</td>
</tr>
<tr>
<td>Most profitable trade</td>
<td>23,373.86</td>
<td>4,426.22</td>
<td>16,322.50</td>
<td>5,195.08</td>
</tr>
<tr>
<td>Least profitable trade</td>
<td>-18,078.68</td>
<td>-5,590.83</td>
<td>-14,995.00</td>
<td>-4,119.52</td>
</tr>
</tbody>
</table>
The summary statistics of trades using the method outlined by Meissner et al (2002) are outlined in Table 4.15 and Table 4.16 below. Table 4.15 shows all cases where the leading index has a positive return greater than 0.5, 1, 1.5, 2, 2.5 and 3 while Table 4.16 shows all cases where the leading index reflected a negative return less than −0.5, -1, -1.5, -2, -2.5 and -3.

As the intention is to provide the best return in the South African market, the purpose was to identify which index or index basket acts as the best leading indicator. From Table 4.15 and Table 4.19 below, the Asian index group provides the best statistical result. The total number of profitable trades amounted to 170 and the trades resulting in losses amounted to 94 trades. Therefore the success rate using this strategy is about 64%.

Table 4-15 Matrix of trades where positive returns are expected in the lagging index given the positive movement in the leading index

<table>
<thead>
<tr>
<th>Leading market</th>
<th>South Africa</th>
<th>US</th>
<th>Europe</th>
<th>Asia</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of profitable trades</td>
<td>Number of loss trades</td>
<td>Number of profitable trades</td>
<td>Number of loss trades</td>
<td>Number of profitable trades</td>
</tr>
<tr>
<td>South Africa</td>
<td>68</td>
<td>50</td>
<td>61</td>
<td>57</td>
<td>55</td>
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<tr>
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<td>34</td>
<td>33</td>
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<tr>
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<td>55</td>
<td>59</td>
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<td>61</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>34</td>
<td>42</td>
<td>31</td>
<td>46</td>
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<td>8</td>
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<tr>
<td>Europe</td>
<td>55</td>
<td>41</td>
<td>57</td>
<td>39</td>
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<tr>
<td></td>
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<td>9</td>
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<tr>
<td></td>
<td>22</td>
<td>10</td>
<td>14</td>
<td>18</td>
<td>26</td>
</tr>
<tr>
<td>Asia</td>
<td>75</td>
<td>59</td>
<td>74</td>
<td>59</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>52</td>
<td>23</td>
<td>39</td>
<td>36</td>
<td>45</td>
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<td>3</td>
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<td>2</td>
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<td>3</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>-</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Table 4.16 below shows those trades where the leading indicator showed a negative return for the day, and the expectation is that the lagging indicator should do the same. Here, again, the Asian basket of indexes provided the greatest success rate in
predicting the ALSI Top 40. The total number of profitable trades is 187 and the loss making trades amount to 93 trades, giving an average success rate of about 66.7%

**Table 4-16 Matrix of trades where negative return on the lagging index is expected given the negative return on the leading index**

<table>
<thead>
<tr>
<th>Leading market</th>
<th>South Africa</th>
<th>US</th>
<th>Europe</th>
<th>Asia</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of profitable trades</td>
<td>Number of loss trades</td>
<td>Number of profitable trades</td>
<td>Number of loss trades</td>
<td>Number of profitable trades</td>
<td>Number of loss trades</td>
</tr>
<tr>
<td>51</td>
<td>60</td>
<td>61</td>
<td>50</td>
<td>74</td>
<td>37</td>
</tr>
<tr>
<td>57</td>
<td>40</td>
<td>56</td>
<td>40</td>
<td>57</td>
<td>39</td>
</tr>
<tr>
<td>26</td>
<td>18</td>
<td>26</td>
<td>18</td>
<td>32</td>
<td>12</td>
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<tr>
<td>10</td>
<td>9</td>
<td>11</td>
<td>8</td>
<td>15</td>
<td>4</td>
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<tr>
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<tr>
<td>7</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>US</td>
<td>56</td>
<td>47</td>
<td>53</td>
<td>50</td>
<td>57</td>
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<tr>
<td>45</td>
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<td>42</td>
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<td>12</td>
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</tr>
<tr>
<td>Europe</td>
<td>69</td>
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<td>43</td>
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</tr>
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<td>45</td>
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<td>31</td>
<td>58</td>
<td>22</td>
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<tr>
<td>25</td>
<td>22</td>
<td>29</td>
<td>18</td>
<td>35</td>
<td>12</td>
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<tr>
<td>23</td>
<td>16</td>
<td>22</td>
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<tr>
<td>17</td>
<td>10</td>
<td>15</td>
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<tr>
<td>Asia</td>
<td>78</td>
<td>51</td>
<td>71</td>
<td>58</td>
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<td>61</td>
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<tr>
<td>29</td>
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<tr>
<td>13</td>
<td>2</td>
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<tr>
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<td>2</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>-</td>
</tr>
</tbody>
</table>

**4.5.5.3 VOLUMES TRADED**

The volumes traded using the Reverre (2001) method is assumed to be 10,000 shares in each trade that is entered into. This assumption was made to avoid issues pertaining to liquidity constraints as the research assumes that at least 10,000 shares can be purchased during the course of the day of the price mismatch.

In applying the method proposed by Meissner *et al* (2002) it was assumed that only ten ALSI Top 40 contracts are to be traded for any given trade signal that is presented in the application of this method. This limit also provided certainty in terms of the liquidity of the futures that will be traded.
4.5.5.4 **Transaction Costs**

The effects of transaction cost on the profitability of the Reverre (2001) method are quite severe, due to the large number of trades that are entered into to generate these profits. As the trades in this example are all transacted on the JSE at a cost of about R60 a trade (presuming only one trade is required to fill an order for 10,000 shares). The costs of executing the 3,044 trades on the JSE is therefore about R365,280 (3,044 x R60 x 2). UST costs amount to about R6,675,288 and was calculated by multiplying each of the trades entered into by the UST rate 0.25%. Securities lending costs are estimated to be R36,625.

When applying the Meissner *et al* (2002) method, the only transaction costs that are factored into the profitability is the cost of the futures transactions. These transaction costs are aligned with the costs reflected in section 4.4.6.1 of this chapter and were set to R3 per trade. Given the fact that there were 264 trade opportunities identified in the research, this implies that the transaction costs amount to R792. No securities lending, UST, or other brokerage costs are incurred in this trading.

4.5.5.5 **Profitability**

The analysis of the Reverre (2001) method of arbitrage is reflected in Table 4.17 below and shows that the method does provide a net return of R5,927,799.80 (R2,712,239.40+R3,215,560.40) before taking into account transaction costs. The profits from these trades were accumulated over the period 1 January 2000 to 4 December 2003, and exclude the effects of cost of capital, UST, and securities lending.

**Table 4-17 Results of the Reverre (2001) statistical arbitrage approach before transaction costs**

<table>
<thead>
<tr>
<th>Correlated shares</th>
<th>Net profit from an over valued perspective</th>
<th>Profit on short position</th>
<th>Profit on long position</th>
<th>Net profit from undervalued perspective</th>
<th>Profit on long position</th>
<th>Profit on short position</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGL BIL</td>
<td>292,132.67</td>
<td>283,900.00</td>
<td>8,232.67</td>
<td>355,981.68</td>
<td>314,000.00</td>
<td>41,981.68</td>
</tr>
<tr>
<td>AMS IMP</td>
<td>1,847,532.65</td>
<td>979,600.00</td>
<td>967,932.65</td>
<td>3,910,759.43</td>
<td>3,094,900.00</td>
<td>-848,140.57</td>
</tr>
<tr>
<td>CRH CRN</td>
<td>58,781.30</td>
<td>16,200.00</td>
<td>42,581.30</td>
<td>73,212.87</td>
<td>-5,800.00</td>
<td>79,012.87</td>
</tr>
<tr>
<td>DUR HAR</td>
<td>-64,621.73</td>
<td>-120,400.00</td>
<td>55,778.27</td>
<td>-77,473.75</td>
<td>-101,300.00</td>
<td>23,826.25</td>
</tr>
<tr>
<td>FSR RMH</td>
<td>58,551.53</td>
<td>44,700.00</td>
<td>13,851.53</td>
<td>17,127.55</td>
<td>-36,400.00</td>
<td>53,527.55</td>
</tr>
<tr>
<td>GFI HAR</td>
<td>168,797.26</td>
<td>-95,100.00</td>
<td>263,897.26</td>
<td>161,023.86</td>
<td>-155,500.00</td>
<td>316,523.86</td>
</tr>
<tr>
<td>INL INP</td>
<td>283,719.93</td>
<td>69,200.00</td>
<td>214,519.93</td>
<td>221,116.71</td>
<td>234,700.00</td>
<td>-13,583.29</td>
</tr>
<tr>
<td>JNC MTN</td>
<td>67,345.78</td>
<td>54,700.00</td>
<td>12,645.78</td>
<td>53,812.04</td>
<td>23,900.00</td>
<td>29,912.04</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,712,239.40</td>
<td>1,132,800.00</td>
<td>1,579,439.40</td>
<td>3,215,560.39</td>
<td>3,368,500.00</td>
<td>-152,939.61</td>
</tr>
</tbody>
</table>
The effects of transaction costs, UST, and securities lending costs on profitability are shown in Table 4.18 below. After factoring in these aspects of trading, the net loss after transaction costs is -R1,149,394.26 (-R847,374.56 - R302,019.70). This strategy shows some degree of profitability over time even though the number of trades and the amount of effort and risk involved in generating these profits should be questioned. Transaction costs amounted to R365,280. while the bulk of the reduction in profitability came from the fact that for each outright purchase of shares, an amount of 0.25% of the consideration (or R6,675,288) was paid to UST. Therefore institutions such as brokers who are exempt from UST costs will be more profitable in this type of strategy.

The cost of capital calculations are excluded from the calculations due to the fact that under this methodology, the shares are generally held for a day or less which negates the effects of the cost of holding the position almost entirely. The effects of securities lending costs is estimated to be about R8,000 and is low, due to the fact that the loans are only in existence for a day at most.

As can be seen in Table 4.18 below, the Net Profit after costs is negative R1,149,394. This implies that the transaction costs reduce the profitability of this trading strategy from a positive R5,562,519 before costs to a negative R1,149,394. Section 4.5.5.4 showed that the bulk of this cost lay in the UST charge that is incurred with each purchase of shares and this amount reduces profitability by R6,675,288. The average loss per trade is therefore about R378 after taking into account the transaction costs.

Table 4-18 Results of the statistical arbitrage approach proposed by Reverre (2001) after transaction and securities lending costs

<table>
<thead>
<tr>
<th>Correlated shares</th>
<th>Net profit from an over valued perspective</th>
<th>Profit on short position</th>
<th>Profit on long position</th>
<th>Net profit from undervalued perspective</th>
<th>Profit on long position</th>
<th>Profit on short position</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGL BIL</td>
<td>-154,302.58</td>
<td>-110,614.78</td>
<td>-43,687.80</td>
<td>-98,724.35</td>
<td>1,764,123.50</td>
<td>-12,612.60</td>
</tr>
<tr>
<td>AMS IMP</td>
<td>-214,646.36</td>
<td>-463,374.33</td>
<td>248,727.97</td>
<td>357,114.48</td>
<td>-371,275.75</td>
<td>-1,407,009.02</td>
</tr>
<tr>
<td>CRH CRN</td>
<td>22,248.08</td>
<td>-613.10</td>
<td>22,861.18</td>
<td>35,783.67</td>
<td>-22,585.00</td>
<td>58,366.67</td>
</tr>
<tr>
<td>DUR HAR</td>
<td>-341,391.18</td>
<td>-372,104.65</td>
<td>30,713.46</td>
<td>-376,939.30</td>
<td>-371,275.75</td>
<td>-5,663.55</td>
</tr>
<tr>
<td>FSR RMH</td>
<td>-4,322.60</td>
<td>6,076.79</td>
<td>-10,399.39</td>
<td>-47,672.72</td>
<td>-75,754.00</td>
<td>28,081.28</td>
</tr>
<tr>
<td>GFI HAR</td>
<td>-267,306.45</td>
<td>-352,767.12</td>
<td>85,460.68</td>
<td>-267,929.62</td>
<td>-398,065.25</td>
<td>130,135.63</td>
</tr>
<tr>
<td>INL INP</td>
<td>157,859.21</td>
<td>5,485.82</td>
<td>152,373.39</td>
<td>124,625.68</td>
<td>187,342.00</td>
<td>-62,716.32</td>
</tr>
<tr>
<td>JNC MTN</td>
<td>-45,512.68</td>
<td>-23,774.20</td>
<td>-21,738.48</td>
<td>-28,777.54</td>
<td>-32,385.75</td>
<td>4,108.21</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>-847,374.56</strong></td>
<td><strong>-1,311,685.56</strong></td>
<td><strong>464,311.00</strong></td>
<td><strong>-302,019.70</strong></td>
<td><strong>965,288.00</strong></td>
<td><strong>-1,267,307.70</strong></td>
</tr>
</tbody>
</table>
When analysing the Meissner *et al* (2002) method in terms of profitability, the focus turns to the Asian market as the leading indicator as mentioned earlier. Table 4.19 below shows that where the Asian basket of indexes increased by an amount that exceeds 0.5% then the ALSI Top 40 would generally also increase. The magnitude of the increase also seems to correlate to that viewed on the Asian basket of indexes. In percentage terms the maximum increase was experienced where the Asian indexes increased by an amount greater that 2.5% but less than 3%. In this instance the ALSI Top 40’s average increase was about 1.969%, and this was the situation in about 75% of the cases.

Table 4-19: Index relationships where the leading index move is positive using Meissner *et al* (2002) method

<table>
<thead>
<tr>
<th>Leading market</th>
<th>Lagging Market</th>
<th>South Africa</th>
<th>US</th>
<th>Europe</th>
<th>Asia</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>% of profitable trades</td>
<td>57.627%</td>
<td>50.746%</td>
<td>61.702%</td>
<td>66.667%</td>
<td>45.000%</td>
</tr>
<tr>
<td>US</td>
<td>% of profitable trades</td>
<td>48.246%</td>
<td>44.737%</td>
<td>57.143%</td>
<td>33.33%</td>
<td>47.059%</td>
</tr>
<tr>
<td>Europe</td>
<td>% of profitable trades</td>
<td>57.292%</td>
<td>58.33%</td>
<td>50.00%</td>
<td>68.750%</td>
<td>56.391%</td>
</tr>
<tr>
<td>Asia</td>
<td>% of profitable trades</td>
<td>56.391%</td>
<td>69.33%</td>
<td>75.000%</td>
<td>100.000%</td>
<td>56.391%</td>
</tr>
</tbody>
</table>

When applying a basic technique to reflect the monetary effects of the above strategy to the results as reflected in Table 4.20, it can be shown that if the ALSI Top 40 index were purchased, the net profitability of this strategy after transaction costs is in the region of R1.177 million. As the shares that constitute the ALSI Top 40 index can’t be purchased outright the positions would in reality have been traded through the futures, but this method acts as a fair proxy. It should also be noted that no capital costs were calculated for these trades as they would only be held for a period of one day and because they are exchange trades. Therefore the maximum cost could be...
the overnight cost of funding the initial margin that would be required by the exchange.

Table 4-20 Profitability when the leading index increases

<table>
<thead>
<tr>
<th>Leading market</th>
<th>Lagging market</th>
<th>Value of profitable trades</th>
<th>Value of loss making trades</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>Asia</td>
<td>683,513</td>
<td>-388,015</td>
<td>&gt; 0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>636,715</td>
<td>-156,365</td>
<td>&gt; 1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>243,565</td>
<td>-85,522</td>
<td>&gt; 1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>142,185</td>
<td>-20,916</td>
<td>&gt; 2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50,201</td>
<td>-4,119</td>
<td>&gt; 2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75,937</td>
<td>-</td>
<td>&gt; 3.0</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1,832,116</td>
<td>-654,937</td>
<td></td>
</tr>
</tbody>
</table>

The effects of the short sale trades that were entered into as a result of the leading Asian index basket showing a loss greater than 0.5%, are shown in Table 4.21. This table also shows that where extreme moves of 2.5% or more occurred on the Asian indexes, the ALSI Top 40 generally generated profitable short trades. While these extreme moves did not occur very frequently, the results of their occurrence would in general result in profitable short trade positions.

Table 4-21 The index relationships where the leading index move is negative using the Meissner et al (2002) method

<table>
<thead>
<tr>
<th>Lagging market</th>
<th>Leading market</th>
<th>% of profitable trades</th>
<th>Change in lagged index</th>
<th>% of profitable trades</th>
<th>Change in lagged index</th>
<th>% of profitable trades</th>
<th>Change in lagged index</th>
<th>% of profitable trades</th>
<th>Change in lagged index</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>US</td>
<td>54.369%</td>
<td>0.939%</td>
<td>51.456%</td>
<td>1.181%</td>
<td>55.340%</td>
<td>0.832%</td>
<td>55.992%</td>
<td>0.952%</td>
<td>&gt;-0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>53.571%</td>
<td>1.054%</td>
<td>50.000%</td>
<td>1.409%</td>
<td>55.992%</td>
<td>0.952%</td>
<td>55.992%</td>
<td>0.952%</td>
<td>&gt;-1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40.476%</td>
<td>1.673%</td>
<td>45.238%</td>
<td>1.939%</td>
<td>50.000%</td>
<td>1.047%</td>
<td>50.000%</td>
<td>1.047%</td>
<td>&gt;-1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>52.174%</td>
<td>1.134%</td>
<td>43.478%</td>
<td>1.460%</td>
<td>56.522%</td>
<td>0.879%</td>
<td>56.522%</td>
<td>0.879%</td>
<td>&gt;-2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>33.333%</td>
<td>0.698%</td>
<td>11.111%</td>
<td>0.641%</td>
<td>66.667%</td>
<td>0.854%</td>
<td>66.667%</td>
<td>0.854%</td>
<td>&gt;-2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>46.667%</td>
<td>1.597%</td>
<td>46.667%</td>
<td>2.635%</td>
<td>53.333%</td>
<td>0.701%</td>
<td>53.333%</td>
<td>0.701%</td>
<td>&gt;-3.0</td>
</tr>
<tr>
<td>US</td>
<td>Europe</td>
<td>62.162%</td>
<td>1.042%</td>
<td>38.739%</td>
<td>0.857%</td>
<td>64.865%</td>
<td>0.982%</td>
<td>64.865%</td>
<td>0.982%</td>
<td>&gt;-0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>56.250%</td>
<td>1.020%</td>
<td>61.250%</td>
<td>1.030%</td>
<td>72.500%</td>
<td>0.871%</td>
<td>72.500%</td>
<td>0.871%</td>
<td>&gt;-1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>53.191%</td>
<td>0.963%</td>
<td>61.702%</td>
<td>0.961%</td>
<td>74.488%</td>
<td>1.015%</td>
<td>74.488%</td>
<td>1.015%</td>
<td>&gt;-1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>58.974%</td>
<td>0.920%</td>
<td>56.410%</td>
<td>1.224%</td>
<td>79.487%</td>
<td>0.812%</td>
<td>79.487%</td>
<td>0.812%</td>
<td>&gt;-2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>75.000%</td>
<td>1.835%</td>
<td>75.000%</td>
<td>2.291%</td>
<td>93.750%</td>
<td>0.928%</td>
<td>93.750%</td>
<td>0.928%</td>
<td>&gt;-2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>62.963%</td>
<td>1.434%</td>
<td>55.556%</td>
<td>1.514%</td>
<td>88.889%</td>
<td>1.147%</td>
<td>88.889%</td>
<td>1.147%</td>
<td>&gt;-3.0</td>
</tr>
<tr>
<td>Europe</td>
<td>Asia</td>
<td>60.465%</td>
<td>0.855%</td>
<td>55.039%</td>
<td>0.848%</td>
<td>62.016%</td>
<td>1.184%</td>
<td>62.016%</td>
<td>1.184%</td>
<td>&gt;-0.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>67.778%</td>
<td>1.073%</td>
<td>57.778%</td>
<td>1.097%</td>
<td>61.111%</td>
<td>1.472%</td>
<td>61.111%</td>
<td>1.472%</td>
<td>&gt;-1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>72.500%</td>
<td>1.463%</td>
<td>62.500%</td>
<td>1.189%</td>
<td>72.500%</td>
<td>1.377%</td>
<td>72.500%</td>
<td>1.377%</td>
<td>&gt;-1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>86.667%</td>
<td>1.386%</td>
<td>53.333%</td>
<td>0.805%</td>
<td>66.667%</td>
<td>1.835%</td>
<td>66.667%</td>
<td>1.835%</td>
<td>&gt;-2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100.000%</td>
<td>1.140%</td>
<td>60.000%</td>
<td>0.561%</td>
<td>100.000%</td>
<td>2.027%</td>
<td>100.000%</td>
<td>2.027%</td>
<td>&gt;-2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100.000%</td>
<td>8.593%</td>
<td>100.000%</td>
<td>1.918%</td>
<td>100.000%</td>
<td>6.663%</td>
<td>100.000%</td>
<td>6.663%</td>
<td>&gt;-3.0</td>
</tr>
<tr>
<td>Asia</td>
<td>AsiaEurope</td>
<td>57.778%</td>
<td>1.073%</td>
<td>57.778%</td>
<td>1.097%</td>
<td>61.111%</td>
<td>1.472%</td>
<td>61.111%</td>
<td>1.472%</td>
<td>&gt;-1.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>72.500%</td>
<td>1.463%</td>
<td>62.500%</td>
<td>1.189%</td>
<td>72.500%</td>
<td>1.377%</td>
<td>72.500%</td>
<td>1.377%</td>
<td>&gt;-1.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>86.667%</td>
<td>1.386%</td>
<td>53.333%</td>
<td>0.805%</td>
<td>66.667%</td>
<td>1.835%</td>
<td>66.667%</td>
<td>1.835%</td>
<td>&gt;-2.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100.000%</td>
<td>1.140%</td>
<td>60.000%</td>
<td>0.561%</td>
<td>100.000%</td>
<td>2.027%</td>
<td>100.000%</td>
<td>2.027%</td>
<td>&gt;-2.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>100.000%</td>
<td>8.593%</td>
<td>100.000%</td>
<td>1.918%</td>
<td>100.000%</td>
<td>6.663%</td>
<td>100.000%</td>
<td>6.663%</td>
<td>&gt;-3.0</td>
</tr>
</tbody>
</table>
Table 4.22 below reflects the profitability of the trading strategy where short positions are required due to the decline in the leading indicator. The method is again to use the ALSI Top 40 values as the proxy measure of the futures that would be traded. The research shows that these trades would generate about R1.032 million over the period under review.

**Table 4-22 Profitability when the leading indicator decreases**

<table>
<thead>
<tr>
<th>Leading market</th>
<th>South Africa</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Value of profitable trades</td>
<td>Value of loss making trades</td>
</tr>
<tr>
<td>Asia</td>
<td>582,353</td>
<td>-415,751</td>
</tr>
<tr>
<td></td>
<td>578,338</td>
<td>-195,590</td>
</tr>
<tr>
<td></td>
<td>377,128</td>
<td>-157,672</td>
</tr>
<tr>
<td></td>
<td>156,049</td>
<td>-7,585</td>
</tr>
<tr>
<td></td>
<td>45,589</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>69,632</td>
<td>-</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1,809,089</strong></td>
<td><strong>-776,598</strong></td>
</tr>
<tr>
<td><strong>Net profit</strong></td>
<td></td>
<td><strong>1,032,491</strong></td>
</tr>
</tbody>
</table>

4.5.5.6 **Conclusions regarding Statistical Arbitrage**

The approach proposed by Reverre (2001) can result in a trading strategy that can generate large profits if it is implemented correctly. This view results from the fact that the shares with high correlations do tend to converge as expected in the majority of cases as is evidenced by the profits before costs reflected in section 4.5.5.5, where the strategy generated in the region of six million rand. The real concern with this strategy lies in the fact that it cannot be implemented in a cost effective manner using the underlying shares due to the high UST charges that are incurred when trading the strategy.

Where the company has an exemption from UST this strategy can be implemented in its basic form. However, the research shows that the economics of the trade can be easily replicated in the derivative markets, as this will generate numerous cost benefits. This relates to the fact that no UST will be incurred, transaction costs will be
negligible at about R3 per trade, and securities lending costs will not be incurred. All these factors in addition to the gearing associated with derivatives may be used to lever the profitability of this strategy.

In addition to the use of derivatives, which aim to reduce the net transaction costs, the strategy will benefit from the adherence to a stop loss which should be set at a level of 0.5% for each day’s move. If, for example, the share prices of either of the shares moves by more that 0.5% in the wrong direction, the position should be closed out. The stop loss will therefore reduce the downside associated with the use of derivative instruments.

The Meissner et al (2002) method is considered to be a superior technique given the improved returns, greater degree of certainty that the trades will perform in the expected manner, and therefore the implied reduction in risk that is associated with the method. The method provided relatively few trade opportunities but has the potential to generate profits from trading relatively few contracts in each trade, as was evidenced in section 4.5.5.5.
CHAPTER 5

A MODEL FOR THE EFFECTIVE MANAGEMENT OF ARBITRAGE TRADING

5.1 INTRODUCTION

The purpose of this chapter is to consolidate all the information gathered through the research into a recommendation, which can be applied by businesses that are trading equity arbitrage or that wish to enter the equity arbitrage trading environment. In defining this process due consideration was given to the feedback received from the entities that were part of the sample in the empirical research. These findings are also viewed in the light of the actual time series analysis, that was performed in the second part of the research.

Various recommendations are made with the view to creating a structured approach that allows for ease of identification of equity arbitrage opportunities, a reflection of the traded positions and their associated risks, the costs involved, the opportunity costs of not taking up positions etc. These factors are reviewed with the view to providing a business model that enhances the trade management, risk management profitability management and overall business effectiveness.

The research views this consolidated approach as a method that can be employed to generate a strategic advantage for the institution as a whole and can therefore assist in the ultimate goal of shareholder wealth maximisation.

The chapter also aims to propose statistical methods using linear algebra and multiple regressions on various indexes to generate statistical trading opportunities on the ALSI Top 40 index.

5.2 EQUITY ARBITRAGE BUSINESS STRUCTURES

The findings show that the majority of the institutions have structured their equity arbitrage within the equity-trading environment, which are housed within their treasuries. In the case of hedge funds and asset managers the trading is set up within the fund that does the arbitrage trades, while brokers who already have an
equity trading infrastructure have also housed the function within the existing trading environments.

The research findings do not aim to prescribe any one business structure as the most appropriate and prefers the view that these structures should be created after due consideration of the business needs, business structure, resources and infrastructure which are present in each of the respective businesses.

However, the opinion held by this research is that a centralised structure is the most appropriate method of dealing with these trading strategies as it allows a degree of specialisation to be developed in this trading, while also allowing the arbitrage desk to benefit from market information that flows across the equity derivative or equity trading desks. This opinion is formed as a result of the fact that the market information is critical where statistical directional views are placed on the books, as the sooner the traders receive the market information, the better their decisions would be.

An additional reason why this structure is proposed is due to the fact that the IT, capital and human resources that are applied in creating the arbitrage application and its database can then be spread across multiple trading desks and the cost per desk is thereby reduced. This investment is required to facilitate the degrees of automation that are proposed in the remainder of this chapter. A large amount of computer power is also required to effectively run the proposed solution to the arbitrage profit maximisation, management and control processes.

5.2.1 CREATION OF A SYSTEM AND STATIC DATA

The only manner in which the arbitrage process can move along the evolutionary scale is for the process to become more automated with less reliance on human intervention. To this end it is proposed that the arbitrage process be automated through the creation of a system that removes the complexity of this trading process by breaking the processes down into their component parts.

The basic system requirements are:

1. All the instruments required for the arbitrage trading should be available in the system – be they underlying contracts, futures, forwards or options.
2. All the pricing functions used to price these instruments must be available to calculate fair values of the instruments involved.

3. All the static data pertaining to the instruments should be housed in the system as these will be required to calculate the fair values, examples of this data are contract settlement dates and projected dividends.

4. All information relating to cost drivers should be stored in the database, as these will be used to calculate the transaction costs, UST charges, and securities lending costs.

5. All information relating to the market risk limits that are applicable to the relevant instruments, or position types should be available. These include notional limits, VAR limits, and limits in terms of the Greeks.

6. An interface to live data in the form of bid offer spreads and available volumes should feed from the data vendors into the system.

7. There should be an interface into the JSE or SAFEX trading systems such that the system can generate the trades in an automated manner without relying on human intervention to load the trades.

8. A manual trade capture facility that allows for trades other than those suggested by the system and over the counter (OTC) trades should be implemented.

9. A statistical package that is flexible enough to allow the traders to simulate historical profitability of arbitrage processes or instruments should be installed. This function should allow for a pre and post trading cost analysis in addition to the cost driver analysis.

10. A database (DB) that stores all daily open, high, low, and closing prices that are fed from the data vendors is essential. The application should also write any proposed trades, that the system suggests to the DB in addition to whether the trades and available volumes were executed; where they were not executed, the reasons provided for not executing the trades should also be stored.

11. A securities lending data table should be created that allows for the volumes of shares available and their respective lending costs to be tracked by the system.

12. Interface into the existing trading system is required to facilitate the transfer of the arbitrage positions into the general trading system.
5.2.2 Arbitrage Feasibility Process

The common approach to trading new strategies is to implement the strategy after the results of simulations and time series analysis has been reviewed – assuming it is considered to be a success. The process described below aims to provide a methodology that can be used in the setup of an arbitrage-trading desk.

This process is illustrated in Figure 5.1 below and has factored in the relevant costs after taking into account the relevant trading limits and volumes as provided by the database.

There are two basic scenarios that should be considered when reviewing the arbitrage feasibility process. The first is where the institutions do not trade arbitrage and do not have the required infrastructure, but want to setup an arbitrage desk (two such institutions were identified in the empirical research) The second is where the company already has an infrastructure that trades arbitrage, but wants to enhance the process or breakdown the profitability into the individual trading strategies such these can be measured on their own merits.

In the first scenario where the institutions do not yet trade arbitrage and do not have the infrastructure to identify and trade arbitrage, but wish to set up an arbitrage-trading desk, it is suggested that some investment into the basic framework be made such that the total feasibility of the trading desk (given the trading strategies and the businesses cost structure) can be factored into the calculations. To achieve this, the models need to be created, the cost structures need to be defined and the historical information required to perform the analysis will need to be loaded. This will allow an analysis of the arbitrage profitability, such that the non-profitable trade types can be removed from the process. This will leave only the profitable trading strategies that can then be reviewed in terms of their ability to meet the companies’ internal rate of return or other benchmark performance figures. Where certain trading strategies do not meet the profitability requirements these can be removed from the trading strategies of the desks.
Figure 5.1 Proposed Arbitrage feasibility process
The next step in the process is to ascertain what the expected number of trades over a given period should be, such that management can determine what the optimum number of traders would be to perform these trading activities. These costs should also be factored into the profitability process to ensure that the IRR (or other profitability) requirements are met by this structure. If the desk will not make money at this stage, management needs to determine whether given these projections they wish to setup the desk for strategic reasons. If the opinion is reached that the business will proceed with the arbitrage business setup, an analysis into the risks that are associated with the trades should be undertaken, with the view to creating the relevant risk limits for each arbitrage type.

Where certain trade types are of a risk type that the institution does not want to include in their operations, these can be excluded from the list of strategies that they are prepared to trade. Once again the profitability should be reviewed to ensure that the business is still feasible after decisions about risk factors have been reached.

Where there is an existing arbitrage process and the institution wants to adopt the methodology described by this model, a similar process to that described above for institution that do not yet trade arbitrage will be followed. The benefits that may be included here are that the institution already has an idea of how profitable some of the trading strategies have been in the past; they may also have an idea of the capabilities of the traders that they have employed and what level of performance they can expect from these traders in the future.

The number of traders that the business needs to employ is a function of the number of arbitrage strategies traded and the participation in these strategies. A further consideration is the degree of automation of the systems as all these factors determine how many traders should be employed in the arbitrage trading business.

### 5.2.3 Simulations and Monte Carlo Analysis Tools

When developing a new trading strategy there is a need to create and test it against historical and live data. To this end the system should have embedded statistical functions that can cater for the statistical analysis that is required in a flexible manner. In addition the system must be able to run simulations to determine the potential outcomes of certain trading strategies in the event that certain pricing
events were to occur. This functionality is key to the trades and the system being successful in the long term.

The proposal is also that the system should be in a position to determine key factors such as the most effective stop loss level for each strategy, and the most profitable time frames for returns, given historic data on the trades that are currently being simulated. This functionality will be helpful in terms of determining when the most appropriate time is to close out medium and long term directional relative value trades.

The Monte Carlo analysis aims to provide the expected returns for the trading strategy within predefined confidence intervals for trade types that are being reviewed after considering the stop loss levels, trade durations etc. This process will allow for profit and loss forecasting prior to entering into the trade and after the trades have been entered into.

5.2.4 Trade Identification Processes

Institutions should invest in upgrading their arbitrage infrastructure in a manner that will allow the mispriced instruments to be identified on a real time basis; i.e. the system will need a feed from the data vendors on a real time basis. The proposed process flow for the trade identification is shown in Figure 5.2 below.

This data should be applied to the appropriate mathematical techniques to determine whether the instruments are trading at a level that is mispriced relative to the underlying instrument or relative to a statistical technique that is being applied to predict its value. Once the trade opportunity has been identified, the system processes will be determined by the nature of the arbitrage opportunity.

Where the trade opportunity is of a pure arbitrage form, the system will determine what the associated cost of processing the trade will be. This information is embedded in the systems table and therefore when this information is applied to the arbitrage type and the actual prices and volumes, the system will be in a position to determine whether the current volumes available on the bid or offer side of the trade can be traded in a profitable manner. The system can then execute the trade if the trade does not require securities lending transactions.
Where the trades do require securities lending transactions, the system will firstly reference the static data table to determine whether the shares are available and at what rate. If the shares are available, the trade will be executed by the system with no human intervention.
If the shares are not available, the traders will be notified of this requirement via a message box, and the traders will need to source the underlying shares prior to the trade being concluded by the system. Alternatively they will need to rely on a combination of derivatives to create a synthetic position that is the equivalent to the required underlying position. Assuming that the shares are available, the trade execution will occur when the securities lending rate and the available number of shares that may be borrowed is entered into the system by way of the message box that will present itself. At this time the system will use this data to again calculate the profitability, given the available volumes and costs before entering into the trade.

Once the trade has been executed the trader will be notified that the trades have been concluded. Where there are not enough shares, the trader will decline the trade with the relevant reason for declining the trade being provided by the trader. Whatever the outcome, the system should store the fact that a trade was done or that the opportunity presented itself but could not be executed as a result of the reason provided by the trader through a drop down list of reasons for declining a trade.

If the trade is a statistical arbitrage trade, the system will calculate the degree to which the current pricing deviates from the normalised price and generate a message to the trader requesting the trader to authorise the trade for execution. The model used to generate the perceived opportunity along with the anticipated profitability after transaction costs (given historical norms) should be displayed as further information for the trader. The trader can then approve the trade and the system will execute the trade at the required price and in the required volume. The increased degree of automation adopted in this process is aimed at reducing deal capture problems that may result in the incorrect instrument being purchased, or the incorrect volumes being entered or the trade may be loaded as a buy instead of a sell, to name a few of the more frequent error types that may be encountered.

The system should also create messages informing the trader when stop loss levels are reached. As discussed below in section 5.2.5 relating to stop losses, the system will automatically create these stop loss trades but will request the trader to authorise the trades prior to executing the transaction. In a similar manner, where the pure arbitrage trades have converged prior to maturity the system should request the trader to close out the trades, as this will result in a saving on the capital cost and hence this improves the overall profitability of the strategy.
In all the above cases where the system has identified or executed a trade or where a trade has been declined, this information should be written to the DB, such that it may be used as management information at a later point in time. The method adopted is to provide the traders with a list of options in a drop down list, such that they can choose the appropriate reason from the list.

In the event that business has gained enough confidence in the application’s ability to consistently perform a particular arbitrage type in the appropriate manner, the system should cater for the option to let the application do all the trading for that arbitrage type without human intervention of any kind. This implies that the scrip lending availability will need to be loaded and maintained on the system so that the system knows up to what levels the shares can be sold short and be covered by the available scrip lending.

It is also recommended that the traders on the desk be specialists who understand the underlying products well but who focus only on the arbitrage trading process as their core function and speciality. This methodology will allow the traders to focus on developing and enhancing existing processes to cater for new instrument types and new methods to enhance profitability.

5.2.5 STOP LOSS PROCESS

Chapter 4 of this research showed that when trading the statistical arbitrage strategies, a large number of trades could be executed. These volumes will result in a situation whereby the traders will not be in a position to manage the stop loss on each trade and therefore the system must be able to provide this functionality.

The system will need to monitor each of the trades on an ongoing basis to determine whether there have been any breaches of the stop loss levels. Where these events occur the system should notify the trader via a message box, that will request the trader to authorise the close-out of the position that has breached the stop loss level.

Once the trader authorises the close-out, the system will automatically generate the entries required on the relevant trading system against the appropriate side of the bid or offer. The system must write the trade details to the database for the position and record purposes. Where the trader does not wish to close out the trade, a reason
should be provided and this will be stored in the database along with the fact that the system recommended a close-out of the position.

The actual stop loss levels and the stop loss mechanism applied will be set up in the static data table. The levels must be specified for each arbitrage type, and should be defined as either the trade price stop loss or a percentage change stop loss level.

5.2.6 Market Risk Measurement and Limits

The systems process should be able to monitor and control the adherence to the market risk limits that are put in place via the static data tables described above. This implies that the required reports should be created that allows for the analysis of the market risk positions at a user and desk level.

These reports are for the use of the traders and market risk managers, as they should facilitate the management of the risks that are pending on the books on a daily basis. Figure 5.3 below provides a flow chart representation of the "Risk Process" proposed by this research.

The reports should allow the market risk function to identify and monitor the exposures of the arbitrage desk separately to those of the general trading desk and this will assist in meeting the traders' requirement expressed in the empirical research leg. In section 4.4.6.3 the traders expressed a view that the arbitrage desk should have separate limits due to the fact that the arbitrage trades have different risk profiles to those of non-arbitrage trades. The report outputs should present all the Greeks and the current limit exposure relative to the authorised exposure to these limits. They should also express the positions in terms of a value at risk and the general limit utilisation that is present at the time of the report.

Where the limit utilisation is 10% from capacity, the system should notify the traders of the fact that the limits are nearing depletion and the traders would in turn request the market risk function to review the limits. If it is decided that the limits will not be adjusted and the limit is breached, all further trades identified should be declined by the system, and the fact that the opportunity did present itself should be recorded by the system, with the reason for not trading being that the limits had been utilised.
Figure 5.3 Proposed risk process
The system should allow for the calculation of risk buckets such as those generated through a partial differential hedge so that the relevant risk areas can be identified and managed accordingly. As the proposed products may include derivatives it is recommended that all components of the Greeks be implemented i.e. gamma, vega, delta, rho and theta as this will facilitate the appropriate risk management to take place at a trading level.

5.2.7 TRANSACTION COSTS

The process aims to allow for more effective management of the costs that affect the trading profitability. This is achieved by setting the benchmark costs that are associated with the various trade types on the various exchanges in the static data component of the system. These costs are loaded into the static data as part of the initial setup, and any changes to these costs must be updated in the system to ensure that the system utilises the most appropriate data in its calculation of the potential profitability of the trades that are recommended.

The costs that will be required in most of the cases include the transaction cost for the JSE, SAFEX, and any other offshore exchanges that may be used, the UST rate and the securities lending cost (which will be estimated cost for that company where no actual data is available). The JSE costs would include the STRATE component that will form part of the cost of trading on the JSE.

When the trades are at a point where they are going to be transacted and committed to the database, the actual securities lending costs will be required prior to the trade being executed. This information will be provided by the trader as the traders will be required to input the costs into the message box provided by the system, prior to deal execution by the system.

A breakdown of trading costs, as recorded by the system should be generated, so that other business functions can compare the actual costs versus the projected cost that would be incurred. In this manner a control method can be created to ensure that the costs entered in the system are set up correctly.

This information in consolidated form will also assist in negotiating better rates in some cases as the high transaction volumes may assist in the negotiating process.
Further benefits of this information are that the actual benefits of using derivatives and synthetics can be encouraged with the view to reducing transaction costs.

5.2.8 Profitability

Figure 5.4 shows the profit control process proposed by this research. It proposes that prior to trade commencing, the products that will be traded should be discussed with the appropriate back office (BO) and legal personnel in an effort to ensure that they are able deal with the product and have the infrastructure required to cater for the product from and accounting, regulatory, settlements and reconciliations perspective. In a similar manner the legal overview will provide certainty that all the appropriate legal documentation is in order and it facilitates adherence to regulations that are in place. If either of these functions identifies additional cost implications these should be identified at this stage of the product trading process and these can then be allocated to the arbitrage area.

The process suggests monthly reviews of the performance of the traders and the arbitrage books relative to the potential performance of the system. In this manner the process setup in the system can be reviewed and where traders are not performing relative to their potential performance. This issue can be addressed either through additional training or other performance enhancement measures used by the institution.

The process should also highlight matters pertaining to risk limits because when these limits are breached it could result in a reduction in trading relative to that suggested by the system. Therefore there should be a constant focus on the limits utilisation, the adherence to these limits and the company’s risk appetite for arbitrage trades.

A further suggestion is that there should be frequent reviews of the costs incurred relative to those generated by the system. The benefit of this is based on the fact that this process will assist in identifying transaction costs that have been incorrectly loaded in the static data. This process also helps to identify costs that are not being accounted for and that should be built into the system for more accurate outputs.
Figure 5.4 Proposed profit control process
The final stage of the profitability and performance review process is the comparison of the actual trading results against potential trading results as recorded by the system. Where the IRR is not met, the information provided by the system can be used to isolate the underlying reasons at each trading strategy level. These can then be used to determine whether the specific trading strategies are providing the required level of return, and where this is not the case, a decision can be made as to whether the institution wishes to continue trading that specific strategy.

5.2.9 PERFORMANCE AGAINST REAL BENCHMARKS

The above process described a method that would allow management to review the actual performance of a trader and/or on a desk over a period of time relative to the potential performance of the trader and for the desk. This can be achieved by obtaining from the database all the proposed trades and their proposed close-out levels as they were presented to the trader.

In this manner the performance can be managed not only against the budget, but the performance can also be measured against all proposed trades that were defined in the system based on implemented strategies.

This implies that where traders have performed better than the system that the underlying reasons for this performance can be analysed such that the system can be modified to improve the results. Where the trader has not performed as well as the system suggests he should have, the reason for this can be analysed and used to improve the trader's performance where possible. This implies that the system will facilitate learning both in the logic applied in the application and for the traders that use the system. Where the system has been developed to a level where it continually performs better than the traders, the business should consider allowing the system to automatically control that type of arbitrage trading.

5.2.10 CONCLUSION REGARDING THE TRADE, RISK AND PROFIT PROCESSES

The process described in this chapter covers some of the key requirements that were identified in the empirical research. These include improved trade identification processes, improved market risk processes, separate market risk treatment for arbitrage trading, and the ability to determine profitability at a trade and trade group level when required. The method described also has the ability to be transferable to
different business types that trade equity arbitrage, be they banks, stockbrokers or investment managers.

In performing these functions the processes used should remain flexible yet robust, in order to cater for new products and trading strategies that will be added to the system. The process should also be viewed as modular in nature as each of the respective functions will rely on the data in the data base, but will apply a separate set of reporting logic in analysing the information at hand.

In summary, the method discussed will allow greater automation. The approach also acts as a catalyst for the improved management of the entire arbitrage trading process, which would include profitability, risk management and human resources management. It also addresses the requirements expressed by the traders in the empirical research in that it caters for improved identification, risk management, profit enhancement and trade monitoring. It also simplifies the process in that the trade information is stored dynamically and the traders are not required to perform continual analysis processes to identify trade opportunities. The traders will therefore be able to work on developing and implementing new arbitrage strategies.

The automated process described is easily extendable to other business areas, such as agricultural, resource, interest rates and currencies. While the focus of this research has been on equity arbitrage, the statistical techniques do not differ in terms of identification of relative value trades. The complexity in extending the concepts to other instrument types lies more in the setup of the instruments and underlying products than the statistical processes. Where these extensions are implemented, the primary factors to consider will be the pricing and the dependent and independent variables. When these are defined, the arbitrage concept can run in a similar manner to that discussed for equities.

5.3 A PROPOSED STATISTICAL ARBITRAGE IDENTIFICATION METHOD

Pure arbitrage processes are clearly defined and well established, but statistical arbitrage processes, although well understood, consists of more complex methodologies. Therefore the ensuing section will focus on a multiple regression methodology, which has proved profitable in the South African context and which can be used as a basis for statistical arbitrage identification and trading.
In defining a multiple regression trading method the first criteria that is required is that the independent variables should contribute to the dependent variable in a significant manner. Therefore a high correlation, or $R^2$, is required between the dependant and independent variables. Furthermore, the results of the regression should be statistically significant, which means that p values should be below 0.05 at a 95% level.

To this end the following were used as independent variables to predict the movements of the dependent variable, being the ALSI Top 40 share index:

- X1 represents the South African Rand.
- X2 represents the FTMIGMI Index, which is the London FTSEI mining Index priced in US Dollars.
- X3 represents the JPLAT index which is the South African Platinum index.

The daily last trade price of each of these indexes was used in the multiple regression analysis after adjusting the price data for public holidays and other non-trading days. The period under review to demonstrate the success of this methodology is January 2000 up to and including December 2003 and includes 983 observations of the respective indexes.

The method applied was to calculate the multiple regression coefficients using the method described by Shao (1976: 728-733) on a rolling 30-day basis and then to apply the regression to the next business day, which falls out of the sample. This process allowed the creation of a theoretical price for the ALSI Top 40, given the regression coefficients. The actual ALSI Top 40 price is then subtracted from the theoretical price to give the difference between the two values. This difference is then divided by the rolling standard deviation of the ALSI Top 40 share price over the same 30-day period, such that a standardised ratio of the differences is created.

These “ratios” were used to identify instances where the price differentials were significant. The assumption was made that any results above 1 or below -1 would be significant. The final results were classified into the following groups: between 1 and 1.5, between 1.5 and 2, between 2 and 2.5 and above 2.5. In a similar manner all values on the negative side were reported. Where any of these ratio levels were breached, a trade resulted and the position was held for the day of the trade and the
day thereafter, following which the trade was closed out as the index should have normalised by that time.

Where the result, referred to above, was is positive, it implied that the current ALSI Top 40 price was too high and the ALSI Top 40 index should be sold and vice versa. Where a buy or sell trigger was reached, the research assumed for simplicity that the ALSI Top 40 index could be bought directly as an instrument. The assumption allowed for the instrument to act as a proxy for one of the futures contracts on the ALSI Top 40, which could be purchased. While the price values may increase, this method is based on the fact that the future is delta 100 and therefore any change in the ALSI Top 40 share prices should translate into the same change in the future given the risk free rate, dividend and time to maturity. Cleary where there is a price mismatch between the index and the future, the index arbitrage process will be initiated as discussed earlier. The profitability of the trading strategy before the implementation of a stop loss is reflected in Table 5.1 below.

Table 5-1 Profitability of the linear trading strategy to predict trading opportunities in the ALSI Top 40 index when not applying a stop loss

<table>
<thead>
<tr>
<th>Profitability</th>
<th>&gt;1</th>
<th>&gt;1,5</th>
<th>&gt;2</th>
<th>&gt;2,5</th>
<th>&lt;1</th>
<th>&gt;-1,5</th>
<th>&lt;2</th>
<th>&gt;-2,5</th>
<th>&lt;2,5</th>
<th>&lt;25</th>
<th>&gt;25</th>
<th>&lt;1,5</th>
<th>&gt;2</th>
<th>&lt;10</th>
<th>&lt;2,5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profitability</td>
<td>4642.15</td>
<td>2389.69</td>
<td>883.55</td>
<td>37.44</td>
<td>5808.88</td>
<td>3240.55</td>
<td>915.88</td>
<td>1145.37</td>
<td>18941.51</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profitable Trades</td>
<td>59</td>
<td>26</td>
<td>11</td>
<td>5</td>
<td>45</td>
<td>20</td>
<td>11</td>
<td>6</td>
<td>183</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non Profitable Trades</td>
<td>37</td>
<td>21</td>
<td>9</td>
<td>11</td>
<td>27</td>
<td>15</td>
<td>16</td>
<td>1</td>
<td>137</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Profitable Trades %</td>
<td>61.459%</td>
<td>55.319%</td>
<td>55.000%</td>
<td>31.250%</td>
<td>62.500%</td>
<td>57.143%</td>
<td>40.741%</td>
<td>85.714%</td>
<td>57.188%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The results show that the trading strategy showed positive returns of R468,977.00 (R4,689.77 x 10 x 10) over the period Jan 2000 to 2003, assuming that only 10 contracts are purchased/sold where a trading opportunity was identified. In total there were 319 potential arbitrage trades that could have been entered into during this period of which 183 or 57.37% were profitable.
Table 5-2 Profitability of the linear trading strategy where trading the ALSI Top 40 index and applying a stop loss of 0.5%

<table>
<thead>
<tr>
<th>Deviation Level</th>
<th>&gt;1 &lt; 1.5</th>
<th>&gt;1.5 &lt; 2</th>
<th>&gt;2 &lt; 2.5</th>
<th>&gt;2.5</th>
<th>&gt;-1 &lt; -1.5</th>
<th>&gt;-1.5 &lt; -2</th>
<th>&gt;-2 &lt; -2.5</th>
<th>&gt;-2.5</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Profitability</td>
<td>2016.72</td>
<td>916.4</td>
<td>181.99</td>
<td>-887.24</td>
<td>3005.42</td>
<td>-446.68</td>
<td>-1141.72</td>
<td>1044.88</td>
<td>4689.77</td>
</tr>
<tr>
<td>Profitable Trades</td>
<td>59</td>
<td>26</td>
<td>11</td>
<td>5</td>
<td>45</td>
<td>20</td>
<td>11</td>
<td>6</td>
<td>183</td>
</tr>
<tr>
<td>Non Profitable Trades</td>
<td>37</td>
<td>21</td>
<td>9</td>
<td>10</td>
<td>27</td>
<td>15</td>
<td>16</td>
<td>1</td>
<td>137</td>
</tr>
<tr>
<td>Profitable Trades %</td>
<td>61.458%</td>
<td>55.319%</td>
<td>55.000%</td>
<td>33.333%</td>
<td>62.500%</td>
<td>57.143%</td>
<td>40.741%</td>
<td>85.714%</td>
<td>57.188%</td>
</tr>
</tbody>
</table>

The strategy became more profitable when a stop loss strategy was applied, such that the position was closed out if the index moved by 0.75% in the opposite direction of the trade. The profitability with a stop loss then became R1,894,151 (R18,941.51 x 10 X10) over the period January 2000 to December 2003. The assumption remained that only 10 contracts are bought each time that a trade opportunity presents itself.

The findings showed that costs did not have an affect on the number of transactions that could be regarded as profitable as a futures trade cost roughly R3 and the total transaction costs amounted to only about R 2,000. Figure 5.7 graphically illustrates the number of profitable and non-profitable trades at each threshold.

Figure 5.5 The number of profitable and non profitable trades at each threshold.

It has been shown throughout this research that there are numerous ways to identify potential arbitrage situations using statistical methods. The methodology described in this section could be applied as a first step and be improved through further research.
of appropriate methods of identifying relative value transactions in the equity markets.

5.4 ARBITRAGE STRATEGY AND STRUCTURE- THE FUTURE OF THE BUSINESS

The proposals discussed thus far have been constructed after reviewing existing literature as well as the business processes and applications used to manage the equity arbitrage processes within the institutions that formed part of the sample.

These conclusions are aimed at providing a holistic framework for management that has or wishes to enter the arbitrage-trading environment. The general business processes defined in the research conclusions aim to provide an enhanced method of managing the arbitrage processes in South Africa or anywhere where businesses aim to setup these operations.

The proposals presuppose a business strategy of maximizing the overall shareholder value of the institution in question, through the development of an arbitrage strategy that provides a competitive advantage. In this regard Ward, 1998:3-4 refers to an increase in shareholder value as “the overriding reason for the existence of most commercial organizations.

This return must be assessed in the context of the particular risk associated with any institution, as it is a fundamental economic principle that increased risk must be compensated for with higher levels of financial returns.” Arbitrage trading as described in the research is admittedly only a fragment of the overall business strategy, but the institutions that indulge in this activity need to develop the capability to consistently improve on their own arbitrage trading processes and thereby improve profitability of the institution. Hence the emphasis of the research on providing a process that is aimed at efficacy and which rejects the idea of the business process stagnating at any level of the arbitrage business. Furthermore the proposed processes are aimed at improving profitability, cost leadership structures, flexibility, and the levels of decision accuracy.
5.5 Summary

In this chapter a process that may be employed to improve and automate the equity arbitrage trading process was discussed. While the view is not to remove the human component in its entirety through the automation described, there is a focus on ensuring that the number of trade types is increased and that their profitability is enhanced while also allowing the institutions to trade in the high volume trading strategies.

While the empirical and time series research was used as the inputs to the creation of the model and process described in this chapter, the view that the arbitrage processes can be improved through the implementation of a number of systems components may also be propagated as this would imply that the business is starting to move through the evolutionary scale which the research shows to be the precursor to high volume arbitrage trading.

Of further importance in light of the findings, is that there are too many arbitrage types for the average of two traders to deal with. This implies that opportunities may be missed either because they are not identified or because the time it takes the trader to identify and execute the trade is greater than the trader’s perceived benefit. Due to the low relative profitability of some of the statistical arbitrage trades, automation is the only practical manner to facilitate the trading. All facets of the research therefore suggest that this process of trade identification and execution must be automated for the maximisation of profitability in the equity arbitrage environment.

The other component of the proposed method is that the market risk function for the arbitrage process should still roll up into the greater market risk figures and VaR limits, but the arbitrage limits for pure and statistical trades should be stripped away into two separate trading limits that are separately identifiable from the normal trading limits as the arbitrage trades have different risk profiles to the proprietary and market making trading books.
CHAPTER 6

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

The research undertaken in this study focused on establishing the manner and extent to which banks, asset managers, insurance companies and stockbrokers capitalise on mispricing within the equities and equity derivative markets. The research investigated 80 institutions from these groups by applying a stratified quota sample. Those institutions forming part of the sample were asked to complete a research questionnaire which posed questions around their current trading strategies, their operational processes and their risk processes.

The second leg of the research was aimed at gathering the historic share prices and the prices of derivative instruments that relate to the underlying instruments, be they futures or options. From this information the arbitrage opportunities that could be identified using different methods were explored. The general research areas included pure and statistical arbitrage.

The findings of the empirical research gathered through the questionnaire was discussed in Chapter 4 and the relative profitability was also explored within the context of each arbitrage type and its associated trading costs. Practical considerations such as stop loss methods and market risk were also covered in this chapter.

Chapter 5 combined the information obtained from a comprehensive literature review as well as the empirical research to provide proposals to establish and run effective arbitrage operations. Chapter 5 also provided a statistical arbitrage identification process, which had been adapted for the South African market and which was aimed at predicting moves in the ALSI Top 40 index. While the intention and design of the model was to predict the moves in the ALSI Top 40, the logic is simple enough and can be easily extended to the prediction of other shares and indexes.
6.2 SUMMARY OF FINDINGS

The most important findings of this study are summarised below.

6.2.1 FINDINGS PERTAINING TO THE RESEARCH QUESTIONNAIRE

The results of the empirical research conducted amongst banks, stock brokers, investment managers and insurance companies showed that the equity arbitrage trading process was not widely applied in the market. In total 27 institutions of the 80 included in the sample confirmed that they do trade equity and equity derivative arbitrage within the South African market. The primary reasons cited by respondents for not trading equity arbitrage are:

- These strategies do not form part of their core business.
- A high degree of outsourcing of the investment functions - mainly the insurance companies.
- The asset managers generally operate the funds within specific client mandates, which exclude the arbitrage process either through the fact that they are not allowed to trade derivatives or because the investment managers that formed part of the random sample are multi-managers who in turn also outsourced the investment function to other investment managers.

As a result of the above, the institutions that do participate in the equity arbitrage process can be narrowed down to the following broad categories:

- Banks: Both local and international banks were found to house equity arbitrage trading within their treasury environments. Of the nine international banks included in the sample, three were of the opinion that the information was proprietary, while five did not trade equities. In total 11 of the 20 banks in the sample traded equity arbitrage.

- Stock brokers: The responses received indicated that nine of the stockbrokers included in the sample trade equity arbitrage. Only six of these completed the questionnaire, while the remaining three felt that the information was of a proprietary nature and therefore did not complete the questionnaire.
• Investment managers: Only six of the investment managers included in the sample trade equity arbitrage.

• Insurance companies: None of the insurance companies included in the sample trade equity arbitrage, due to the fact that they all outsource their investment function.

All the institutions that were included in the sample and that do trade equity arbitrage did however not provide feedback on their operations as eight regarded the information as proprietary in nature. Therefore only 19 provided details regarding their arbitrage trading activities.

Chapter 4, section 4.4.1, showed that 14 of the respondents that participate in equity and equity derivative arbitrage are involved in single stock futures and index arbitrage, while the balance felt that this was not part of their core business and therefore they are not involved in this activity. Only two of the 19 respondents who trade equity arbitrage are involved in dual listed arbitrage, and those who do not partake in this arbitrage type either do not have the legal ability or any interest in this type of trading activity. Of the 19 respondents, eleven are involved in risk arbitrage. Only eight of the 19 institutions trading arbitrage looked at statistical arbitrage opportunities, with the primary reasons for not being involved in this arbitrage type being that they do not have the systems or that this is not one of their core business areas. Three of the 19 respondents show interest in volatility arbitrage as a trading strategy. The primary reason for not getting involved in this type of trading is that it is not part of their core business and the institutions have no systems for identification.

The methods used to identify arbitrage processes can according to 16 of the respondents be improved. The general nature of the applications used to identify the price mismatch is to build the pricing logic into a spreadsheet, which is linked to live market data. The spreadsheet is then used to identify the trading opportunities, but the traders are still required to manually deal and capture all the trades that they wish to enter into. The research points out that this process is a weakness in terms of profit maximisation, as there is no certainty that all profitable trades are effected.

The research also found that the general business structure that is applied by the respondents is one that is centralised as the arbitrage desk is considered to be part
of the equity and equity derivative desks within the treasury department. This they felt, allowed the overall positions to be managed more effectively.

All respondents felt that the arbitrage strategies was profitable and this fact was strengthened by the fact that in general they had been trading the strategies for an average period of about three years. Of further interest is the fact that two of the stock brokers who are not currently trading equity arbitrage are in the process of setting up desks that would focus on capitalising on the pricing mismatches that are present in the market.

The research also found that the respondents generally rate the cost drivers that affect the profitability of their trades in a similar manner. While there are cost variations between the arbitrage types, the respondents generally felt that the transaction costs are the largest cost component in their trading, followed by securities lending costs, then staff and then systems.

These costs become a strategic problem in practice as the different institutions reflect varying cost structures in terms of their transaction costs, securities lending costs and in a less direct way, their cost of capital. Clearly the ability to compete is affected by this factor and the institutions need to drive these costs down where possible.

6.2.2 TIME SERIES FINDINGS

The time series analysis of arbitrage types in the South African market shows that all of the arbitrage types discussed in this research are profitable after taking into account transaction costs, taxes and securities lending costs. While the periods of investigation differed between arbitrage types, the general time horizon of the study spanned 3 to 4 years, with the exception of single stock futures where only two years’ data was available. In particular, the study made certain findings with regard to futures arbitrage, index arbitrage, risk arbitrage, dual listed arbitrage and statistical arbitrage, as is indicated in the ensuing sections.

6.2.2.1 FUTURES ARBITRAGE

The single stock futures analysis into the futures relating to the ALSI Top 40 shares shows a general profitability per trade of R1,746, given the constraints applied to the volumes that could be traded and there were about 1,155 trade opportunities
identified by the research. Of these, 699 trades proved to be profitable after taking into consideration the effects of transaction costs, securities lending costs and cost of capital. This leaves a net profitability over the two-year period of about R1.22 million.

One of the factors that restricted the profitability as discussed in this research is the fact that a strong focus was given to ensuring that the information used in the research was of such a nature that both the futures trade and the underlying trade were effected within 30 minutes of one another. In reality, the profitability of this strategy may be greater due to the fact that execution could occur over a longer period, as the mismatches are generally visible for a longer period according to the empirical research results obtained from respondents who trade this type of arbitrage.

The research showed that the SSF positions could be closed out prior to the contract maturity in cases where the market prices have converged to the expected levels and the profits have been realised. Where the trading strategy was applied in this manner, a capital saving resulted due to the shorter duration of the trade and a reduction in the securities lending costs and the funds used.

6.2.2.2 INDEX ARBITRAGE

The time series analysis and the findings pertaining to index arbitrage on the ALSI Top 40 futures was positive. The research identified 1,737 profitable trade opportunities over the four year period and these trades netted an average profitability of about R6,500 per trade and a total profitability of about R11.28 million after transaction costs. The transaction costs involved in this trading activity were found to be extremely high as a result of the fact that where the physical shares were to be purchased the traders would need to trade each of the shares in the index twice, once to acquire the position and once to get rid of the position at the respective institutions trading costs.

For the purposes of the research the average transaction cost of R60 was applied. However, it should be noted that the research assumed that the required order would be filled through one transaction, but in reality it may take a number of hits to fill the order. In this case the cost may go up by the STRATE and JSE charges levied on each trade.
The research did not differentiate between brokers and banks or asset managers, but assumed that all parties would incur the UST costs associated with the trades – in reality, the brokers would not incur this cost. Securities lending costs applied in the research was set to the average of the empirical research, which was indicated to be 1%.

### 6.2.2.3 Risk Arbitrage

The analysis of risk arbitrage proved that this is an extremely profitable trading strategy and that the South African environment is no different to the international environment, based on the reported research findings, in that the strategy provides double digit returns on both a real and annualised return basis.

The method applied was to analyse the SENS data provided by the JSE and identify companies that were in the process of being taken over. Shares in the company being acquired were then purchased or sold depending on the premium or discount at which the takeover transaction was taking place.

Corporate events that were excluded from the research included the take over of private companies, as there was no share price data against which to track the convergence to the premium or discount, and corporate events that involved offshore companies were also excluded. The reason why the offshore leg was excluded was due to differing legislation and the local exchange control factors, which inhibit the majority of the companies in the South African environment from partaking in these events.

Therefore only local events pertaining to listed companies were analysed, and the findings presented relating to these corporate events. This trading strategy provided profits after costs of about R3 million, given the trading costs and trade volume assumptions that were made.

### 6.2.2.4 Dual Listed Arbitrage

Dual listed arbitrage was also found to be a profitable strategy, although there are a limited number of institutions with the legal ability to trade these strategies given the interference by the government through exchange control.
The view held by the research was that in the event that the exchange control factor was removed the market would become significantly more efficient as a result of the local and international markets’ ability to act on the price mismatches in both the underlying markets and the derivative markets of South Africa and the markets where the alternate listing occurs. The results of the analysis showed there were about 2400 trade opportunities, and these trades generated about R13.7 million after costs.

6.2.2.5 Statistical Arbitrage

Under the review of statistical arbitrage a couple of identification strategies were explored. The first was the method described by Reverre (2001), which is basically an extension of pairs trading, as it relies on the fact that the shares involved are correlated in a significant manner – even if they are not in the same industry or related/sister companies.

The findings around the Reverre (2001) method were that the strategy is successful before transaction costs are factored into the equation. There are a large percentage of trades, that lose money, and the actual costs involved in trading this strategy were large enough to remove all of the profits from the trades that did make money. This is due in part to the assumptions made in terms of the number of shares that were traded, and as the volume traded increases the effect of transaction costs diminishes up to a point.

As with many trading strategies that are put forward, the results look impressive when viewed in isolation; however, the aim of the research was to incorporate an element of reality in terms of the practical costs that need to be covered when trading the strategies, and only where these practicalities are catered for and the strategy still performs well is it worthwhile to pursue the strategy. The problems surrounding this strategy become obvious when comparing the net profit before costs which was about R5.9 million against the R6.6 million UST costs that are incurred in the trading. When factoring in other costs the total loss for this strategy was about R1.149 million. Therefore the strategy can only find application with institutions that are UST exempt.

The Meissner et al (2002) method proved to be more profitable and reliable in that its degree of success in predicting the out-of-sample moves of the ALSI Top 40 index. In this analysis the ALSI Top 40 was set to be the lagging market relative to the European and Asian markets.
The findings showed that the Asian market was the best predictor of the ALSI Top 40 and that where the Asian market moved by a significant percentage on any given day, the ALSI Top 40 was very likely to move in the same direction the following day. The results of the research for the four-year period over which the analysis was done can be summarised as follows:

- In all cases where the Asian weighted basket moved up by more than 3% the ALSI Top 40 moved in same direction by roughly 1.947%. In cases where the Asian weighted basket of indexes moved up by between 2% and 2.5% or 2.5 and 3%, the ALSI Top 40 moved up by 1.405% and 1.969% respectively. This trading strategy netted 544 trades of which 65% were profitable. The net profit generated by this strategy was about R2.2 million when trading ten contracts per trade signal.

- Where the move in the Asian weighted index was downward the relationships were even more impressive and for the relative moves of 2% and 2.5%, 2.5% and 3% and above 3%, the respective instances where the ALSI Top 40 moved in the same direction were 86.66%, 100% and 100% with the respective percentage moves being −1.386%, -1.140% and −8.593%. This last figure was driven by an outlier position that resulted in this large percentage increase.

### 6.3 Conclusions

The research showed that of the 80 institutions that were included in the sample, only 27 of the respondents traded any form of equity and equity derivative arbitrage. Of these institutions that were involved in these arbitrage forms, it is obvious that certain arbitrage types are traded more actively than others. Of the respondents who completed the questionnaire 14 were involved in pure arbitrage trading while only eleven institutions were involved in risk arbitrage and only eight were involved in statistical arbitrage trading. Three were involved in volatility arbitrage and only two traded dual listed arbitrage. It is evident that arbitrage trading is limited within the South African market.

Chapter 5 provided a blueprint that can be used to establish an arbitrage operation, and also suggests some enhancements which aim to increase profits through the creation of a process that relies less on human intervention and which implies that
systems can in reality perform many of the routine processes surrounding the pure arbitrage processes such as SSF, index arbitrage and dual listed arbitrage. These systems can also be extended to various statistical arbitrage types that may not receive a high degree of attention simply because they generate a relatively low profitability on a per trade basis. The idea is that the system can perform the basic analysis and execute the trades without human intervention. Even in the case of arbitrage types where the profitability is marginal.

A key component to this automation should be the ability of the process to introduce stop loss limits as all statistical trading strategies do have a down side which needs to be actively managed for profitability to be enhanced. The stop loss limits should be implemented at a trade level, and monitored through an automated process to ensure that where these stop loss limits are breached that the trades are closed out within a minimum period of time.

The proposed enhancements to the arbitrage trading process also imply that where the system’s calculation of proposed directional trades is overridden by the traders, these must be recorded such that the system’s theoretical performance over time can be compared to the performance of the trader. This then implies that additional measures have been created to measure the performance of the traders, as the general approach that is presented is that if the traders attained their budgets then they performed adequately and hence they will be remunerated on that basis. This additional measure will allow for an improved manner in which to control the arbitrage trading environment, while facilitating a learning process whereby traders can be shown where their views were incorrect, relative to that predicted by the system. An added advantage would be situations where the trader follows a different methodology to that of the system, and consistently attains enhanced results relative to the system. In such circumstances the system should be updated to reflect the improved process – assuming that due diligence has been performed to ensure that the results were not of a short-term nature.

This process not only addresses the common problem highlighted in the empirical findings regarding the requirement for improved equity arbitrage identification and execution, but it also aims to improve decision making by allowing the measurement of the expected profitability of each deal in a manner which considers all the cost drivers at the trading limit levels specified by the business.
Clearly, the solutions offered in this research are not an off-the-shelf products and will require the South African and international markets to improve their systems capabilities within the context of their own infrastructure. In terms of providing a meaningful management solution there are no simple or manual processes that will truly provide the answers that are required to effectively measure and control the arbitrage trading processes. A further consideration is that the results should be reviewed periodically to determine the relevance of the statistical and mathematical models that are applied in the system and which are used to identify the trading opportunities. Technological systems capabilities are therefore important in applying the proposed processes.

Chapter 5 also provides a statistical technique similar to that of Meissner et al (2002) and Lo & MacKinley (1995) that can be applied to predict moves in the ALSI Top 40 using three resource-based indexes. While this method provides profitable results, it should again be stressed that applying stop loss limits enhances these results. While the focus of this research was on equity derivative arbitrage, the methodology applied in Chapter 5 is transferable to other areas of arbitrage – given that the appropriate mathematical models are applied to cater for the pricing requirements.

The above arbitrage management concept may be extended to the prediction of index movements by applying the appropriate in-sample independent variables to predict the out-of-sample dependent variable. This process provides an illustrative example of the application of statistical processes beyond the information provided in the literature review section covered in Chapter 2.

6.4 RECOMMENDATIONS FOR FURTHER RESEARCH

Although the research was undertaken within the South African environment, international published methodologies were applied. For this reason the findings should be easily transferable to other markets. Furthermore, the application of the mathematical pricing formula is fairly homogenous and only subtle adjustments for settlement methods, rate fixes and day count conventions should be required in different countries/markets.

The next level of analysis in the statistical and volatility arbitrage areas could pertain to the creation of predictors from predictors in that each arbitrage type is conventionally viewed in an independent manner which looks for a specific factor or
leading indicator or a deviation from a mean. No research or model has to date been created which attempts to bring all these factors together in one cohesive unit that creates probabilities from a host of other silos of probabilities. It is this consolidated view of arbitrage that will be the next level of arbitrage theory and it will rely on the basic building blocks that this research has discussed.

Dual listed arbitrage was covered in this research, and found to be extremely profitable. The logical extension of this research should be into an analysis of other exchanges that trade South African shares and also into the area of American Depository Receipts (ADRs) and Global Depository Receipts (GDRs), as these instruments should show results that are similar in nature to the findings of this research. Further analysis that may be considered and that could prove valuable, would relate to the volatility arbitrage between markets in that where dual listed instruments have options traded in both markets, there should be cases where the implied volatility of the same shares differ between countries. This volatility difference may create mispricing between the markets and participants that have the ability to trade both markets may be in a position to buy in the cheap market and sell in the expensive market, while hedging the currency risk. This will create another form of dual listed arbitrage, that may be researched.

The topic of convertible arbitrage has received a fair amount of focus in the international markets. Published research has not been done in this area in South Africa and should therefore be commenced to provide information regarding its occurrence and the extent to which institutions trade this type of arbitrage.

The final suggestion in terms of further research would be the arbitrage opportunities that present themselves between the credit default swap (CDS) markets and the equity default swap (EDS) markets. This research will be cutting edge (for now) in that the EDS market is still in its infancy within the global market place and empirical data within the South African environment could be limited to a couple of institutions in the South African market. This type of arbitrage is primarily correlation related and relies on the fact that the equity default spreads will increase in a similar manner to those of the credit spreads at times when the company is in distress.
BIBLIOGRAPHY


Cornelli F. & Li LD., 2000, “Risk Arbitrage in Takeovers”


Money. 1995: “How you too can profit big from todays takeover manie with a minimum of risk”. Vol. 24 Issue 4, p181,


Prebon Training Services SA. 2001: Registered Person Examination. Johannesburg


Websites without author references


# APPENDIX 1

## DUAL LISTED SHARES

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<tr>
<td>Tongaat-Hulett Group Limited, The THGL</td>
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<tr>
<td>Trans Hex Group Limited TSX</td>
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<tr>
<td>Truworths International Limited TRU</td>
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<tr>
<td>Wankie Colliery Company Limited WAKA</td>
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<tr>
<td>Company Name</td>
<td>Ticker</td>
<td>Exchange 1</td>
<td>Country 1</td>
<td>Exchange 2</td>
<td>Country 2</td>
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<tr>
<td>Wooltru Limited</td>
<td>WLO</td>
<td>JSE Securities</td>
<td>Namibia</td>
<td>Stock</td>
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<tr>
<td></td>
<td></td>
<td>South Africa Stock</td>
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<tr>
<td>Woolworths Holdings Limited</td>
<td>WOWOW</td>
<td>JSE Securities</td>
<td>London Stock</td>
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<td></td>
<td></td>
<td>South Africa Stock</td>
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<tr>
<td>Zambia Copper Investments Limited</td>
<td>ZAKK</td>
<td>JSE Securities</td>
<td>London Stock</td>
<td>Euronext Paris</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>South Africa Stock</td>
<td></td>
<td>Societe Anonyme</td>
<td></td>
</tr>
</tbody>
</table>
APPENDIX 2

RESEARCH QUESTIONNAIRE

Empirical Research into Arbitrage in the SA Market

1. Index Futures and Single Stock Futures

General

If you do not trade index and single stock futures arbitrage please answer question 1 of this section; if you trade index and single stock futures arbitrage please answer questions 2 onwards.

1. If you do not trade futures arbitrage, why is this the case? (please tick the all applicable boxes)
   - No system
   - No interest
   - Not part of your core business
   - It does not exist
   - Other (please specify) 

2. Do you believe that your futures arbitrage process can be improved and in which areas? Please check appropriate blocks.
   - No, it can't be improved
   - Improved identification processes
   - Improved execution processes
   - Improved market risk processes
   - Improved ability to measure the MTM of the performance of each trade
   - Other (please specify)
3. For how long have you taken advantage of futures arbitrage opportunities?
   
   - < 1 Year
   - > 1 year < 3 years
   - > 3 years < 5 years
   - > 5 years

4. What is the average time that opportunities are visible in the market?
   
   - = 1 day
   - > 1 day < 1 week
   - > 1 week < 2 weeks
   - > 2 weeks < 1 month
   - > 1 month

5. Do these trade opportunities meet your profitability requirements?  
   Yes  No

6. What is your profitability requirement?

7. What is the average number of index arbitrage transactions you enter into on a weekly basis?
   
   - < 5 transactions
   - > 5 < 10 transactions
   - >10 < 20 transactions
   - > 20 < 50 transactions
   - > 50 transactions

8a. Do you have a formal system to identify the futures arbitrage opportunities?  
   Yes  No
   If yes, which system is used?

8b. Do you use spreadsheets linked to a live data sources to calculate any price differences?  
   Yes  No
9. What percentage of the index and SSF arbitrage positions do you close out prior to the future maturing?
   < 10%  
   > 10% but < 30%  
   > 30% but < 50%  
   > 50%  

10. Do you adopt a stop loss strategy in the futures arbitrage strategy?
    For all positions  
    For some positions  
    Never  

11. What is the average stop loss level?
    <5%  
    >5% < 10%  
    >10% > 15%  
    >15% > < 20%  
    >20%  

12. Why do you apply this particular stop loss level?

**Dividends.**

13. Do you use continuous or discreet dividends for the index arbitrage?
    Continuous  
    Discreet  
    Both  
    In what proportion?  

14. In SSF and index arbitrage, do you use continuous or discreet dividends?
    Continuous  
    Discreet  
    Both  
    In what proportion?
15. What dividend forecast do you use?
- Bloomberg
- Inet
- Reuters
- Analysts forecasts
- Other (please specify)

16. If you are using discreet dividends, how do you apportion the interim and final dividend flows in Index Arbitrage?
- Apportioned equally
- Analysts forecasts
- Other (please specify)

17. If you are using discreet dividends how do you apportion the interim and final dividend flows in SSF Arbitrage:
- Apportioned equally
- Analysts forecasts
- Other: please specify.

**Risks**

18. What are the risks that you consider meaningful in these future arbitrage trades? Please mark all applicable options.
- Execution Risk
- Credit Risk – counterparty risk
- Market Risk – sensitivity to the underlying instrument
- Other
19. Do you generally use static hedges to manage the market risks that result from the Index and SSF futures trades? Yes No
If not, please define the method used.

20. Do you use a partial differential hedge (PDH) to determine the hedge requirements? Yes No

21. What do you use to hedge the Index and SSF positions? (check the relevant boxes)
Underlying % of the time
Futures % of the time
Options % of the time
Warrants % of the time
Other

22. Do you find liquidity to be a constraint in index arbitrage in the context of the ALSI index? Yes No

23. When going short stock and long the ALSI future, can you readily source the ALSI contracts and the underlying shares? Yes No

24. Do you use a representative basket of the ALSI to effect your hedge in order to reduce cost? Yes No

25. If you answered “No” to question 24 above, why do you not use a representative basket to hedge out your risk?
You do not wish to be exposed to the residual risk that may result from hedging only in the representative basket.
You consider the representative basket to be an ineffective means to hedge the exposure.
Other (please specify):
26. What risk limits are applied to Index and SSF trades? Please specify.

Cost Associated With Futures Arbitrage

27. Please rank the cost drivers that you incur in futures arbitrage form 1 to 4, with 1 being the smallest and 4 being the largest.
   Transaction / Hedging costs
   Securities lending cost
   Staff
   Systems

2. Risk or Merger Arbitrage

Def: Arbitrage opportunities that present themselves as a result of corporate activities, e.g. takeovers, cash share offers etc.

General

If you do not trade risk arbitrage, please answer question 1 of this section; if you do trade risk arbitrage, please answer questions 2 onwards.

1. If you do not trade risk arbitrage, why is this the case?
   No system
   No interest
   Not part of your core business
   It does not exist
   Other (please specify).
2. Do you believe that your risk arbitrage process can be improved and in which areas? Please check appropriate blocks.
   No, it can't be improved
   Improved identification
   Improved execution
   Improved market risk
   Improved ability to measure the MTM of the performance of trades or structures
   Other (please specify)

3. For how long have you taken advantage of risk arbitrage opportunities?
   < 1 Year
   > 1 year < 3 years
   > 3 years < 5 years
   > 5 years < 10 years
   > 10 years

4. What is the average time that opportunities are visible in the market?
   = 1 day
   > 1 day < 1 week
   > 1 week < 2 weeks
   > 2 weeks < 1 month
   > 1 month

5. Do these trade opportunities meet your profitability requirements? Yes No

6. What is your profitability requirement?

7a. Do you have a formal system to identify the risk arbitrage opportunities? Yes No
   If yes, which system is used?
7b. Do you use spreadsheets linked to a live data source to identify opportunities to calculate the opportunities?  

8. Do you adopt a stop loss strategy in the risk arbitrage strategy?  

9. What is the average stop loss level?  
   - <5%  
   - >5% < 10%  
   - >10% > 15%  
   - >15% < 20%  
   - >20%  

Risks  
10. Do you use a PDH to determine the hedge requirements?  

11. How do you hedge the exposure created by risk arbitrage?  
   - Underlying Instruments  
   - Options  
   - Forwards  
   - Futures  

12. What do you use to establish the hedging requirement?  
   - Partial Differential Hedge/Delta on the futures curve  
   - Partial Differential Hedge on volatility curve  
   - Delta  
   - Vega  
   - Gamma  
   - Other (please specify)  

13. What are the risks that you consider meaningful in these types of trades?  
   - Execution Risk  
   - Credit Risk – counterparty risk  
   - Market Risk – sensitivity to the underlying  
   - Legal Risk  
   - Other (please specify)
14. Do you generally find these transactions converge according to your expectations; and if not, why is this the case?

Transaction do converge according to expectations
Regulatory reasons
Deal is revised in a direction which inhibits price convergence to expected level
The time it takes to conclude the deal – the cost of holding the position removes the potential margin that was expected

15. What market risk limits are applied to risk arbitrage trades? Please specify.

Cost Associated With Risk Arbitrage

16. Please rank the cost drivers that you incur in risk arbitrage form 1 to 4, with 1 being the smallest and 4 being the largest.

Transaction / Hedging costs
Securities lending cost
Staff
Systems

3. **Dual Listed Arbitrage**

**General**

If you do not trade dual arbitrage please answer question 1 of this section, if you trade dual listed arbitrage, please answer questions 2 onwards.

1. If you do not trade any dual listed arbitrage opportunities, why is this the case?

No system
No interest
Not part of your core business
Don't have the legal ability to trade dual listed arbitrage
It does not exist
Other (please specify).
2. Do you believe that your dual listed arbitrage process can be improved and in which areas? Please check appropriate blocks.

No, it can't be improved
Improved identification
Improved execution
Improved market risk
Improved ability to measure the MTM of the performance of trades and structures
Other (please specify)

3. Do you use derivatives in any manner to gain additional gearing?

No, only the underlying is traded
Yes, warrants and OTC options and are traded
Yes, futures and forwards are traded

4. Do you trade dual listed arbitrage for:

Dividend effects % of trades
Currency effects % of trades

Other reasons (please specify):

5. Do these trade opportunities meet your profitability requirements? Yes No

6. What is your profitability requirement?
7. For how long have you traded dual listed arbitrage?
   < 1 Year
   > 1 year < 3 years
   > 3 years < 5 years
   > 5 years < 10 years
   > 10 years

8. What is the average number of dual listed transactions you enter into on a monthly basis?
   < 5 transactions
   > 5 < 10 transactions
   > 10 < 20 transactions
   > 20 < 50 transactions

9a. Do you have a formal system to identify the dual listed arbitrage opportunities? Yes No
   If yes, which system is used?

9b. Do you use spreadsheets linked to a live data sources to calculate and identify the trading opportunities? Yes No

10. Do you adopt a stop loss strategy in the dual listed arbitrage strategy? Yes No

11. What is the average stop loss level?
    <5%
    >5% < 10%
    >10% > 15%
    >15% > < 20%
    >20%
12. How do you hedge the dual listed securities arbitrage transactions that you enter into? (mark all applicable options)

- By taking the equal and opposite position on the London Stock Exchange
- By trading futures and forwards in a manner which neutralises the exposure created by the long/short position in the underlying instrument on the local exchange
- By trading put and call options in a manner which creates a net Delta-neutral position
- By hedging out the currency exposure that is created by transacting on the LSE
- Other (please elaborate)

**Risks**

13. Do you use a PDH to determine the hedge requirements? Yes No

14. How do you hedge the exposure created by statistical arbitrage?

<table>
<thead>
<tr>
<th>Hedging Instrument</th>
<th>% of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underlying</td>
<td></td>
</tr>
<tr>
<td>Futures</td>
<td></td>
</tr>
<tr>
<td>Options</td>
<td></td>
</tr>
<tr>
<td>Warrants</td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
</tr>
</tbody>
</table>

15. What do you use to establish the hedging requirement?

- Partial Differential Hedge/Delta on the futures curve
- Partial Differential Hedge on volatility curve
- Delta
- Vega
- Gamma
- Other (please specify)
16. What are the risks that you consider meaningful in these types of trades?

Execution Risk
Credit Risk – counterparty risk
Market Risk – sensitivity to the underlying
Legal Risk
Currency Risk
Other (please elaborate)

17. Do you find liquidity to be a constraint in these transactions? Yes No

18. Do you find the international market for the dual listed securities (underlying and derivatives) to be more liquid than the local market? Yes No

19. What risk limits are applied to dual listed trades? Please specify.

Costs Associated With Dual Listed Arbitrage

20. Please rank the cost drivers that you incur in dual listed arbitrage form 1 to 4, with 1 being the smallest and 4 being the largest.

Transaction / Hedging costs.
Securities lending cost.
Staff
Systems
4. **Statistical Arbitrage**

**General**

If you do not trade statistical arbitrage, please answer question 1 of this section; if you do trade statistical arbitrage, please answer questions 2 onwards.

1. If you do not trade any statistical arbitrage opportunities, why is this the case?
   - No system
   - No interest
   - Not part of your core business
   - Don’t have the legal ability to trade dual listed arbitrage
   - It does not exist
   - Other (please specify).

2. Do you believe that your statistical arbitrage process can be improved and in which areas? Please check appropriate blocks.
   - No it can't be improved
   - Improved identification
   - Improved execution
   - Improved market risk
   - Improved ability to measure the MTM of the performance of trades and structures
   - Other (please specify)

3. Do you participate in any of these statistical arbitrage types?

   **Underlying securities**
   - Pairs trading.
   - Statistical relationships.
   - Other (please specify).
Derivatives
Statistical arbitrage between derivative and or the underlying
Volatility arbitrage.
Other (please specify).

4. Are there any other types of statistical arbitrage types that your firm trades? Yes No
If yes please specify:

5. If yes to any one of question 3 and 4 do you use derivatives in any manner to gain additional gearing? Yes No

6. Do these trade opportunities meet your profitability requirements? Yes No

7. What is your profitability requirement?

8. For how long have you traded statistical arbitrage?
   < 1 Year
   > 1 year < 3 years
   > 3 years < 5 years
   > 5 years < 10 years
   > 10 years

9. What is the average number of statistical arbitrage transactions you enter into on an monthly basis?
   < 5 transactions
   > 5 < 10 transactions
   >10 < 20 transactions
   > 20 < 50 transactions
   Other (please specify)
10a. Do you have a formal system which is used to identify statistical arbitrage opportunities?  
Yes  No
If yes which system is used?

10b. Do you use spreadsheets linked to a live data sources to calculate and identify trading opportunities?  
Yes  No

11. Do you apply statistical arbitrage trading to all shares or only the liquid shares?  
Yes  No

12. Do you adopt a stop loss strategy in the statistical arbitrage strategy and at what level do you apply the stop loss?  
<5%  
>5% < 10%  
>10% > 15%  
>15% > < 20%  
>20%

Risks

13. How do you hedge the exposure created by statistical arbitrage?  
Underlying Instruments  
Options  
Forwards  
Futures

14. What do you use to establish the hedging requirement?  
Partial Differential Hedge/Delta on the futures curve.  
Partial Differential Hedge on volatility curve.  
Delta  
Vega  
Gamma  
Other (please specify)
15. What are the risks that you consider meaningful in these types of trades?

- Execution Risk
- Credit Risk – counterparty risk
- Market Risk – sensitivity to the underlying
- Legal Risk
- Currency Risk
- Greeks
- Other

16. Do you find the lending pool to be adequate to facilitate these transactions? Yes No

17. Do you use a partial differential hedge to determine the size and the direction of the hedges that are required to neutralise the exposures on the book? Yes No

If not, what do you use?

18. What risk limits are applied to statistical arbitrage trades? Please specify.

Cost Associated With Statistical Arbitrage

19. Please rank the cost drivers that you incur in statistical arbitrage form 1 to 4, with 1 being the smallest and 4 being the largest.

- Transaction / Hedging costs.
- Securities lending cost.
- Staff
- Systems
5. **Volatility Arbitrage**

**General**

If you do not trade volatility arbitrage, please answer question 1 of this section; if you do trade volatility arbitrage, please answer questions 2 onwards.

1. If you do not trade volatility arbitrage, why is this the case?
   - No system
   - No interest
   - Not part of your core business
   - Don't have the legal ability to trade dual listed arbitrage
   - It does not exist
   - Other (please specify).

2. Do you believe that your volatility arbitrage process can be improved and in which areas? Please check appropriate blocks.
   - No, it can't be improved
   - Identification
   - Execution
   - Market Risk
   - Ability to measure the MTM of the performance
   - Other (please specify)

3. Do you participate in volatility arbitrage via statistical arbitrage types?
   - Yes
   - No

4. Do you have instances where these volatility arbitrage trades are considered pure arbitrage? Please elaborate.
   - Yes
   - No
5. Do these trade opportunities meet your profitability requirements?  
   Yes ☐ No ☐

6. What is your profitability requirement?

7. What types of volatility arbitrages do you capitalise upon?
   - Spread Arbitrage
     Different issuers – where companies have similar structures and balance sheets and operate in the same industry
   - Speculative, i.e. increase or decrease in volatility
   - Reversion to theoretical (historical) volatility
   - Other Statistical (please elaborate)

8. Do you apply volatility arbitrage to all shares or only the liquid shares?  
   Yes ☐ No ☐

9. For how long have you traded volatility arbitrage?
   - < 1 Year
   - > 1 year < 3 years
   - > 3 years < 5 years
   - > 5 years < 10 years
   - > 10 years

10. What is the average number of statistical arbitrage transactions you enter into on an annual basis?
    - < 5 transactions
    - > 5 < 10 transactions
    - > 10 < 20 transactions
    - > 20 < 50 transactions
    - Other (please specify)
11a. Do you have a formal system to identify volatility arbitrage opportunities? Yes No
If yes, which system is used?

11b. Do you use spreadsheets linked to a live data sources to calculate and identify the opportunities? Yes No

12. Do you adopt a stop loss strategy in the statistical arbitrage strategy? Yes No

13. What is the average stop loss level?
   <5%
   >5% < 10%
   >10% > 15%
   >15% > < 20%
   >20%

14. What do you use to establish the hedging requirement?
   Partial Differential Hedge/Delta on underlying curve.
   Delta
   Vega
   Gamma
   Other (please elaborate)

Risks

15. How do you hedge the exposure created by volatility arbitrage?
   Underlying Instruments
   Options
   Forwards
   Futures
16. What do you use to establish the hedging requirement?
Partial Differential Hedge/Delta on underlying curve, e.g. Delta buckets
Partial Differential Hedge on volatility curve, e.g. vega buckets
Delta
Vega
Gamma
Other (please specify)

17. What are the risks that you consider meaningful in these types of trades?
Execution Risk
Credit Risk – counterparty risk
Market Risk – sensitivity to the underlying
Legal Risk
Currency Risk
Greeks
Other (please specify)

18. Do you find the lending pool to be adequate in these transactions?  
Yes  No

19. Do you use a partial differential hedge to determine the size and the direction of the hedges that are required to neutralise the exposures on the book?
Yes  No
If not, what do you use?

20. What risk limits are applied to volatility arbitrage trades? Please specify.
Cost Associated With Volatility Arbitrage

21. Please rank the cost drivers that you incur in volatility arbitrage from 1 to 4, with 1 being the smallest and 4 being the largest.
   - Transaction / Hedging costs.
   - Securities lending cost.
   - Staff
   - Systems

6. Strategic and Operational Processes

General

1. Do you have the ability to model arbitrage opportunities based on:
   - Historical profit maximisation scenarios?
   - Monte Carlo profit maximisation scenarios?
   - Other (please specify):

2. Are all the equity arbitrage types managed in one area
   - Centralised?
   - Decentralised?
   - Combination of both? Please elaborate.

3. Why do you prefer this structure?

4. Do you believe that your arbitrage operations can be improved?
   - Yes
   - No
   - How?
5. Does the risk management process for equities and equity derivatives fall within the general business market risk framework?

   Yes  No

6. How do you measure the general effectiveness of the arbitrage traders?

   Performance against budget

   Other

7. At what point would you consider discontinuing your arbitrage operations?

   If it does not meet profitability requirements for 1 year

   If it does not meet profitability requirements for 2 years

   If it does not meet the profitability requirements for 3 years

   If it does not meet the profitability requirements for 4 years or more

8. Do you consider arbitrage operations to provide any strategic advantage in the event that the trading is not profitable?

   Yes  No

   Why?

9. Do all arbitrage trades roll up into your existing risk framework, i.e. risk and trading systems?

   Yes  No

   If no, why not?

10. Do you believe the arbitrage risks need to be viewed independently?

    Yes  No

    If yes, why?

11. What are the average securities lending costs expressed as a percentage of the notional amount borrowed?

12. What are the average futures trading costs?

13. What are the average equity trading costs?
14. What management tools do you use to manage the arbitrage operations?
   Identification tools
   Risk tools
   Trader monitoring tools
   Profit maximisation tools
   Other (please specify).

15. What additional management tools would you consider useful in managing arbitrage opportunities?

16. What is the arbitrage management business structure used in your treasury?
   Equity Arbitrage forms part of Equity Derivatives
   Equity Arbitrage forms part of a general arbitrage desk
   Other (please specify)

17. How many traders are used in your arbitrage operation?
   1
   2
   3
   4
   > 4

18. What is the average cost of a trader annually?
   < R250 000
   >250 000 < 350 000
   > R400 000 < 550 000
19. Are the traders specialists who only focus on arbitrage trading? Yes No
Why or why not?

20. Do you intend to expand your arbitrage operations into areas discussed within this questionnaire? Yes No
Why or why not?

21. Do you intend to expand your arbitrage operations into other arbitrage types not covered in this research? Please specify. Yes No
Why or why not?

22. Do you have the ability to calculate the Rho that results from the arbitrage positions? Yes No

23. Do you actively manage the interest rate risk (Rho) that results from the arbitrage positions? Yes No
How?

24. Do you have the ability to calculate the Vega of the arbitrage positions? Yes No

25. Do you actively manage the volatility risk (Vega) that results from the arbitrage positions? Yes No
How?

26. Do you have the ability to calculate the Delta of the arbitrage positions? Yes No

27. Do you actively manage the risk that results from changes in the price of the underlying instrument (Delta) that results from the arbitrage positions? Yes No
How?
28. Do you have the ability to calculate the gamma of the arbitrage positions?  
Yes  No

29. Do you actively manage the Gamma risks that results from the arbitrage positions?  
Yes  No
How?

30. How do you test for the sensitivities that are associated with these and other limits?
# APPENDIX 3

## CONTENT VALIDITY QUESTIONNAIRE

1) Does the questionnaire flow in a natural manner?  
   - [ ] Yes  
   - [ ] No

2) Is it clear what the questionnaire hopes to determine?  
   - [ ] Yes  
   - [ ] No

3) Were the questions clear? If not, which ones should be reviewed?  
   - [ ] Yes  
   - [ ] No

4) Were the questions ambiguous in any manner? If so, which ones?  
   - [ ] Yes  
   - [ ] No

5) Were all the questions relevant? If not, which questions should be reviewed?  
   - [ ] Yes  
   - [ ] No

6) Were the questions too sensitive in nature and therefore avoided?  
   - [ ] Yes  
   - [ ] No

7) How long did it take to complete the questionnaire?  
   - [ ]

8) Do you have any comments about the questionnaire, other than those covered in the above questions?  
   - [ ]
   - [ ]
   - [ ]
   - [ ]